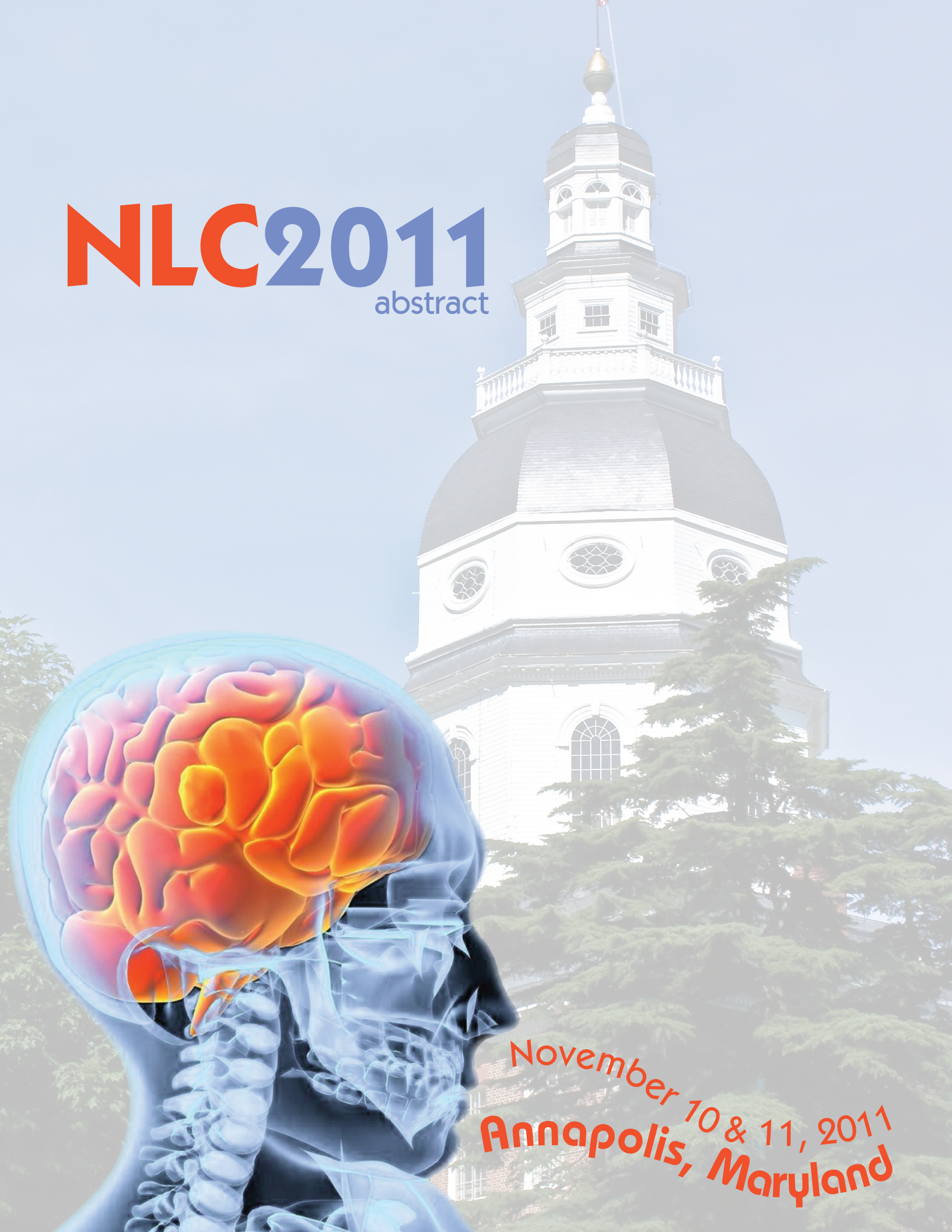
NLC2011
abstract



November 10 & 11, 2011
Annapolis, Maryland

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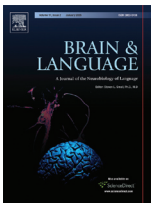

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Welcome to NLC 2011

Welcome to the Third Annual Neurobiology of Language Conference (NLC) and the first NLC to be formally run by our new organization, the Society for the Neurobiology of Language (SNL)! You may have noticed some growing pains over the last year as we worked to coordinate websites, rules for Society membership, conference abstract submission, and conference registration systems. It turns out that setting up and managing a new society and planning an annual meeting is a lot work and a bit overwhelming for a group of mere neuroscientists. Happily we were able to secure the help of a team of professionals –Tara Miller Events (TME), the same management group that runs the Cognitive Neuroscience Society, among others. TME is helping us with management and planning so that we can spend more time doing what we do best – fighting for grant money and arguing about the neurobiology of language.

By all accounts, the Neurobiology of Language Conference has been a resounding success. In just a couple of years, the NLC has emerged as the primary meeting in our field. We can thank Steve Small and his group (i.e., Pascale Tremblay) for getting the ball rolling. But now with the formation of our new Society and the realization that operating a quasi-satellite to SfN is not feasible in the long term, we are beginning a new phase in the development of our organization. We are growing up – and that's where you come in. Although it may seem like meetings and societies exist independently of the scientists and students who decide (or not) to partake in what these entities have to offer, this is not the case. Meetings and societies exist because people like you and me recognize a need and decide to put in the effort to make them happen. What this means is that if you value what we all have created, it is your responsibility to keep it going by participating in and promoting the effort. You don't have to run for office. There are lots of ways to participate: join the Society, nominate and vote, submit abstracts and attend the meeting, provide feedback and suggestions, tell your friends and colleagues about how cool we are. You get the idea. This is our Society and annual meeting. Let's work together as a community to help it grow and prosper. It won't do it on its own.

I would personally like to thank the SNL Board of Directors, the Program Committee, the Nomination Committee, as well as Shauney, Shawna, and Tara at TME – all of whom worked very hard to pull things together. I would also like to thank our invited speakers for accepting our invitation. It is important to acknowledge NIDCD who provided funding to support our invited speakers and provide, for the first time, merit and travel scholarships.

On behalf of the Board, welcome to Annapolis!

Gregory Hickok

Chair, Society for the Neurobiology of Language

Schedule of Events

Wednesday, Nov. 9

4:00 - 7:00 pm **Pre-Registration Check-in and Onsite Registration**
Capitol A Pre-Function

Thursday, Nov. 10

7:00 am - 6:00 pm **Pre-Registration Check-in and Onsite Registration**
Capitol A Pre-Function

7:30 - 8:45 am **Continental Breakfast**
Capitol A Pre-Function

8:45 - 9:00 am **Opening Remarks: *Greg Hickock, President***
Capitol Ballroom B & D

9:00 - 10:00 am **Keynote: *Troy Hackett***
Primate Auditory Cortex: Principles of Organization and Future Directions
Capitol Ballroom B & D

10:00 - 10:30 am **Coffee Break**
Capitol Pre-Function

10:00 - 11:30 am **Poster Session A**
Speech Perception, Prosody, Acquisition, Manual & Sign Language, Pathology, Speech Production
Senate, Capitol C, and Capitol C Pre-Function

11:30 am - 12:50 pm **Slide Session A**
Capitol Ballroom B & D

12:50 - 2:00 pm **Lunch Break**
on your own

2:00 - 3:20 pm **Slide Session B**
Capitol Ballroom B & D

3:20 - 3:50 pm **Coffee Break**
Capitol Pre-Function

3:20 - 4:50 pm **Poster Session B**
Speech Perception, Prosody, Multilingualism, Reading & Writing, Social & Emotional Processing
Senate, Capitol C, and Capitol C Pre-Function

4:50 - 6:10 pm **Discussion Panel: *David Poeppel & Sophie Scott***
Mechanisms underlying the lateralisation of speech perception
Capitol Ballroom B & D

6:15 - 8:15 pm **Poster Session C and Welcome Reception**
Multilingualism, Reading & Writing, Social & Emotional Processing, Acquisition, Manual & Sign Language, Pathology, Speech Production
Senate, Capitol C, and Capitol C Pre-Function

Friday, Nov. 11

7:00 am - 6:45 pm	**Pre-Registration Check-in and Onsite Registration** *Capitol A Pre-Function*
7:30 - 8:45 am	**Continental Breakfast** *Capitol A Pre-Function*
8:50 - 9:00 am	**Opening Remarks: *Greg Hickock, President*** *Capitol Ballroom B & D*
9:00 - 10:00 am	**Keynote: *Katrin Amunts*** *Broca's region – architecture and novel organizational principles* *Capitol Ballroom B & D*
10:00 - 10:30 am	**Coffee Break** *Capitol Pre-Function*
10:00 - 11:30 am	**Poster Session D** *Anatomy, Cognitive & Executive Processing, Syntax, Conceptual/Semantic/ Discourse Processing* *Senate, Capitol C, and Capitol C Pre-Function*
11:30 am - 12:50 pm	**Slide Session C** *Capitol Ballroom B & D*
12:50 - 2:00 pm	**Lunch Break** on your own
2:00 - 3:20 pm	**Slide Session D** *Capitol Ballroom B & D*
3:20 - 3:50 pm	**Coffee Break** *Capitol Pre-Function*
3:20 - 4:50 pm	**Poster Session E** *Anatomy, Cognitive & Executive Processing, Syntax, Conceptual/Semantic/ Discourse Processing* *Senate, Capitol C, and Capitol C Pre-Function*
4:50 - 5:20 pm	**Business Meeting** *Capitol Ballroom B & D*
5:20 - 6:40 pm	**Discussion Panel: *Alfonso Caramazza & Friedemann Pulvermuller*** *What is the Role of the Motor System in Action Concepts?* *Capitol Ballroom B & D*

Awards

The Society for the Neurobiology of Language (SNL) awards several Travel Awards funded by the National Institute on Deafness and Communication Disorders (NIDCD) to help cover travel and registration costs for the 2011 Neurobiology of Language Conference (NLC) in Annapolis, Maryland.

ABSTRACT MERIT AWARDS

Abstract Merit Awards were given to the two students and two postdocs submitting the highest ranked abstracts.

The SNL 2011 Merit Awards were given to:

Elisabeth Karuza, *The University of Rochester, NY, US*

Hannah Snyder, *University of Colorado at Boulder, US*

Siyuan Liu, *National Institutes of Health, National Institute on Deafness and Other Communication Disorders, US*

Michael Wolmetz, *Johns Hopkins University, MD, US*

TRAVEL AWARDS

12 Travel awards were given to students and postdocs to help defray the costs of attending the meeting.

The SNL 2011 Travel Awards were given to:

Teon Brooks, *New York University, US*

Brea Chouinard, *University of Alberta, Canada*

Kimiko Domoto-Reilly, *Massachusetts General Hospital and Harvard Medical School, US*

Sarah Grace Hudspeth, *University of South Carolina, US*

Nina Hsu, *University of Pennsylvania, US*

Shinae Kang, *University of California, Berkeley, US*

Mikel Lizarazu, *Basque Center on Cognition, Brain and Language (BCBL), Spain*

Aya Meltzer-Asscher, *Northwestern University, US*

Takenobu Murakami, *Goethe-University, Frankfurt, Germany*

Tepring Piquado, *University of California, Irvine, US*

Rubén Torres, *National Autonomous University of Mexico, Mexico*

Jean Mary Zarate, *New York University, US*

Keynote Lectures

PRIMATE AUDITORY CORTEX: PRINCIPLES OF ORGANIZATION AND FUTURE DIRECTIONS

Thursday, November 10, 9:00 – 10:00 am, Capitol Ballroom B & D

Chair: ***Greg Hickok****, University of California, Irvine, US*

Speaker: ***Troy Hackett****, Department of Hearing and Speech Sciences, Vanderbilt University School of Medicine, USA and Department of Psychology, Vanderbilt University, US*

Every major region of the brain contains areas that are involved in the processing of sound, and each of these areas is thought to perform unique functional roles. After decades of inquiry, however, we have not been able to determine even the primary function of any of these areas. In part, progress has been limited by methodological and technological constraints, especially for studies of the human brain. As a result, much of what is known about central auditory processing depends on studies in species chosen as model systems. As an animal model of central auditory processing, nonhuman primates play an important role in bridging the findings from research conducted in humans with those derived from other species. But, like all animal models, the nonhuman primate is unavoidably incomplete as a model system for understanding human audition. The expanded auditory-related capabilities of humans, including language, make use of extensive adaptations and elaborations of brain structures and associated networks – most of which are waiting to be discovered. This expansion is most obvious in the cortex. Compared to the subcortical auditory pathway, which appears to be more highly conserved across species, the organization of auditory areas in cortex varies so widely that the establishment of homologous areas is currently limited to only one or two primary fields. Yet, amidst this diversity, a growing number of shared anatomical and physiological features are being identified. These common 'principles of organization' are not only a means of comparing and contrasting model species, but their extension to studies of the human brain is also moving us closer to establishing a working model of human auditory cortex that can be tested and refined. These efforts will provide an improved foundation for advanced functional imaging and electrophysiological studies of normal and impaired auditory processing both now and into the future.

BROCA'S REGION – ARCHITECTURE AND NOVEL ORGANIZATIONAL PRINCIPLES

Friday, November 11, 9:00 – 10:00 am, Capitol Ballroom B & D

Chair: ***Murray Grossman****, University of Pennsylvania, Philadelphia, US*

Speaker: ***Katrin Amunt****s, Institute of Neuroscience and Medicine, Research Center Juelich, Germany and Department of Psychiatry, Psychotherapy and Psychosomatics, RWTH Aachen University, Germany*

Different aspects of language processing are associated with localized activations in specific brain regions and networks. Modern neuroimaging has opened the possibility to analyse language in the human brain during experimentally well-controlled tasks. However, the microstructural correlates of such activations and their relationship are not well understood. Apart from the classical concept of two language centres, Broca's and Wernicke's, there was little progress in the last decades with respect to their structural segregation, localization and extent, and distinctiveness as "language" region. Evidence will be provided that the segregation of Broca's region is more complex than previously assumed. The talk will show how the inferior frontal cortex has been analysed using multivariate statistical tools for the definition of cortical borders. Cytoarchitectonic and receptorarchitectonic analysis of six transmitter receptors show a more detailed parcellation of areas 44 and 45, but also indicate a new landscape of areas in neighbouring regions of the frontal operculum, precentral gyrus and inferior frontal sulcus. The relevance of such new parcellation will be discussed with respect to different aspects of language function and dysfunction.

Discussion Panels

MECHANISMS UNDERLYING THE LATERALISATION OF SPEECH PERCEPTION

Thursday, November 10, 4:50 - 6:10 pm, Capitol Ballroom B & D

Chair: ***Jeff Binder****, Department of Neurology, Medical College of Wisconsin, US*

Speakers: ***David Poeppel****, Department of Psychology, New York University, US and* ***Sophie Scott****, Institute of Cognitive Neuroscience, University College London, UK*

For the past dozen years, in part stimulated by the availability of non-invasive recording techniques, there has been increasing research on the brain mechanisms underlying speech perception. Several themes have emerged that have led to consensus and debate. One major generalization about which there is consensus is that there exist concurrent processing pathways responsible for different aspects of speech perception. However, the organization and relative lateralization of these pathways remain vigorously debated. While the classic neuropsychological approach to language processing has emphasized a left dominance for language processing, controversies exist as to the extent to which this is true, and also around the mechanisms that might underlie any such asymmetries. On one hand, generic computational operations have been suggested to underlie specialization, at least in part, including temporal strategies. On the other hand, more functional differences between the two hemispheres have been identified as relevant to candidate asymmetries in language processing. There is also considerable debate about the levels of analysis that are relevant to brain asymmetry. In this debate we will try to lay out a few major findings and arguments for and against these positions.

Funding Opportunities at NSF

William Badecker, a program officer in NSF's Linguistics Program, will be on-hand on Friday to discuss funding and job opportunities available at NSF. A sign-up sheet will be located at the Registration desk.

WHAT IS THE ROLE OF THE MOTOR SYSTEM IN ACTION CONCEPTS?

Friday, November 11, 5:20 - 6:40 pm, Capitol Ballroom B & D

Chair: ***Greig de Zubicaray****, School of Psychology, University of Queensland, Brisbane, Australia*

Speakers: ***Alfonso Caramazza****, Cognitive Neuropsychology Laboratory, Harvard University, US and Center for Mind/Brain Sciences, University of Trento, Italy and* ***Friedemann Pulvermuller****, Cognition and Brain Sciences Unit, Medical Research Council, UK and Brain Language Lab, Free University of Berlin*

ASPECTS OF THE REPRESENTATION AND ORGANIZATION OF CONCEPTUAL KNOWLEDGE

Alfonso Caramazza - Many reports claim to provide evidence for the view that concepts are no more than recapitulations of sensory-motor experiences. However, those claims do not withstand close scrutiny: the proffered experimental results do not allow unambiguous inferences about the nature of conceptual representations and the theoretical proposals lack specificity. I will outline an alternative proposal that assumes distinct, progressively more abstract levels of representation of action and object knowledge.

NEURONAL MECHANISMS FOR SEMANTIC KNOWLEDGE ABOUT ACTION, ABSTR-ACTION, PERCEPTION, EMOTION, RECOMBINATION, AND CONSTRUCTIONS. – WHAT'S LEFT FOR THE SYMBOL BOX?

Friedemann Pulvermuller - Some words are used to speak about objects and actions and one may therefore propose that the brain mechanisms linking symbol (form) and meaning tie neuronal circuits for actions and objects to linguistic cell assemblies. This view has gained plausibility from studies documenting focal and rapid activation of sensorimotor brain systems reflecting the meaning of presented symbols, along with studies documenting an influence of sensorimotor activation or lesion on the processing of symbols. This research shows that, at least for some symbols, embodied sensorimotor systems and representations are semantically relevant.

However, not all words are used to speak about specific objects and actions. Some words are so abstract in meaning that an "embodied" approach to their semantics seems to be prone to fail. Therefore, meaning has been proposed to require a semantic-conceptual symbol box dealing with the really difficult stuff, especially with abstract words, such as "beautiful", "free" or "dread". In a symbolic approach, each concept and meaning has its abstract symbolic representation. "Dread" can be learned because we connect the word with this abstract concept – which is possibly given to us. I will show that this approach to meaning is flawed. Even if we had an inborn concept of "dread"-ness, how should one know which word to connect with it? In contrast, an explanation of the meaning of abstract words such as "dread" requires that the emotions such words are used to speak about can be expressed by actions. The theoretical argument will be bolstered by brain imaging evidence. Without such action-grounded meaning, abstract symbolic meaning cannot be explained. Abstract meaning resulting from combinatorial information and construction storage will also be addressed, as for example in the case of "grasping ideas" or "cooling down". A range of concrete sensorimotor, affective-emotional, combinatorial and construction-related brain mechanisms are available for mechanistically explaining meaning and concepts. So is a semantic symbol box still needed?

General Information

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

ATM
Located near the Annapolis Grill

BAGGAGE CHECK
All Attendees, even those not staying at the Westin, are welcome to check their bags at the front desk or with the valet.

BUSINESS CENTER
The Business Center is located on P1 level and is open 24 hours a day.

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.

CONTACT US
To contact us onsite, visit the Registration Desk in the Capitol A Pre-Function, or send an email to Info@neurolang.org. We will respond to your email at our soonest opportunity.

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.

FITNESS CENTER
The Fitness Center is located on P1 level, next to the Business Center. The Fitness Center is open 24 hours a day and can be accessed using a guest key. There is also a small indoor pool, open Monday – Friday, 6:00 am – 10:00 am and 4:00 pm – 10:00 pm; and Weekends, 8:00 am – 10:00 pm.

FOOD SERVICE
Complimentary food and beverage service is available to all registered attendees at the following times in Capitol A Pre-Function.

Thursday
- Continental Breakfast, 7:30 – 9:00 am
- Coffee Break, 10:00 – 10:30 am
- Coffee Break & Light Snack, 3:20 – 3:50 pm
- Welcome Reception, 6:15 – 8:15 pm

Friday
- Continental Breakfast, 7:30 – 9:00 am
- Coffee Break, 10:00 – 10:30 am
- Coffee Break & Light Snack, 3:20 – 3:50 pm

HOTEL OUTLETS
The hotel restaurant, **Azure**, is located on the Lobby level. Hours: Monday – Friday, 6:00 am – 2:00 pm for breakfast and lunch; Weekends: 7:00 am – 2:00 pm. Light Fare can also be ordered in the Lobby Lounge from 2:00 – 11:00 pm. Room service is available 6:30 am – 11:00 pm.

FUTURE MEETING
NLC 2012 will be held in San Sebastian, Spain, from October 25-27, 2012.

LOST & FOUND
Please check with the NLC Registration Desk for items lost and found.

MESSAGES
A bulletin board will be available for messages and job postings near the NLC Registration Desk in Capitol A Pre-function.

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

NAME BADGES
For security purposes, all attendees are asked to 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 NLC Registration Desk is located in Capitol A Pre-function. The Registration Desk hours are:

Wednesday, November 9, 4:00 – 7:00 pm
Thursday, November 10, 7:00 am – 6:00 pm
Friday, January 28, 7:00 am – 6:00 pm

PARKING
Self-parking is available for $1.25/hour, up to $5.00 a day. Valet parking is $10.00 for day parking and $23.00 for overnight parking. Self-parking cannot be put on your hotel bill and must be paid for every time you exit the garage (located beneath the hotel).

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

SLIDE SESSIONS

An LCD projector (e.g., for PowerPoint presentations) will be provided in the talk room; 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 in their scheduled room a minimum of 30 minutes before their talk so that they know how to set up their equipment.

SMARTPHONE APP

NLC 2011 has a Smartphone application (Grupio) that makes attending NLC 2011 a lot more convenient and fun! It provides easy access to event information, schedules, maps, speaker information and a whole lot more to all Attendees.

iPhone, download "Grupio" from the app store.

Android, download "Grupio" from Android Market, look for the SNL event listed.

Blackberry, (Storm and Torch) only if you have a touch screen device with OS 5.0 and above.

No Smartphone? No problem – you can use the mobile application website at **www.grupio.com/snl2011**

TRANSPORTATION

Airport Transportation – Discounted transportation is available with **SuperShuttle** for transportation between *Baltimore Washington International* (BWI), *Dulles* (IAD), and *Regan National* (DCA) airports and the Westin Annapolis. Discounted rates: $2.00 off one-way; $5.00 off round-trip fare. Book more than one reservation at the same time will result in greater savings. For reservations, call 1-800-BLUE-VAN and use code **ZXVUA**.

Transportation to SfN – For those traveling on to SfN, we will offer a complimentary bus service from the *Westin Hotel* to the *New Carrollton Metro*. SfN attendees can take the metro rail directly into DC. This transportation will be provided by *Huber's Bus Service*. Motor coaches will be available in front of the hotel at the following times:

Friday, Nov 11: 6:30 pm, 7:45 pm, 9:00 pm and 10:15 pm

Saturday, Nov 12: 7:30 am, 8:45 am, 10:00 am, and 11:15 am

SAVE THE DATE!
NLC 2012
October 25-27 2012
San Sebastian, Spain

Slide Sessions

Slide Session A

Thursday, November 10 11:30 am - 12:50 pm
Capitol Ballroom B & D

Chair: ***Pascal Tremblay****, Université Laval*

A1 11:30 am

Did auditory localization drive the development of complex speech? ***Lenhardt, M****, Virginia Commonwealth University, Richmond, VA* – Evolution of speech and eventually language is not a topic lacking hypothesized selective pressures. Clearly there was a fitness advantage to individuals who developed a vocal repertoire.The foundations of an expansive vocal repertoire are in the functioning of the peripheral and neural motor systems; such underpinnings are also essential in modern human speech communication. There is not one selective pressure to such a complex cultural and social system as speech; however the role of speech as an acoustic event to be spatially localized has received little attention.The objective is to review the basis for an auditory localization theory of complex speech evolution. Speech is modeled as a source filter mechanism (Fant, 1960). The power in this model is the lungs, the acoustic source is the vocal folds and the acoustic filter is the supralaryngeal vocal tract. The fundamental vocal frequency is considered the identifier of the speaker while the vocal tract filter carries the acoustic properties of the spoken message.It hypothesized that the filter played an initial role in producing vocal sounds that could be more easily localized in a primitive hominid environment than actually provide any more than crude linguistic information.It is argued complex vocalization evolved because it could be readily generated and accurately detected in space.There is convergent anatomic evidence supporting this view in the "what"/"where" pathways, the multimodal sensory pathway and lemniscal and non-lemniscal parallel auditory pathways.The source would be principally processed in the "where" pathway whereas the message, only after linguistic development, would be coded in the "what" pathway.The "where" pathway is presumably the older of the two and initially both the source and filter would have activated it.The Stebbins lab (Brown et al, 1978) reported more than 30 years ago that macaques coo calls were better localized when they were more complex (by enhanced frequency modulation [FM]) which required greater neural control that less modulated coos. The difference in minimal audible angle performance was notable with FM calls yielding an angle was 40, in contrast to an angle 150with little modulation.Recently (Chevilet et al, 2011) reported that the human analogous area of auditory cortex to the macaque coo area in the superior temporal lobe was the planum temporale with direct lemniscal pathway input characterized by narrowly tuned tonotopically organized neurons. In parallel the non-lemniscal pathway targets association cortex with broadly turned neurons coding position in space; each pathway has separate limbic inputs which contribute to "where". The 'where" pathway is also more responsive to multimodal stimulation; an example of which is the ventriloquism effect.In perception, auditory visual neurons in the superior colliculi trump the unimodality lemniscal auditory neurons.If the sound source and the movement are incongruent in space, the ventriloquism effect disappears (Kanaya and Yokosawa, 2011).Thus, complex speech sounds are better localized and activate the multimodal neural system to produce orientation with increased attention and salience.With a complex vocal system already in place, speech was co-opted for expanded role in communication.

A2 11:50 am

Neural correlates of statistical learning in a word segmentation task: An fMRI study ***Karuza, E.A.*** *(1),* ***Newport, E.L.*** *(1),* ***Aslin, R.N.*** *(1),* ***Davis, S.J.*** *(1),* ***Tivarus, M.E.*** *(1), &* ***Bavelier, D.*** *(1). 1. The University of Rochester, Rochester, NY, US.* – Saffran, Aslin, & Newport (1996) proposed that statistical learning is a mechanism for human language acquisition, demonstrating that infants and adults can segment word-like units from a stream of continuous speech by rapidly calculating transitional probabilities between constituent syllables and segments [1].The capacity to acquire structure by computing statistical regularities has also been shown with non-linguistic auditory [2] and visual stimuli [3].Only a few studies have sought to uncover the neural mechanism underlying statistical learning. Crucially, most have not shown behavioral evidence of learning in the scanner (e.g., [4], [5]), presumably due to the brevity of exposure or to the circumstances of scanning. Without a direct link between neural activation and behavioral evidence of learning, activity of a hypothesized learning mechanism cannot be differentiated from the neural response to word familiarity or time on task. The present fMRI study addresses this shortcoming and examines neural activation during an on-line word segmentation task, along with behavioral measures of learning during a sequence of scanning runs. Our study was designed to measure neural activation over time in relation to the learning curve of each participant. Our miniature language was adapted from Newport & Aslin (2004) [6]. A speech stream was composed of 16 tri-syllabic nonsense words, presented in random order and produced by a speech synthesizer with no acoustic cues to word boundaries. A control stream was produced by playing the stream backwards (which pre-testing showed was not learned). Exposure consisted of randomized blocks of forward and backward speech streams, each lasting 30 seconds, with no breaks or silences except between blocks. Following each of four 9-minute exposure runs, participants rated the familiarity of forward and backward 'words' (tri-syllabic sequences that comprised the stream and had high transitional

probabilities between consonants, as in Hebrew or Arabic) and 'partwords' (tri-syllabic sequences that crossed a word boundary and therefore had one low transitional probability). Changes in neural activity specific to each participant were determined by weighting each run with a measure of learning for that run, calculated as the change in word-partword rating since the previous test. These were then analyzed across subjects, allowing us to make inferences about areas of learning-related neural activation based on individual behavioral performance. Results show significant learning-related increases in neural activation in left frontotemporal areas, including the pars opercularis and pars triangularus of the inferior frontal gyrus (LIFG) for forward vs. backward speech. Given the specificity of our analyses, these patterns of activation are not due merely to hearing speech or recognizing familiar syllables, but rather indicate that these areas are involved in the computational process underlying statistical learning of words.Interestingly, in the visual domain, familiarity ratings of statistically regular shape sequences have also been shown to correlate with increases in LIFG activation for structured shape streams vs. random shape streams [7]. Ongoing studies investigate the domain-generality of the LIFG with regard to statistical learning of sequential stimuli. References: [1] Saffran, J.R., Aslin, R.N., & Newport, E.L. (1996). Statistical learning by 8-month old infants. Science, 274, 1926-1928. [2] Saffran, J.R., Johnson, E.K., Aslin, R.N., & Newport, E.L. (1999). Statistical learning of tonal sequences by human infants and adults. Cognition, 70, 27-52. [3] Fiser, J., & Aslin, R.N. (2001). Unsupervised statistical learning of higher-order spatial structures from visual scenes. Psychological Science, 12, 499-504. [4] McNealy, K., Mazziotta, J.C., & Dapretto, M. (2006). Cracking the language code: Neural mechanisms underlying speech parsing. The Journal of Neuroscience, 26(29), 7629-7639. [5] McNealy, K., Mazziotta, J.C., & Dapretto, M. (2010). The neural basis of speech parsing in children and adults. Developmental Science, 13(2), 385-406. [6] Newport, E.L., & Aslin, R.N. (2004). Learning at a distance: I. Statistical learning of non-adjacent dependencies. Cognitive Psychology, 48, 127-162. [7] Turk-Browne, N.B., Scholl, B.J., Chun, M.M., & Johnson, M.K. (2009). Neural evidence of statistical learning: Efficient detection of visual regularities without awareness. Journal of Cognitive Neuroscience, 21(10), 1934-1945.

A3 12:10 pm

Auditory discrimination in illiterates: How effective is alphabetization? ***Schaadt, G.*** *(1),* ***Pannekamp, A****. (1), and* ***van der Meer, E****. (1) 1. Humboldt University of Berlin, Berlin, Germany* – **Objective:** One challenge of the modern society is to educate their members in written language skills. However, illiteracy is still a major problem. Therefore, understanding and improving the effectiveness of alphabetization programs is of great interest. It is evident that auditory discrimination contributes to reading acquisition (Mann, 1984). The Mismatch Negativity (MMN), the characteristic ERP marker for auditory discrimination (Näätänen, 1978), was shown to be reduced in dyslexic children and adults (Corbera, 2006, Schulte-Körne 2001). Further, discrimination training increases reading skills in dyslexic children (Kujala, 2001). However, little is known about auditory discrimination performance of illiterate adults and the impact of reading acquisition on discrimination performance and the MMN. The current study aimed to investigate auditory discrimination in illiterates and the impact of alphabetization. Method: We assessed auditory discrimination in 10 illiterate adults with migration background (10 women, Mage = 38.00 years, SDage = 11.87). Before and after a one-year alphabetization course the event-related potential MMN was recorded, while participants listened to standard and deviant phonemes (oddball paradigm). The phonemes /ga/ and /da/ were used. They were recorded by a German native speaker. Stimuli did not differ in parameters such as frequency and amplitude. The alphabetization course consisted of a curriculum divided into three modules. Every week a different topic was dealt with e.g. environment. By means of these topics participants learned to read and write letters and words. Performance was compared with the performance of 10 literate adults (10 women, Mage = 28.70 years, SDage = 6.83). We hypothesized inferior auditory discrimination performance of illiterates before alphabetization, compared to literate controls. We expected improvement in auditory discrimination to be significant after the alphabetization course and no further difference between illiterates and literate controls. Results: The study yielded the following main findings: First, literate controls showed a significant MMN. No significant MMN was found in illiterates before alphabetization. Second, illiterates showed a significant MMN after alphabetization. Improvement in auditory discrimination from before to after the alphabetization course was significant. Third, no difference between MMN of illiterates after alphabetization and MMN of literate controls was found. Conclusion: These findings indicate substantial deficits in auditory discrimination of illiterates compared to literate controls before alphabetization. During the acquisition of reading and furthermore, a correspondence between graphemes and phonemes takes place (Gibson, 1966). Matching graphemes and phonemes requires auditory discrimination. If graphemes and phonemes do not maintain each other, auditory discrimination is not stressed. Investigations on critical phases of the MMN show regression of MMN when not being presented with stimuli that elicit MMN (Cheour, 1998). It is assumed that MMN has regressed in illiterates. However, after alphabetization the amplitude of MMN has increased, although reading performance was still below the third grade standard. Similar results were found by Kraus (1995) who argued that the neuro-physiologic improvement in discrimination has not yet been integrated into a voluntary response. The results indicate the importance to investigate and alter alphabetization programs for illiterates by means of discrimination trainings and evaluate them by parameters such as MMN.

A4 12:30 pm

Cortical mechanisms of selective listening in a multi-speaker environment ***Mesgarani, N.**,(1,2), **Chang, E.**(1,2). 1. University of California, San Francisco, CA US. 2. Keck Center for Integrative Neuroscience* – A unique and defining property of human speech perception is the ability to robustly process speech sounds in the context of noisy and interference-filled acoustic conditions. A common, everyday condition is the multi-speaker environment, where selective listening is required for listening, also known as the "cocktail party effect". The mechanism by which the human auditory system carries out sound processing under these conditions is largely unknown. An attractive mechanism for speech encoding in multi-speaker environments is the implementation of dynamic "top-down" modulation of attention towards the intended signal. In this study, we used high-resolution intracranial direct recordings (electrocorticography) from the superior temporal gyrus (STG) in patients with intractable epilepsy in order to investigate the neural correlates of auditory selective attention. The behavioral paradigm was based upon the Coordinate Response Measure (CRM) corpus which is widely used for multi-speaker communications research. The patients are instructed to report the color and number associated with a call sign (e.g. "Tiger") in a mixture of two speakers, without knowing a priori which speaker will be the target in a given trial. We used a stimulus reconstruction method from the high-gamma envelope of neural responses to investigate the encoding of the spectrotemporal features of speech. The reconstructed spectrograms from the same acoustic sound mixture, but in two different attention conditions resembled the spectrogram of the target speaker in isolation, indicating an enhanced neural representation of the attended voice. In addition, using a linear classifier trained on the representation of single speakers, we successfully decoded the spoken words and the identity of the target speaker from the responses to the mixture. Finally, we investigated how the tuning properties of different areas in STG changed rapidly in order to enhance the features of the attended voice while at the same time suppressing the representation of the distractor speaker voice. Our results show that attention modulates the neural representation of speech in STG in order to provide a selective and robust representation of the attended speaker.

Slide Session B

Thursday, November 10 2:00 - 3:20 pm
Capitol Ballroom B & D

Chair: ***Vincent Gracco**, McGill University*

B1 2:00 pm

The role of task-specific feedback mechanisms in the categorical perception of speech: A Kalman-filter driven Granger analysis of MRI-constrained MEG/EEG data ***Gow, D** (1,2,3), **Sachdeva, R.** (1,2), **Ahlfors, S.** (1,2). 1. Massachusetts General Hospital, Boston, MA, US. 2. Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA, US. 3. Salem State University, Salem, MA, US.* – The early discovery of the categorical perception of speech led to a historical division between the study of speech perception - roughly the mapping from sounds to idealized phoneme categories- and the study of spoken word recognition - conventionally treated as the mapping from phonemes to word forms. In this work we examine the neural dynamics that produce categorical perception in explicit and implicit language perception tasks and find evidence for continuity in the form of direct two-way interaction between the perceptual analysis of speech sounds and spoken word recognition. We used a Kalman-filter technique to model high spatiotemporal resolution activation data obtained through MRI-constrained source space reconstructions of MEG/EEG data collected during task performance, and submitted these models to high dimensional partial Granger causation analysis to reveal directional influences between phase-locked brain regions. Two tasks were used. In Experiment 1, subjects performed an explicit 2AFC delayed phoneme categorization task with synthetic CV speech continua (e.g. /bæ/-/dæ/). No top-down influences on left posterior temporal gyrus (pSTG) or superior temporal sulcus (STS) were seen for endpoint tokens from the speech continua. In contrast, boundary tokens (those adjacent in the continua to dramatic categorization shifts) produced angular gyrus (AG) influence on pSTG, and left inferior frontal gyrus influence on STS activation. In Experiment 2 subjects heard the same continua in lexical contexts (e.g. bash-dash) and performed a 2AFC delayed word-picture matching task. Once again, there was no evidence of top-down influences on STS or pSTG activation for endpoint tokens. However, in boundary tokens showed a pattern of top-down STS/MTG influence on pSTG activation. These results suggest that: (1) categorical perception is the result of top-down influences on phonetic processing, (2) the specific interactions that produce categorical perception effects in classic metalinguistic tasks do not play a role in speech categorization during more natural word recognition tasks, and (3) lexical process associated with the MTG interact directly with acoustic phonetic processes associated with the pSTG.

B2 2:20 pm

How we store the sounds of words: Testing the neurocognitive predictions of abstract and exemplar models of spoken word recognition ***Wolmetz, M.** (1), **Wilson, C.** (1), and **Rapp, B.** (1). 1. Johns Hopkins University, Baltimore, MD, US.* – Objective. We hear thousands of words each day, and with each word a meaning is evoked automatically and seemingly instantaneously.To accomplish this, listeners must form and access a phonological lexicon made up of memories of word sounds. These memories must be flexible enough to accommodate new and different speakers across diverse listening conditions. There are currently two different types of theories of the phonological lexicon: abstractionist and exemplar. In abstractionist theories, entries in the phonological lexicon are ordered lists of abstract segments (e.g. phonemes, phonetic

features, syllables) that correspond to each known word. Under this account, the hardest part of speech recognition is identifying the segments. In exemplar theories, entries in the phonological lexicon are acoustic traces of each instance of heard words. Here, the hardest part of recognition is effectively and efficiently comparing a heard word to the mass of accumulated acoustic information. Some behavioral phenomena, most notably a listener's ability to generalize learned phonetic distributions to novel contexts, are difficult to account for with exemplar theories. Other results, like a listener's long-term sensitivity to the acoustic characteristics of heard words, are difficult to account for with abstractionist theories. In this work, we test a neural prediction of these theories using functional Magnetic Resonance Imaging. Methods. We recorded neural responses while participants listened to words and pseudowords spoken by three different talkers, and tested whether talker-specific information was present in lexical memory. In their strictest interpretations, abstractionist theories predict that lexical representations are abstracted away from speaker-specific information, and therefore, that lexical activation patterns evoked by a particular word will be equivalent for different talkers. Exemplar theories predict that speaker-specific characteristics are part of lexical memory, and therefore, that lexical activation patterns evoked by the same word will differ across speakers. To test these predictions, we first identified lexical processing regions corresponding to voxels with statistically different responses to words, as compared to phonotactically-matched pseudowords. Multi-voxel pattern analysis techniques were then used to test whether talker information was present within the responses at these locations. As an additional verification of lexical processing, these voxels were also tested for lexical frequency and phonotactic probability information. Results & Conclusions. Across participants, voxels sensitive to lexicality were primarily found in bilateral superior temporal regions. Talker identity information was present in these lexical processing voxels, as demonstrated by a group average 37% classification accuracy for the three talkers ($p < .001$). As would be expected of a lexical processing region, high versus low frequency classification performance was above chance ($p < .05$), and high versus low phonotactic probability classification was at chance. The presence of talker information in lexical processing regions is inconsistent with strictly abstractionist accounts of the phonological lexicon and predicted by exemplar accounts. However, additional analyses suggest that talker classification may be driven, for many participants, by differing rates of comprehension difficulty across the three talkers. These findings, in the context of previous behavioral work, motivate a hybrid model in which some talker-specific features can be stored in the lexicon.

B3 2:40 pm

Can irony reveal extensive Theory of Mind activation?

Spotorno, N. *(1),* ***Koun, E.*** *(1),* ***Prado, J.*** *(2),* ***Van Der Henst, J.B.*** *(1), and* ***Noveck, I.*** *(1). 1. Laboratory L2C2, CNRS (FRE3406), Bron, France. 2. Northwestern University, Evanston, IL, US.* – Introduction. Irony provides prima facie evidence that the linguistic code is insufficient for communicating a speaker's intended meaning. Consider an opera singer who tells her interlocutor: "Tonight we gave a superb performance!" when the performance in question was clearly awful.At a minimum, the ironic speaker transmits a dissociated attitude [1].In terms of neuro-imagery, this ought to translate into cerebral activity linked to "Theory of Mind" (ToM), a critical component for interpreting others' mental states [2].Nevertheless, no fMRI investigation has isolated extensive ToM activation when contrasting utterances used ironically versus literally [3].Instead, most studies report language-related activation.The present study, unlike prior ones, uses a classic text-comprehension paradigm as it employs fMRI techniques to determine the extent to which ToM activity is elicited by irony. Methods. 20 healthy adults were tested in an event related fMRI design (1.5 T scanner) while they read 60 7-sentence-long stories in a self-paced manner.Twenty-four stories were devoted to the present investigation.The first five lines of the stories in the Ironic condition set up a negative context (e.g., one where a performance was disappointing) which was followed by a Target-line delivering an ironic utterance (e.g., "Tonight we gave a superb performance!") and a seventh wrap-up sentence.Matched stories designed for the Literal condition were practically identical except the context was positive (e.g., the performance was as good as expected); the Target-line and wrap-up sentence remain the same as above. We also included Decoy stories in which a negative event (e.g., an awful performance) leads to a banal utterance (e.g., "We'll do better next time"). The decoys prevent negative contexts from being cues for ironic remarks.Overall, each participant read 24 stories (10 ironic, 8 literal and 6 decoys) that were drawn from an ongoing behavioral investigation. Story themes were rotated across (literal and ironic) conditions so that each participant encountered a unique set of items. Data were analysed using standard SPM8 methods (random effects, cluster-wise FDR corrected $p<0.05$ and voxel-wise uncorrected $p<0.001$). Results. The irony > literal contrast on the target sentence reveals activation of areas conventionally associated with ToM (see Figure 1). Strong activation was found bilaterally in the Medial Prefrontal Cortex (MPFC) and bilaterally in the Temporal Parietal Junction (TPJ). Moreover, we found activation in the left Insula (which we take as an indication of emotion or empathy processing). Conclusions. This is the first study on ironic utterances that recruits an extensive Theory of Mind network (that includes the MPFC and TPJ bilaterally). For example, no prior study has recruited the right TPJ, which some consider primary to ToM processing [4].Story length and the presence of decoys may well account for these original findings.

References. [1] Sperber, D. & Wilson, D. (1981). In Cole (ed.) Radical Pragmatics, 295-318. [2] Van Overwalle, F. & Baetens, K. (2009). NeuroImage, 48, 564-584. [3] Eviatar, Z. & Just, M. A. (2006). Neuropsychologia, 44, 2348-2359. [4] Saxe, R. (2010). In Leslie & German (eds.) Handbook of Theory of Mind.

B4 3:00 pm

Actor identification in natural stories: Qualitative distinctions in the neural bases of actor-related features ***Alday, P.*** *(1),* ***Nagels, A.*** *(1),* ***Schlesewsky, M.*** *(2),* ***Bornkessel-Schlesewsky, I.*** *(1). 1. Philipps-Universität Marburg, Germany. 2. Johannes Gutenberg Universität Mainz, Mainz, Germany* – Many investigations of the neural bases of language have sought to identify the neural substrates of macroscopic linguistic domains (e.g. syntax, semantics). However, this approach has yielded widely varying results, thus suggesting that data of a different granularity may be required. Indeed, cross-linguistic studies of sentence comprehension using behavioural (e.g. Bates et al., 2001) and electrophysiological techniques (Bornkessel-Schlesewsky & Schlesewsky, 2009) have provided evidence for a range of fine-grained ""cues"" to interpretation (e.g. animacy, word order, case). These cues cut across the syntax-semantics divide and vary cross-linguistically in availability (e.g. animacy and order, but not case are available in all languages) and strength. A current neurocognitive model of cross-linguistic sentence comprehension (Bornkessel-Schlesewsky & Schlesewsky, 2009) posits that these cues primarily mediate competition for the actor role (i.e. the participant primarily responsible for the state of affairs). However, it is as yet unknown how the brain implements the interaction and weighting of actor-identification cues and how cue strength and availability modulate the neural networks involved in their processing. Here, we shed some initial light on these questions by means of an fMRI and an ERP study on natural story listening in German. Naturalistic stimuli provide a natural setting for a rich set of cues and do not require an explicit task. For the fMRI data, we reanalysed the data from Whitney et al. (2009), a study in which participants listened to a German novella. EEG data were collected using the same auditory stimulus. We time-locked ERPs and fMRI event onsets to the noun phrases in the story and examined the correlates of four actor-related cues: animacy (animate vs. inanimate), humanness (human vs. non-human), position (initial vs. non-initial), case marking (nominative vs. non-nominative). The first three of these are universal, while the fourth is only available in some languages. For universal features, fMRI results showed increased activation for the non-actor vs. actor feature contrast (e.g. inanimate - animate) in overlapping left-lateralised networks involving the fusiform gyrus and ventral premotor cortex. The identical ERP contrast revealed a broadly distributed negativity between approx. 300 and 500 ms post onset of the word at which the critical information became available. The language-specific feature case marking engendered activation for the actor (nominative) vs. non-actor (non-nominative) feature contrast in a completely different set of regions, including the left temporal pole and hippocampus, right parietal cortex and SMA. Here, ERPs showed a frontal positivity between 100 and 300 ms for nominative vs. non-nominative.

Our findings indicate that the neural processing of case differs qualitatively from that of the other features. This may be initial evidence that language-specific features for actor interpretation engage different neural networks to universal features. Alternatively, the distinction could be due to cue dominance (case is dominant in German). Crucially, both interpretations speak against a global ""hub"" that serves to integrate and weight all cues.

Slide Session C

Friday, November 11 11:30 am - 12:50 pm
Capitol Ballroom B & D

Chair: ***Cynthia Thompson****, Northwestern University*

C1 11:30 am

Modality Independent Decoding of Semantic Information from the Human Brain ***Simanova I.*** *(1,2),* ***Oostenveld R.*** *(2),* ***Hagoort P.*** *(1,2),* ***van Gerven M.*** *(2,3). 1. Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands. 2. Donders Institute for Brain, Radboud University Nijmegen, The Netherlands. 3. Institute for Computing and Information Sciences, Radboud University Nijmegen, Nijmegen, The Netherlands* – **Objective.** What is the shared substrate for semantic processing of different input modalities, for example a picture of a dog, the auditory or visual word "dog", and the sound of barking? Our study addresses this question using multivariate pattern analysis (MVPA) of functional magnetic resonance imaging (fMRI). We aimed at decoding the semantic category of objects from four different stimulus presentation modalities. Furthermore, we generalized the classifier across the four modalities and localized the contributing areas in the brain. Methods. Brain activity was measured in 9 participants using fMRI. Twenty exemplars of animals, and 20 exemplars of tools were presented in four different modalities: photographs, natural sounds, spoken names and written names. The experiment consisted of two runs, with different exemplars presented in each run. Each run included 32 blocks, eight blocks for each modality. During each block, stimuli of one category were presented one at a time. Participants were instructed to judge whether each stimulus within a block was semantically consistent with the others. We used a multivariate searchlight technique together with a linear support vector machine (SVM) classifier to decode the object category. The searchlight sphere was centered on each grey matter voxel in turn and the classification accuracy and significance were computed from the local neighborhood (sphere diameter of 17.5 mm, 5 voxels). The classifier was trained and tested within each of the four modalities (with the exemplars of different stimuli subsets defining the training and testing sets), and across modalities. Classification accuracy (proportion of correctly classified trials) for each sphere was assigned to the sphere's central voxel, producing individual subjects' accuracy maps. At the group level we addressed the question which brain regions have a consistent and a high performance of the searchlight classifier across subjects. Results. Significant decoding accuracies were achieved for each subject

in each modality. Averaged maps of classification accuracies in the within-modalities tests are shown on the Figure 1A-D. We have achieved significant classification accuracies in all the four modalities. Overall, the localization results in within-modality tests confirm previous works on animal-tool dissociations in the brain. We were able to generalize the classifier across modalities (Figure 1E), i.e. the classifier trained on three modalities was able to correctly decode exemplars in the fourth modality. The generalization analysis revealed a number of voxels in the left inferior temporal cortex and bilateral frontal regions. Conclusions. The successful performance in the generalization test implies that neuronal circuits in these regions support retrieval and integration of information about object properties independently of the modality of the object presentation. Our study contributes to the fast growing promising area of brain decoding research. Our results contribute to the understanding the mechanisms underlying storage and retrieval of conceptual information in the brain and have implications for the development of novel kinds of brain computer interfaces that are driven by amodal concept selection.

C2 11:50 am

Theta coherence as a mechanism for long-range network formation for lexical-semantic processing ***Mellem, M. S****., (1),* ***Medvedev, A. V****., (1),* ***Friedman, R. B****., (1). 1. Georgetown University Medical Center, Washington, DC.* – **Introduction:** Different types of lexical-semantic processing may engage different brain resources.For example, controlled lexical-semantic processing is thought to engage a top-down network to retrieve semantic information whereas automatic processing does not utilize top-down retrieval.It is difficult, however, to use traditional event-related potential (ERP) analysis to investigate long-range network formation.In contrast, EEG coherence analysis of oscillatory signals measures phase synchronization between channels and is thought to reflect the creation of long-distance processing networks in the brain.We used coherence analysis of a semantic priming paradigm with a long SOA to investigate controlled processing.If long-range coherence is present, it may reflect a top-down network engaged for controlled lexical-semantic processing. Methods: We used high density EEG (Electrical Geodesics Inc., 128 channels) to study coherence during a semantic priming paradigm.Data were collected from 21 healthy subjects.Stimuli consisted of 100 semantically related word pairs which were then scrambled to form an additional 100 unrelated word pairs.This approach ensured matching on all lexical variables.Stimuli were presented serially on a computer monitor.A single trial appeared as follows: prime word (150ms), blank (850ms), target word (150ms), blank (850ms).A single letter was displayed at the end of each trial, and subjects determined whether the letter had appeared in either of the previous two words. This delayed letter-search task was chosen to minimize overlap of the N400 and the decision-making P300 ERP component.Artifact-free EEG epochs sampled at 200 Hz were analyzed offline using Fieldtrip software.ERP analysis demonstrated that the N400 amplitude for unrelated target words was larger than for related words (t-test, p=0.02).Then we performed coherence analysis on related and unrelated target words over the range 4-60 Hz.Several of the 128 channels located in the left frontal quadrant were used as reference channels for coherence.Statistical comparison between related and unrelated words included a nonparametric permutation test with the false discovery rate algorithm (at α=0.05) for multiple comparisons correction. Results: Relative to related words, unrelated words showed significantly greater coherence in the theta (4-7Hz) range from 600-800ms between several left frontal channels and posterior channels.Coherence for a representative reference electrode is shown in Figure 1.Graphs a and b show unrelated and related coherence, respectively, at posterior channels.Graphs c and d show the raw difference and significant difference.Graph e shows the topography of those posterior channels exhibiting coherence with the reference channel 34. Conclusions: Using a semantic priming paradigm, we found significantly greater theta coherence for unrelated than related words.Based on the topography of the effect, theta coherence may reflect a long-distance network engaged for lexical-semantic processing.More specifically, this anterior-posterior coherence suggests that theta phase synchronization could be a mechanism for creating a top-down network for semantic retrieval.fMRI studies have pointed to specific anterior and posterior areas involved in controlled semantic processing but cannot suggest a mechanism for their communication.EEG coherence analysis has the necessary time resolution and complements fMRI data by suggesting theta phase synchronization as that mechanism.

C3 12:10 pm

Predicting language: MEG evidence for lexical preactivation ***Dikker, S****. (1,2) and* ***Pylkkänen, L****. (2). 1. Sackler Institute for Developmental Psychobiology, Weill-Cornell Medical College, NY, US. 2. New York University, NY, US.* – **Introduction:** The aim of this study was to investigate the neural mechanisms that underlie predictive language processing. It is widely assumed that prediction plays a substantial role in language comprehension. However, despite ample research demonstrating that contextual information facilitates both syntactic and lexical-semantic processing (e.g., [1,2,3]), to our knowledge there exists no direct evidence pertaining to the neural correlates of the prediction process itself. Design/procedure. To overcome the methodological challenge of varying the predictability of a stimulus while also controlling the input material in the pre-stimulus interval, in this initial investigation we used a simple picture-noun phrase matching task, where pictures either probed specific (+predictive; e.g., apple) or more general predictions (-predictive, e.g., a picture of a grocery bag representing "any food item"; see examples 1a/b) regarding a subsequent noun. By inserting some semantically ""light"" material between the picture and the noun (specifically, a fixation and a determiner) we created a 1,500ms interval during which the input was constant between conditions while the specificity of the prediction was still being

varied. Magnetoencephalography (MEG) signal was recorded while 15 subjects performed the matching task. CONDITION PICTURE PREDICTIVE INTERVAL NOUN (1,500ms parallel input between conditions) 900ms 300ms 300ms 300ms 300ms 300ms 300ms 1a #NAME? [APPLE] BLANK "+" BLANK "the" BLANK "apple" (+match) "tomato" (-match) 1b #NAME? [GROCERY BAG] BLANK "+" BLANK "the" BLANK "apple" (+match) "dog" (-match) Analysis. Whole-brain minimum norm estimates were calculated to compare activity for +predictive and –predictive contexts during the predictive interval (thresholds: 40 ms / 10 adjacent sources / $p < .05$). Results. Results are shown in Figure 1. Brain activity was modulated by whether or not a specific noun could be predicted, given the picture prime: before the noun was presented, predictive contexts triggered enhanced activation in middle left-temporal cortex (implicated in lexical access; e.g., [4]; Fig1a), ventro-medial prefrontal cortex (associated with top-down and predictive processing; e.g., [5]; Fig1b), and visual cortex (hypothesized to index the preactivation of predicted form features; e.g., [6]; Fig1c), successively. The same brain regions that exhibited enhanced activation for predictive contexts before the onset of the noun showed effects of congruence during the target word, but, crucially, following a bottom-up processing stream, i.e., in reverse order. Discussion. These findings suggests that predictive language processing recruits a top-down network where predicted words are activated at different levels of representation, from more 'abstract' lexical-semantic representations in temporal cortex, all the way down to visual word form features. To our knowledge, this study is the first to provide direct neural evidence in favor of the widely held assumption that language processing is highly predictive and top-down in nature. References 1 "Altmann GTM, Kamide Y (1999) Cognition 73:247-264. 2 "DeLong KA, Urbach TP, Kutas M (2005) Nat Neurosci 8:1117-1121." 3 "Van Berkum JJA, et al. (2005) J Exp Psychol Learn 31:443-467." 4 "Lau EF, Phillips C, Poeppel D (2008) Nat Rev Neurosci 9:920-933." 5 Bar M. (2007). Trends Cogn Sci 11: 280-289. 6 "Dikker S, Rabagliati H, Pylkkänen L. (2009). Cognition 110:293-321.

C4 12:30 pm

Parkinson's disease selectively disrupts processing of action verbs ***Fernandino, L., Conant, L.L., Binder, J.R., Blindauer K., Hiner, B., Spangler K., Desai, R.H.*** *The Medical College of Wisconsin, Department of Neurology, Milwaulkee, WI, US.* – According to the embodied view of conceptual processing, word meaning is grounded in sensorimotor representations, which are instantiated by sensory and motor brain circuits. One implication of this view is that words referring to bodily actions would rely more on the integrity of the motor system than words referring to more abstract concepts. We tested this hypothesis by comparing the performance of patients with Parkinson's disease (PD) with that of age-matched controls on a lexical decision (LD) task and on a semantic similarity judgment (SJ) task. PD is characterized primarily by motor impairments due to basal ganglia dysfunction. The tasks were chosen to reflect different degrees of explicit semantic processing demands.Several previous studies have compared action verbs to nouns. Here, we compare action verbs to abstract verbs to avoid the grammatical class confound. The LD task used a set of 80 verbs and 80 phonologically legal pseudowords, where half of the verbs referred to voluntary hand/arm actions (e.g. to grasp, to squeeze) and the others to abstract concepts (e.g. to depend, to improve). Each item was preceded by a masked prime stimulus, displayed for 50 ms. The prime was either the target word or a consonant string. Primes were presented in upper case and targets in lower case font. Participants were asked to indicate as quickly and accurately as possible whether the target was a word or not, using two response keys. In the SJ task, three verbs were presented simultaneously in a triangular arrangement. Participants were instructed to decide which of the two words on the bottom was most similar in meaning to the one on top. There were 80 trials, divided equally between action and abstract verbs. In both tasks, each item was preceded by to. We tested 21 patients (mean age = 64.7, 10 females; 18 on dopaminergic medication; mean UPDRS = 27.8 [SD=15.7[) and 16 controls (mean age = 63.6, 9 females). Patients and controls were screened for dementia (MMSE2 > 25). We calculated the difference in RT and accuracy between the two conditions for each group, filtered for outliers that differed from the first or third quartiles by more than 3 interquartile ranges (1 patient and 2 controls removed in the PPT task), and computed group (patient, control) x condition (Action, Abstract) interactions. Relative to the Abstract condition, patients made more errors than controls in the Action condition, both in the LD ($p < .025$) and in the SJ ($p < .05$) tasks. No differences were found for RT in either task. The priming data revealed a marginal interaction ($p = .08$), with a trend toward weaker priming in the Action condition for patients. These results indicate that impairments of the motor system are accompanied by selective impairments in processing action verbs relative to abstract verbs. These impairments are seen whether the semantic processing demands are relatively implicit or explicit, suggesting an automatic role of motor systems in action verb processing. Furthermore, the deficit does not reflect a general verb processing impairment.

Slide Session D

Friday, November 11 2:00 - 3:20 pm
Capitol Ballroom B & D

Chair: ***Ghislaine Dehaene-Lambertz****, CNRS*

D1 2:00 pm

Neurotransmitter receptor distribution in Broca's area and the posterior superior temporal gyrus ***Bacha-Trams, M.*** *(1,2),* ***Zilles, K.*** *(2,4),* ***Amunts, K.*** *(2,3) and* ***Friederici, A.D****. (1). 1 Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany. 2 Institute of Neuroscience and Medicine, Research Center Juelich, Germany. 3 University Hospital Aachen, Germany. 4 Heinrich Heine University Duesseldorf, Germany* – The density of

neurotransmitter receptors varies between different regions in the human cerebral cortex. We hypothesize that this variation may be correlated with the functional organization of the cortex. In order to test this hypothesis, activation clusters from functional imaging studies concerning human language processing in German syntax are analyzed by quantitative autoradiography to search for correlations between brain functions and the underlying cerebral structure. In recent functional MRI studies (Makuuchi et al., 2009; Friederici et al., 2009) a posterior part of Broca's area, the cortex of the left pars opercularis in the inferior frontal gyrus is activated by the processing of complex language structures, e.g., in response to hierarchical structured sentences, like center-embedded clauses. In contrast to another activation, which is engaged in the processing of the verbal working memory and found in the left inferior frontal sulcus, the left pars opercularis computes solely the syntactical hierarchy of a sentence or phrase. In addition, a third activation cluster situated in the left posterior superior temporal gyrus and sulcus, a part of Wernicke's area, is found when an integration of lexical and syntactic information is necessary to fully understand the sentence, a requirement only relevant in natural languages. The three regions are distinct but work in strong cooperation, so a similar receptorarchitectonic anatomy is hypothesized. To reveal the receptor organization of the cortex we use quantitative receptor autoradiography, which permits an anatomical identification of receptor localization at high spatial resolution. The coordinates of the three activation clusters are registered in post mortem brains to determine the regional densities of different receptor types representing all classical neurotransmitter systems. The receptor distribution patterns are very similar in the different cortical areas with a co-operative function in hierarchical syntax processing in the inferior frontal gyrus and the posterior superior temporal gyrus and sulcus, despite the relatively large spatial distance between these regions in the brain. In contrast, the densities of the neurotransmitter receptors of these areas is clearly segregated from those of other cortical areas, such as the primary sensory cortices or the motor cortex. The structural resemblances between the different examined cortical regions in language studies with German sentence processing underline the functional cooperation between verbal working memory, syntax processing and their integration with lexical information. Thus, receptor densities represent an organizational structure strictly correlated with specific cognitive brain functions in the human cerebral cortex. These data provide furthermore a molecular-anatomical evidence for the existence of a neural network which comprises the inferior frontal gyrus and the posterior superior temporal gyrus and whose function is to identify grammatical dependencies in complex sentences of a natural language as German. The role of the inferior frontal gyrus in this language network is, to compute hierarchical syntax structures whereas the posterior superior temporal gyrus and sulcus is required for the successful integration of lexical-semantic and syntactic information by the interpretation of the thematic relationship of the verb and its arguments.

D2 2:20 pm

The role of competitive neural inhibition in language production: Insights from the effects of trait anxiety on selecting among competing words ***Snyder, H. R., Kaiser, R., Whisman, M.*** *and* ***Munakata, Y.*** *University of Colorado at Boulder, CO, US* – During language production, words must constantly be selected in the face of multiple possible alternatives. There is broad consensus that our ability to respond in such underdetermined situations requires cognitive control and relies on left ventrolateral prefrontal cortex (VLPFC). The current study investigates specific neural mechanisms that may support selection of responses during language production, by assessing predictions from a neural network model regarding the effects of anxiety (Snyder et al., 2010). Our model demonstrates how competitive neural inhibition, carried out by GABAergic interneurons in prefrontal circuits, can play a key role in selection between competing options. Specifically, these competitive dynamics serve to sharpen cognitive representations by amplifying activity in the most active, task-relevant, representations (e.g., the most appropriate word to complete a sentence) and suppressing competing representations (e.g., for the many other word possibilities). As predicted by our model, our previous research found that anxiety (associated with reduced neural inhibition) impairs selection among options and reduces associated prefrontal cortical activity in a simple, non-affective language-production task, while the GABA agonist midazolam improves selection (Snyder et al., 2010). In the current study, we extend this research to a more clinically-relevant high trait anxiety sample to further test specific neural mechanisms of language production and to explore the implications for understanding cognitive impairments associated with anxiety disorders.
We demonstrate that high trait anxiety participants show impaired selection across three language production tasks: verb generation, sentence completion, and blocked cyclic naming. This impairment is not due to differences in IQ, processing speed, or comorbid depressive symptoms (dysphoria). Instead, we find that dysphoria may mask or suppress the effects of anxiety on selection, in contrast with theories suggesting that comorbid anxiety and depression lead to more pronounced cognitive control deficits than either disorder alone (e.g. Basso et al., 2007).Our results suggest that specific neural mechanisms associated with individual cognitive control processes may be affected differently by each kind of psychopathology. Specifically, while anxiety is linked to reduced GABAergic function, depression is linked to reduced glutamatergic function in prefrontal cortex (e.g. Hashimoto, 2009; Yuksel & Ongur, 2010). We test the interaction of these mechanisms in our neural network model, and show how reduced glutamatergic function can improve selection, by reducing activation of competing responses. Thus, we confirm that anxiety is associated with a robust and specific impairment in selection between competing options during language production, while

dysphoria may mask these effects, and we simulate the neural mechanisms that may give rise to these patterns. Implications for models of language production and of neuropsychological function in anxiety, as well as implications for treatment approaches, are discussed.

D3 2:40 pm

A neuroanatomically grounded model of spontaneous word generation in the human brain ***Garagnani, M.***, *(1),* ***Pulvermüller, F.*** *(1). 1. MRC Cognition and Brain Sciences Unit, Cambridge, UK.* – Which brain mechanisms underlie the rapid and automatic selection of a single word out of a set of possible lexical candidates in speech production? In the past, several neuroimaging studies have used word generation tasks (e.g., sentence completion, verb generation) to investigate the origins of the neural processes at the basis of the "free", spontaneous activation and selection of lexical items. These studies have identified two areas within the left perisylvian (language) cortex (namely, inferior prefrontal cortex, Broca's area, and posterior-superior temporal cortex, Wernicke's area) that are reliably active during novel word selection. At present, however, no model exists which can explain, at the cortical-circuit level, the mechanisms underlying word-selection processes and, importantly, their observed cortical loci. Here we present a neural architecture grounded in well-documented neurobiological principles known to be pervasive in the cortex (Hebbian synaptic plasticity, spontaneous neuronal firing, and spreading of activation) and closely replicating structure and connectivity of relevant sensory (three superior-temporal: auditory core, belt, and parabelt) and motor (three inferior-frontal: prefrontal, premotor and motor) areas of the brain. This model of the language cortex was first taught a set of artificial "words" by means of repeated simultaneous presentation, to its sensory and motor areas, of predefined random activation patterns, representing auditory and articulatory features of words. In presence of learning mechanisms this lead to the spontaneous formation of strongly linked, distributed sensorimotor circuits (word-related cell assemblies, CAs) mapping articulatory to associated auditory activation patterns. After the training, spontaneous network activity was recorded in absence of any input stimulus (i.e., while activity was driven solely by uniform neuronal noise). During this time we repeatedly observed and documented episodes of spontaneous, single word-CA activation, brought about by the random accumulation and reverberation of background neuronal noise within such sensorimotor CA circuits. Statistical analysis of the data revealed that the first traces of spontaneous reverberant activity within lexical circuits took place in the model correlates of the inferior prefrontal (Broca's) and auditory parabelt (Wernicke's) areas, subsequently spreading from there to adjacent perisylvian secondary (premotor and auditory belt) areas, and finally reaching primary motor and sensory cortices. This simulated pattern of spatio-temporal activations closely matches the patterns of brain activity observed during verb generation, sentence completion, auditory verbal imagery and speech-Bereitschaftspotential experiments. Our model provides the first mechanistic answer to the where and how questions of the spontaneous word generation in the brain, pointing to the intrinsic connectivity of the sensorimotor cortical systems within which the correlation learning mechanisms operate as to the main factor determining the observed topography of the underlying neuronal processes. These results provide further support for an integrated account of language, working memory and action based on the spontaneous formation and automatic reactivation of long-term memory circuits, emerged in the cortex as a result of repeated correlated sensory-motor experiences and by means of Hebbian associative learning mechanisms.

D4 3:00 pm

Functional connectivity at rest predicts word comprehension after stroke ***Wei, T.*** *(1),* ***Hamilton, C.*** *(1),* ***Ellmore, T.*** *(2),* ***Schnur, T.*** *(1). 1. Rice University, Houston, TX, US. 2. The University of Texas Medical School, Houston, TX, US.* – To understand a word, we map a written or spoken word to its meaning, which requires selecting the proper lexical and semantic information. Diffusion tensor imaging and functional connectivity approaches demonstrate that language comprehension regions in the frontal, temporal and parietal lobes are anatomically and functionally connected (e.g., Saur et al., 2010; Turken & Dronkers, 2011). However, it is unclear whether these connections are necessary for word comprehension. To address this question, we examined which connections predict word comprehension performance of speakers with acquired language deficits as a result of chronic stroke. We collected resting-state functional magnetic resonance images from 11 left hemisphere aphasic speakers with varying degrees of word comprehension impairment and 10 healthy controls. We used control data to identify connections between language-sensitive regions of interest (ROIs) involved in word comprehension (Fedorenko et al., 2010). Using this control network, we investigated which connections predicted patients' word comprehension performance. To measure word comprehension, we used an auditory word picture verification task (Freedman & Martin, 2001) where aphasic speakers indicated ("yes" or "no") whether a spoken word corresponded to a simultaneously presented picture. The spoken target words (e.g., "cake") occurred four times with different pictures: correct (e.g., CAKE), semantically related (e.g., PIE), phonologically related (e.g., SNAKE), and unrelated (e.g., TELEPHONE). Failure to reject phonologically related pictures indicates impaired phonemic-input processing, while failure to reject semantically related pictures suggests a semantic-level deficit (Rogalsky et al., 2008). Overall, aphasic speakers were 90% accurate (range, 62%-99%), making 26% (range, 4%-81%) semantic errors, 8% (range, 0-44%) phonological errors, 4% (range, 0-28%) unrelated errors, and 1% (range 0-6%) false reject to target errors. Because healthy speakers are at ceiling in this task (Freedman & Martin, 2001), only aphasic speakers

were tested. Functional connectivity in controls revealed 33 (of 55) ROI pairs with significant connections (see Figure 1A). We used these 33 ROI pairs to examine functional connectivity in our aphasic group excluding ROIs (n = 4) with more than 50% damage across more than five patients, yielding 11 ROI pairs for analysis (see Figure 1B). Functional connectivity strength between two ROI pairs predicted accuracy to reject the semantic foil: left orbital inferior frontal gyrus (LIFGorb) and left anterior temporal lobe (LATL) ($r = 0.88$, $p = 0.003$), and a bilateral anterior temporal lobe connection ($r = 0.72$, $p = 0.01$). After Bonferroni correction for multiple comparisons, the association between semantic errors and the connection between the LIFGorb and LATL remained significant ($p = 0.03$); the association between semantic errors and the bilateral anterior temporal connection was marginally significant ($p = 0.11$). No ROI pair showed correlation with accuracy to reject the phonological foil. These findings demonstrate which language-sensitive regions functionally interact and how functional architecture of the brain constrains word comprehension after stroke. We propose that the connection between the LIFGorb and LATL subserves the controlled retrieval of semantic representations, as consistent with previous lesion-deficit evidence (Jefferies & Lambon Ralph, 2006). The finding that greater connectivity between bilateral anterior temporal areas is related to better performance on semantic trials underscores the importance of inter-hemispheric interactions in word comprehension.

Poster Schedule

Poster sessions are scheduled on Thursday, November 10 and Friday, November 11. Poster sessions are 1½ hours and presenting authors are expected to be present the entire time. Posters are located in the Senate room, Capitol C ballroom and the pre-function space outside of Capitol C.

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 "Take-down Complete" time will be discarded. The doors will close and lock for the evening at 8:45 pm on Thursday. There is no re-entry after this time. Do not leave personal items in the poster room.

	Date & Time	Set-up Begins	Session Begins	Session Ends	Take-down Complete	Topics
A	**THURSDAY, NOVEMBER 10**	8:00 am	10:00 am	11:30 am	1:30 pm	Speech Perception, Prosody, Acquisition, Manual & Sign Language, Pathology, Speech Production
B	**THURSDAY, NOVEMBER 10**	1:30 pm	3:20 pm	4:50 pm	5:30 pm	Speech Perception, Prosody, Multilingualism, Social & Emotional Processing, Reading & Writing
C	**THURSDAY, NOVEMBER 10**	5:30 pm	6:15 pm	8:15 pm	8:30 pm	Multilingualism, Reading & Writing, Pathology, Manual & Sign Language, Speech Production, Acquisition
D	**FRIDAY, NOVEMBER 11**	8:00 am	10:00 am	11:30 am	1:30 pm	Syntax, Cognitive and Executive Processing, Anatomy, Conceptual/ Semantic/Discourse Processing
E	**FRIDAY, NOVEMBER 11**	1:30 pm	3:20 pm	4:50 pm	5:30 pm	Syntax, Cognitive and Executive Processing, Anatomy, Conceptual/ Semantic/Discourse Processing

Poster Sessions

Poster Session A

Thursday, November 10 10:00 - 11:30 am
Senate, Capitol C, and Capitol C Pre-Function

SPEECH PERCEPTION

A1 Different spatial scales of categorical phoneme processing in Broca's area and the supramarginal gyrus: feasible evidence for a posterior-to-anterior gradient in pre-lexical speech processing ***Lee, Y.-S.*** *(1),* ***Granger, R.*** *(2),* ***Raizada, R.*** *(3); 1. University of Pennsylvania, Philadelphia; 2. Dartmouth College, Hanover, NH; 3. Dartmouth College, Neukom Institute, Hanover, NH* – Information processing in the brain operates at multiple spatial scales, ranging from intra-columnar neural circuits to broadly distributed representations. For instance, a gradient exists of finer spatial-scale processing in more posterior regions such as V1 and broader scale processing in more anterior regions such as IT. We hypothesized that a similar gradient of spatial scale might hold true for speech processing. To investigate this, we exploited the fact that different fMRI task-designs and analysis approaches are able to probe neural processing at a wide range of spatial scales. 15 native English speakers were scanned while they pseudo-passively listened to each of 10 synthesized phonetic sounds along the /ba/-/da/ category. Outside of the scanner, individuals' own categorical boundary was measured. When fMRI activities were divided into binary classes (e.g., /ba/ vs. /da/) in subject-specific manner, the whole-brain MVPA identified significant neural patterns within part of Broca's area. In contrast, the same analysis did not yield any region when fMRI activities were compared between the absolute mid-point along the continuum. This was replicated when the MVPA was applied to an independent dataset (Raizada & Poldrack, 2007) that previously implicated SMG at intra-voxel scale.Collectively, these MVPA results in conjunction with the previous results from adaptation paradigm are consistent with, but constitute only a first step towards establishing, the novel hypothesis that speech processing may follow a posterior-to-anterior gradient of spatial scale.

A2 The latency of lexical access in visual and spoken word recognition ***Lewis, G.****,(1),* ***Marantz, A.*** *(1); 1. New York University, NY* – **Objective:** The time course of word recognition appears similar in visual and auditory input modalities. The cortical timing and location of N400/N400m effects associated with word predictability in sentential context in ERP/MEG reading studies are similar when elicited by speech (Helenius et al., 2002). Additionally, a response similar to the N400m is modulated during visual and auditory processing by the meaning entropy of homographic homophones (orthographically and phonetically identical words) at the same latency and location across modalities (~300ms post-stimulus onset, in similar temporal regions (Simon et al., in press; Lewis et al., under review)). Is the timing similarity of these effects due to (a) an interaction between the rate of stimulus input and processing mechanisms shared across modalities, or (b) an intrinsic brain clock set off by the onset of the stimulus? We tested these competing hypotheses by increasing the rate of stimulus input for auditory words through time-compression and by tracking whether increased rate of stimulus input expedited brain sensitivity to input variables reflecting lexical access, as predicted by hypothesis (a) but not by hypothesis (b). These variables were surface frequency (SF) and derivational family entropy (DFE), which summarizes the frequency distribution of a derivational family. Previous work shows that these variables are highly predictive of response time (RT) in lexical decision and suggests that DFE should modulate lexical access to a stem (Moscoso et al., 2004). Methods: Stimuli were speech files generated from 200 bi-syllabic monomorphemic nouns and 200 nonwords of similar length and bigram frequency. Words were evenly split between initial and final stress and syllabic lexicality. Speech files were continuously reduced in tempo to 75%. The average difference in duration between compressed and uncompressed stimuli was ~245ms. Nine subjects responded to speech stimuli in a lexical decision experiment with continuous MEG data acquisition. Analyses were in source-space using MNE and structural MRIs. Stimulus variables were employed in analyses with activation from transverse-temporal regions of interest. Results: Higher values of DFE and SF were associated with stronger activation (similar to stem frequency and entropy effects from similar MEG experiments). DFE most strongly correlated with activation beginning ~389ms for the compressed items* and beginning ~519ms for the uncompressed items* (~130ms acceleration). SF most strongly correlated with activation beginning ~316ms for the compressed items* and beginning ~528ms for the uncompressed items (~212ms acceleration). RT was faster for the compressed items* (average acceleration of ~118ms), and was negatively correlated with SF and DFE.** Discussion: Compressing the auditory input, thus speeding up information relevant to lexical access, decreased the latency of correlations between DFE and SF (each associated with lexical access) and the brain response in the temporal lobe proportionately to the amount of compression, and sped up RT, supporting the hypothesis that the similarity in latency between visual and auditory word recognition is not due to an intrinsic brain clock (hypothesis (b)), but rather to an interaction between rate of stimulus input and processing mechanisms shared across stimulus modalities (hypothesis (a)). *p<.05 **p<.001

A3 Bilateral Temporal Regions Involved in Monosyllabic Word Intelligibility ***Maddox, C.D.*** *(1),* ***Okada, K.*** *(1),* ***Venezia, J.*** *(1),* ***Hickok, G.*** *(1); 1. The University of California, Irvine* – **Introduction:** There are two divergent claims regarding the cortical organization of speech perception.One model proposes a bilaterally organized system in the posterior

superior temporal region involved in the recognition of speech sounds (Hickok & Poeppel, 2007). A competing claim is that speech perception and comprehension is governed by a left-lateralized anterior temporal lobe pathway (Scott, et al., 2000). This claim is based predominantly on functional imaging studies reporting that intelligible speech compared to unintelligible speech produces activation predominantly in the left anterior temporal lobe (Narain et al., 2003; Scott et al., 2000). One problem with studies of speech intelligibility is that they used relatively small sample sizes. Indeed, a more recent fMRI study that used a sample size of 20 subjects found activation along the entire length of the STS bilaterally (Okada et al., 2010).A second problem is that most of these studies, including Okada et al., are confounded with respect to the level of analysis that is driving the activation.This is because stimuli are usually comprised of sentences and when the speech signal is rendered unintelligible, it affects processes at the phonological, lexical, syntactic, and prosodic levels of processing. The current fMRI study examined speech intelligibility using individually presented words. We also address two of the criticisms concerning the Okada et al. (2010) study by using sparse rather than continuous sampling and passive listening rather than an active task. Methods. Participants heard a set of 160 monosyllabic words (intelligible speech) and spectrally rotated versions of the same words (unintelligible speech) in a passive listening experiment. A sparse sampling paradigm was employed and all stimuli were presented in silence. Results. Intelligible speech (clear minus rotated) produced activation in both anterior and posterior regions of the STG/STS bilaterally. Discussion. Our study replicated Okada et al.'s finding of bilateral activation in both posterior and anterior STG/STS regions.This effect held even when stimuli were presented in silence and with a passive listening task.This finding is consistent with the proposal that speech is processed in a bilateral network including both posterior and more anterior regions. Scott, S. K., Blank, C. C., Rosen, S., & Wise, R. J. S. (2000). Identification of a pathway for intelligible speech in the left temporal lobe. Brain, 123, 2400-2406. Okada, K., Rong, F., Venezia, J., Matchin, W., Hsieh, I. H., Saberi, K., et al. (2010). Hierarchical Organization of Human Auditory Cortex: Evidence from Acoustic Invariance in the Response to Intelligible Speech. Cerebral Cortex, 20, 2486-2495. Narain C, Scott SK, Wise RJ, Rosen S, Leff A, Iversen SD, Matthews PM. (2003). Defining a left-lateralized response specific to intelligible speech using fMRI. Cereb Cortex, 13, 1362–1368. Hickok G., Poeppel D. (2007). The cortical organization of speech processing. Nat. Rev. Neurosci. 8, 393–402.

A4 Temporal receptive fields in auditory cortex: An FMRI study using periodic noise ***Okada, K.** (1), **Fillmore, P.T.** (2), **Hsieh, I.** (3), **Serences J.T.** (4), **Muftuler, L.T.** (5), **Saberi, K.** (1), **Hickok, G.** (1); 1. University of California, Irvine; 2. University of South Carolina, Columbia, SC; 3. National Central University, Taiwan; 4. University of California, San Diego; 5. Medical College of Wisconsin, Milwaukee* – **Introduction:** It has been proposed that the auditory system analyzes acoustic information over different timescales or temporal windows of integration.One way to think about these integration windows is that they are the receptive field size of an auditory unit.Conceptualized in this way, we might predict a systematic increase in temporal integration windows as one progresses from lower to higher levels of the auditory system. Previous imaging work using amplitude modulated noise showed precisely this in the response preference to different modulation rates in the brainstem (256Hz), superior colliculus (32-256Hz), thalamus (16Hz), primary auditory cortex (8Hz), and secondary auditory cortex (4-8Hz). In the present experiment, we sought to map the range of temporal integration window preferences specifically within the cortical auditory system.We hoped to answer: (1) are there wider (longer) temporal receptive fields (TRF) in auditory cortex than previously identified, (2) are multiple TRFs represented, or are some time windows (e.g.,20-30Hz and 4-5Hz) preferentially represented, and (3) are there different lateralization patterns for different TRFs? Methods. To address these questions, we conducted an fMRI experiment using repeated frozen noise that varied in repeat frequency.These stimuli are composed of a segment of noise of some duration that is repeated (looped). An advantage of frozen noise is that to detect periodicity, the auditory system must use spectrotemporal patterns and cannot use amplitude information alone. In a sparse sampling design, subjects were presented with frozen noise at the following segment durations: 25ms, 50ms, 100ms, 200ms and 400ms. Thus we sample periodicity rates from 2.5Hz–40Hz. Each stimulus lasted 2s and stimuli were presented in silence. Results. Group analysis revealed strong focal activation in medial auditory regions bilaterally for all periodicities.As duration increased from 25ms to 400ms, activation radiated anterolaterally from HG.Periodic noise with short durations maximally activated regions near primary auditory cortex (PAC) whereas periodic noise with longer durations activated lateral sites along superior temporal cortex.A voxel tuning curve analysis identified voxels with TRFs tuned to each of the repeat durations that we used. To address the issue of hemispheric asymmetries in processing stimuli along different timescales, we contrasted listening to periodic noise repeated at 200ms duration compared to 25ms duration.This contrast was chosen since 200ms is the approximate time to resolve syllabic level information and 25ms, phonemic level information. This contrast yielded a small cluster of activation in left STG, with greater activation to repeat duration of 200ms compared to 25ms condition. Discussion. Our main finding is that auditory cortex demonstrates sensitivity to stimuli that vary in temporal receptive field size.We identified, for the first time, an anterolateral region that is particularly sensitive to the slowest repeat rate (400ms, 2.5Hz). We found that sounds occurring over short durations engage PAC and sounds occurring over longer durations engage additional sites along lateral STG. Voxel tuning analysis showed that auditory cortex represents a range of TRF sizes.Some evidence for hemispheric asymmetries was identified but not in the typically assumed direction (left hemisphere=shorter integration windows).

A5 Phonological underspecification in the mental lexicon: an investigation of the P2 ERP component and lexical decision latency ***Tanigawa, N.*** *(1),* ***Rahni, R.*** *(1),* ***Kim, J. J.*** *(1),* ***Geisler, M. W.*** *(1); 1. San Francisco State University, CA* – The present study utilizes electrophysiological and behavioral measures to determine the extent to which predictable abstract information about speech sounds is stored in the mental lexicon. Past studies investigated this question by contrasting the processing of coronals (/n /, /d/) that have alternating surface forms (e.g., /n/ pronounced as [n] in rain, [m] in rainbow) with that of non-coronals (/m/, /b/) that do not. To tease out the Lexicality (real word vs. pseudoword) x Place (coronal vs. non-coronal) interaction, we added Manner (nasal /n/, /m/ vs. oral /d/, /b/) and Quantity (neutralized geminate vs. singleton, e.g., nn vs. n). Following Friedrich et al.'s (2006) auditory lexical decision paradigm, monomorphemic English nouns were selected with coronal or non-coronal uniqueness points for the first phoneme of the second syllable. A pseudoword was created from each real word by switching the place of articulation between coronal and non-coronal (e.g., picnic to *picmic; helmet to *helnet). Spoken stimuli (n = 320) were presented to participants via headphones. Predictions were derived using the Featurally Underspecified Lexicon (FUL) model with inputs matching, mismatching, or no-mismatching lexical representations (Lahiri, 1999). When event-related potentials (from 22 participants with lexical decision accuracy > 90%) were time-locked to word onset, the N1-P2-N400 complex emerged, confirming that this auditory-only paradigm elicited not only sensory perceptual components, but a lexical processing component as well. Next, because the time taken from word onset to place manipulation point varied across stimuli, the time-locking point was shifted to micro-events involving the place alternations – preceding phoneme's offset (T1) and target phoneme's burst point (T2). These adjustments reduced the N1 amplitude, but left the P2 peak intact. Centroid latency was shorter for mismatching non-coronal pseudowords (e.g., *helnet), but longer for no-mismatching coronal pseudowords (e.g., *picmic), relative to their real-word counterparts. The directions of the latency difference support FUL from its assumption – immediate rejection for mismatch and prolonged retention for no-mismatch. Moreover, amplitude was greater for specified match (i.e., noncoronal real) than for underspecified match (i.e., coronal real). Thus, FUL's ternary logic may be subsumed under the theory of the neural processing underlying the P2 component, whereby features extracted from signals are compared against target features' mental representations (Luck & Hillyard, 1994). Considering the correlation between the P2 latency and lexical decision timing (McGinnis et al., 1997), reaction times measured from T1 and T2 were fitted with linear mixed-effects models with crossed random effects for participants and items. Regarding T2 reaction times, after partialing out autocorrelations across 320 trials, psycholinguistic effects (e.g., lemma frequency x lexicality), biological effects (gender and age), by-participant and by-item random intercepts, and correlations between by-participant intercepts and slopes for stimulus properties (e.g., the number of phonemes), the Lexicality x Coronality interaction was still significant. T1 electrophysiological and T2 behavioral data jointly revealed a time course of asymmetric place feature processing leading to lexical decision, as observed in gating experiments (Marslen-Wilson, 1992) – processing started as F2 frequency changed toward preceding phoneme's offset and decision accuracy above 75% was achieved toward target phoneme's burst point.

A6 Enhancing left lateralization of posterior temporal cortex using tDCS shifts perception on a voice-onset time continuum ***Turkeltaub, P.E.*** *(1,2),* ***Benson, J.*** *(2),* ***Hamilton, R.H.*** *(2), and* ***Coslett H.B.*** *(2); 1. Georgetown University, Washington, DC; 2. University of Pennsylvania, Philadelphia* – **Introduction:** Both hemispheres participate in initial stages of speech perception, but later processing is left lateralized. Debate remains as to when left lateralization occurs: during access of speech sound representations, or later during lexical access. We evaluated the lateralization of sublexical categorical speech perception using a voice-onset time (VOT) continuum while applying transcranial direct current stimulation (tDCS). We predicted that enhancing left lateralization would enhance access to phoneme representations resulting in more discrete perception of categories on the VOT continuum. Methods: Twelve adult right-handed native English speakers participated. Each subject received three forms of tDCS on different days: left lateralizing (LL), right lateralizing (RL), sham. In each condition, one electrode was centered between T7 and TP7 and the other between T8 and TP8. In the LL condition, the anode was on the left and the cathode on the right; in the RL condition, the polarity was reversed. During active conditions, 1.5 mA of current was delivered for 20 minutes. During sham stimulation, current was ramped up and then down within 30 seconds. Subjects performed identification and same-different discrimination tasks on a nine-item /ba/-/pa/ VOT continuum before tDCS and again during tDCS. Data were analyzed using standard repeated measures ANOVAs. Results: Electrical field modeling confirmed that the LL condition is expected to increase cortical excitability in the left posterior temporal lobe and reduce excitability in the right; the opposite is expected with RL tDCS. A Condition x Stimulation x Phoneme effect was observed in the identification results in which perception of ambiguous stimuli (VOT 25-35 msec) shifted towards /ba/ during LL tDCS (P = .026). No significant effects of tDCS were observed in the discrimination performance, although the trend was toward better discrimination within /ba/ and between phonemes during LL tDCS. Discussion:Enhancing left lateralization of temporal lobe processing did not increase the degree to which speech perception relied on categorization as we had predicted. Instead, enhancing left lateralization induced a shift in perception towards /ba/. This might occur due to preferential consolidation of the voiced consonant representation, but the trends in the discrimination data do not support this. Alternatively, a change in the temporal sensitivity of auditory cortex due to differences in time-scale computational properties of the two hemispheres

might explain the results. Follow-up studies are underway.

A7 Brain Signature of Comprehending Sentences with Acoustic Noise: An fMRI study ***Alexei A. Smaliy*** *(1),* ***Melody S. Berens*** *(1),* ***Joseph Dien*** *(1),* ***Valerie Karuzis*** *(1),* ***Suzanne Freynik*** *(1),* ***Peter Osthus*** *(1),* ***Henk J. Haarmann*** *(1); 1.University of Maryland* – It has long been established that a small degree of sound obliteration has minimal to no impact on speech comprehension (cf. Warren, 1970), but relatively few studies have looked at the impact of larger, full sentence, sound obliterations. Investigating the impact of full-sentence sound obliteration enables the study of how the brain processes degraded speech communications in an ecologically valid context, such as in time-sensitive urgent situations in which emergency workers must be able to quickly process, and immediately act upon, spoken utterances.Studies have shown that lexical context can influence perceptual restoration, and more recent studies have investigated how bottom-up and top-down processes influence auditory language processing in the presence of sound obliteration. The goal of the current research is to investigate how lexical context and level of sound obliteration impact behavioral listening comprehension. Using 3T functional Magnetic Resonance Imaging (fMRI), we also investigate the underlying neural and cognitive mechanisms that mediate how listeners cope with this type of auditory degradation. Participants (N = 18) were right-handed monolingual English speakers. Listeners were presented with pairs of auditory sentences: a context sentence directly followed by a target sentence. The context sentences were vocoded, or overlaid, with white noise to produce four levels of sound obliteration – no obliteration, recoverable obliteration, unrecoverable obliteration, and complete obliteration. The target sentence was not noise-vocoded. Participants performed a lexical decision task (word vs. non-word) on the last word of the target sentence. The cloze probability of real-word targets was manipulated, such that the target was expected or unexpected depending upon whether the presented context sentence could be understood (was recoverable).Behaviorally, all participants' accuracy was at ceiling on the lexical decision task. Reaction time results show a main effect of recoverability ($p < .001$), such that listeners responded faster to recoverable words.There also was a main effect of word expectancy ($p < .002$) with listeners responding faster to expected words.The interaction between recoverability and expectancy approached significance ($p < .07$). Initial fMRI results show greater activation in left Superior Temporal Gyrus (STG; BA 21) and left Middle Temporal Gyrus (MTG; BA22) and right Middle Temporal Gyrus (BA 22) while processing recoverable obliteration, compared to unrecoverable obliteration, $p(FWE) < .05$.We also found significantly greater activation in bilateral STG and MTG when listening to unrecoverable obliteration as compared to complete obliteration $p(FWE) < .05$.These findings provide information about the neural mechanisms involved in coping with such sound distortions.Our discussion will focus on the implications of these findings for understanding the psychological mechanisms the brain employs when listening to spoken sentences that are distorted with noise overlay.

A8 ERP measures response to violations of voicing agreement constraint ***Chandlee, J.*** *(1),* ***Hestvik, A.*** *(1); 1. University of Delaware, Newark, DE* – We present an ERP study comparing the response to syllables that either obey or violate a phonotactic constraint on voicing agreement. There has been increasing interest in neural correlates of the knowledge used in production and acceptability judgment tasks. Flagg et al. (2006) found with MEG a difference in the response to an oral consonant following a nasal vowel, but not to a nasal consonant following an oral vowel, even though both sequences are violations. And Monahan et al. (2009) likewise found a response with MEG to violations of the constraint against syllable-final obstruent clusters that do not agree in voicing, but only for the voiced-voiceless incongruency, not for the voiceless-voiced. The current study aimed to replicate the results of Monahan et al. with ERP using identical stimuli and experimental design. The stimuli were VCC words (e.g. [uds], incongruent because of the voiced-voiceless sequence, and [uts], which is congruent). In Experiment 1, 21 subjects (20 female, ages 18-23, 16 right-handed) passively listened to 150 trials of 12 stimuli types (3 places of articulation x 2 categories (congruent, incongruent) x 2 directions of incongruence). The ERPs were recorded with open filters on 128 channels; they were epoched with a 200ms baseline, time locked to the onset of the vowel. The sibilant occurred 200ms into the word and was followed by a 600ms epoch. The result was an ERP that showed a congruency effect distributed at the central anterior electrodes. Contrary to Monahan et al., an effect was observed for both directions of incongruence (i.e. voiced preceding voiceless and voiceless preceding voiced). But again, we observed an asymmetry: the waveform for incongruent stimuli ending in [z] is more negative than that of the congruent stimuli, but for stimuli ending in [s] the waveform of the congruent stimuli is more negative than that of the incongruent stimuli. The attached figure shows the average referenced data for 21 subjects of the main effect of congruency for the AFz channel (the effect and the corresponding component were located with ICA). This result works against Monahan et al.'s conclusion regarding underspecification, but it strengthens the claim that phonotactic violations are relevant to early stages of speech processing. Furthermore, eight additional subjects (all female, ages 18-19) participated in Experiment 2, a behavioral phonotactic acceptability task with the exact same stimuli. Subjects rated each word for how closely it resembles an English word, but the results show that they were not able to distinguish the congruent from incongruent sequences. The fact that the passive measure of ERP (subjects performed a distracter task) revealed what a behavioral experiment could not detect further emphasizes the use of this measure in studies that aim to tap into phonotactic knowledge. The processing of constraint violations at the phoneme-sequence level is available to the perceptual systems that ERPs can access, but the effect may not extend to

the level of cognition used in behavioral experiments. Thus we believe the effect observed via ERP is fast-acting, automatic, and generated by underlying linguistic knowledge. References - Flagg, E., Oram Cardy, J.E., and Roberts, T.P.L. (2006). MEG detects neural consequences of anomalous nasalization in vowel-consonant pairs. Neuroscience Letters 397, 263-268. Monahan, P. J., Hwang, S-O., and Idsardi, W. J. (2009, under revision) Predicting Speech: Neural Correlates of Voicing Mismatch using MEG. Brain Research.

A9 Responses to sub-categorical mismatches in auditory word-recognition following picture contexts in native English speakers ***Datta, H.*** *(1)* ***Zevin, J.*** *(1); 1. Sackler Institute of Developmental Psychobiology, Weill Cornell Medical College, New York* – As active processors of language, humans are likely to predict upcoming information from existing knowledge and preceding stimulus (e.g., visual context, world knowledge, and auditory context), increasing efficiency of language processing. There is evidence that word-form predictions from lexical knowledge can have strong top-down influence on phonetic perception (reference) of an auditory word (e.g., Ganong, 1980). It is also true that native speakers of a language are sensitive to bottom-up acoustic-phonetic information and can anticipate upcoming acoustic information from preceding sub-phonemic context in an auditory word. In order to study interactive processes in prediction, we designed an experiment where in which we manipulated acoustic information in auditory words preceded by predictive picture contexts. We tested native English speakers in a picture-word paradigm where pictures provided the predictive context for auditory words presented 150 ms after the pictures. The participants were asked to silently name the picture, and then press the "1" key if the word matched the picture and the "5" key if it did not. The auditory words were either unaltered or cross-spliced across competing words (e.g., neck and net). The splicing procedure involved attaching the onset of a word to the coda of its competitor (e.g., ne(t)ck) and (e.g., ne(ck) t), i.e., a sub-categorical mismatch manipulation (e.g., Dahan et al., 2001). To track the temporal resolution of how acoustic splicing affected the predicted word-form from the preceding picture, we recorded Event Related Potentials (ERPs). In order to understand how expectations from the pictures were modulated by the auditory words, we examined the N400, an ERP component reported to index lexical access (Holcolmb and Neville, 1990)). We expected that the amplitude of the N400 response would depend on congruency between the expectations generated from the picture context and those generated from the sub-categorical contexts through the course of the auditory word. In conditions where both the picture and the sub-categorical contexts lead to the same expectations, we expected a smaller N400. However, when these two sources of information conflicted, we expected a larger N400 response for the participants. Results (see Figure 1) suggest that native speakers were sensitive to both predictive picture contexts and sub-categorical contextual cues within words. Specifically, when a word-splice lead to a sub-phonetic context that mismatched (e.g., ne(t)ck) the picture context (e.g., neck) in the early portion of the word, it elicited a small N400 that ended early. In contrast, when a word-splice lead to a match between itself (ne(ck)t) and the picture context (neck) early on but a conflict later, it elicited a larger and much later N400.Thus, when a conflict between a prediction based on the picture and early auditory information in a word is detected right away, and the word ends as expected, an early-ending response suggests reconciliation. However, when both sources of information lead to the same prediction that is violated in the end, a later and more robust response is elicited. Thus both semantic and acoustic information contribute to predictive mechanisms in language processing.

A10 Cortical processing of continuous speech in auditory cortex during monaural and dichotic listening ***Nai Ding*** *(1),* ***Jonathan Z. Simon*** *(1); 1. University of Maryland, MD* – We study the neural representation of speech in human auditory cortex during natural speech perception. The Magnetoencephalographic (MEG) response was recorded from human subjects listening to a spoken narrative, either in quiet or in the presence of interfering speech. The subjects answered comprehension questions after every one-minute duration section. By using advanced data analysis methods, we extracted the neural coding strategy on a single trial basis and therefore avoided excessively repeating the speech stimuli. For a monaurally presented spoken narrative, it is demonstrated that the ongoing neural activity in auditory cortex precisely tracks the slow temporal modulations (< 10 Hz) of speech. This neural tracking is particularly faithful in the right hemisphere, regardless of which ear the spoken narrative is presented to. This result suggest that the temporal envelope of speech, which contains information about the syllabic structure, is precisely encoded in auditory cortex and is lateralized to the right hemisphere. To examine the neural basis of speech perception in complex listening environment and further explore the hemisphere lateralization of speech encoding, we presented two spoken narratives dichotically and instructed the listeners to focus on one of them. In auditory cortex, we find the neural representation of the attended speech is substantially stronger than that of the unattended speech. This occurs at a short latency, ~ 100 ms, even on subjects' first exposure to the spoken narrative. The neural representation of speech is more strongly modulated by attention in the contralateral hemisphere, perhaps due to the anatomy of the auditory system. These results suggest that the neural processing of the slow temporal structure of speech in each ear is intrinsically lateralized to the right hemisphere, while the attentional modulation of such a neural processing is lateralized to the contralateral hemisphere. Furthermore, since the attentional modulation has a relatively short latency and is seen in auditory cortex, feed-forward auditory processing must play an important role in segregating simultaneous speech signals.

Finally, we establish a single-trial based experimental paradigm that allows the analysis of neural processing of speech in a more ecologically valid manner.

A11 The Role of Broca's area in Speech Perception:Evidence from Aphasia Revisited ***Hickok, G.*** *(1),* ***Costanzo, M.*** *(2),* ***Capasso, R.*** *(2,3),* ***Miceli,*** *(2); 1. University of California, Irvine, CA; 2. Università di Trento, Rovereto, Italy; 3. Fondazione Santa Lucia IRCSS, Rome, Italy* – Motor theories of speech perception have been re-vitalized as a consequence of the discovery of mirror neurons.Some authors have even promoted a strong version of the motor theory, arguing that the motor speech system is critical for perception.Part of the evidence that is cited in favor of this claim is the observation from the early 1980s that individuals with Broca's aphasia, and therefore inferred damage to Broca's area, can have deficits in the ability to discriminate speech sounds.However, this early work did not confirm involvement of Broca's area and did not use signal detection analysis methods and therefore may not have measured discrimination ability veridically. Here we re-examine this issue in 24 patients with lesions to Broca's area and various degrees of associated non-fluent speech production.Patients performed two same-different discrimination tasks involving pairs of CV syllables, one in which both CVs were presented auditorily, and the other in which one syllable was auditorily presented and the other visually presented as an orthographic form. Discrimination performance on the all-auditory (A-A) task was four standard deviations above chance, as measured using d', and was unrelated to the degree of non-fluency in the patients' speech production (see figure, left panel). Performance on the auditory-visual (A-V) task, however, was worse than, and not correlated with, the all-auditory task. The auditory-visual task was related to the degree of speech non-fluency (see figure, right panel).We conclude that the motor speech system is not necessary for speech perception as shown the by the all-auditory task, but may play a role in orthographic decoding or in auditory-visual matching of phonological forms.

A12 Brain responses to figurative language during story perception: an fMRI study ***Nagels, A.*** *(1),* ***Kauschke, C.*** *(1),* ***Schrauf, J.*** *(1),* ***Whitney, C.*** *(3),* ***Krach, S.*** *(1),* ***Kircher, T.*** *(1); 1. Philipps-University Marburg, Marburg, Germany; 2. University of York, York, UK* – Numerous figurative expressions are fully conventionalized in everyday speech. Regarding the neural basis of figurative language processing, research has predominantly focused on metaphoric expressions in minimal semantic context. It remains unclear in how far other forms of conventionalised figurative expressions (e.g., similes) during continuous text comprehension activate similar neural networks as isolated metaphors. We therefore investigated the comprehension of similes (figurative language, e.g. "He smokes like a chimney!") occurring in a short story. Sixteen healthy, male, native German speakers listened to similes that came about naturally in a short story, while BOLD responses were measured with functional magnetic resonance imaging (fMRI). For the event-related analysis, similes were contrasted with non-figurative control sentences. The stimuli differed with respect to figurativeness, while they were matched for frequency, number of syllables, plausibility and comprehensibility. Similes as contrasted with control sentences resulted in enhanced BOLD responses in the left inferior and adjacent middle frontal gyrus. Activation of the left IFG for similes in a short story resembles previous functional imaging results on single sentence metaphor processing. The results strengthen the importance of the left prefrontal lobe in the processing of figurative speech even during continuous, ecologically-valid speech comprehension.

A13 Investigating the temporal evolution of speech comprehension using time-resolved sparse fMRI ***Peelle, J. E.*** *(1),* ***Sohoglu, E.*** *(2),* ***Davis, M. H.*** *(2); 1. The University of Pennsylvania, Philadelphia; 2. Medical Research Council Cognition and Brain Sciences Unit, Cambridge, UK* – The speech signal is inherently temporal, and thus our understanding of spoken language—and its neural support—develops over the course of an utterance. However, speech is both acoustically and linguistically complex, making the isolation of brain networks supporting any particular cognitive process challenging.This process is further complicated by the acoustic noise associated with echoplanar fMRI, forcing most researchers to choose between presenting stimuli in quiet (but with impoverished temporal resolution) or in the presence of background noise (and thus of questionable generalizability). In the current study we used stimuli with finely-controlled temporal properties and a novel instantiation of Interleaved Silent Steady State (ISSS) imaging with multiecho echoplanar imaging to obtain information about the timing of the neural response to speech, unconfounded by background noise.Sentences of varying length were presented as originally recorded (speech) or noise-vocoded using a single channel (noise).Importantly, noise-vocoding preserves the overall temporal envelope of the sentence, but renders it unintelligible.We modeled the onset and offset of each sentence separately, resulting in a 2x2 factorial design (speech/noise x onset/offset).Onset responses to noise and speech did not differ in primary auditory areas, although speech showed greater extra-auditory activity.There were no reliable offset response for noise, but significant bilateral temporal activity for speech, extending into left inferior frontal cortex. Of most interest was the interaction of timing and intelligibility, which showed greater sentence offset effects for intelligible speech in this same network ($p < .05$, corrected).These regions reflect combinatorial and conceptual processes associated with sentence"wrap-up" effects unique to intelligible speech. The anatomical organization of these regions is consistent with nonhuman primate neurophysiology, and multiple processing hierarchies that radiate out from auditory cortex in service of speech comprehension.

A14 Individual differences in older adults' hearing acuity affect the neural systems supporting speech

comprehension ***Peelle, J. E.*** *(1),* ***Troiani, V.*** *(2),* ***Wingfield, A.*** *(3),* ***Grossman, M.*** *(1); 1) Department of Neurology, University of Pennsylvania, Philadelphia PA, US, 2) University of Pennsylvania, Philadelphia PA US, 3) Volen National Center for Complex Systems, Brandeis University, Waltham MA USA* – Hearing loss is one of the most common complaints in adults over the age of 60 and a major contributor to difficulties in speech comprehension. However, hearing acuity—and age-related hearing loss—can differ significantly across listeners.To examine the effects of individual differences in hearing ability on the neural processes supporting speech processing, we used functional magnetic resonance imaging (fMRI) to monitor brain activity while older adults with age-normal hearing listened to short sentences that varied in their linguistic demands.We tested 16 adults over the age of 60, to whom we presented short sentences that varied in their linguistic complexity (i.e., containing a subject-relative or object-relative center-embedded clause).For each participant we conducted standard pure-tone audiometry, quantifying hearing ability as the pure tone average (average threshold of 1, 2, and 4 kHz in each participants' better ear) (individual profiles and mean for left and right ears shown in Figure 1A).We then performed a whole-brain correlation analysis to see whether hearing ability was related to the response to linguistic complexity. Individual differences in hearing ability predicted the degree of language-driven neural recruitment during auditory sentence comprehension in bilateral superior temporal gyri (including primary auditory cortex), thalamus, and brainstem (Figure 1B).In a second experiment we examined the relationship of hearing ability to cortical structural integrity using voxel-based morphometry (VBM).Each participant's structural MRI image was segmented into different tissue classes, and the resulting gray matter images were spatially normalized into a standard space using a high-dimensional registration routine.We performed a region of interest analysis looking at gray matter volume in bilateral auditory cortex, as well as bilateral motor cortex (which served as a control region).These analyses demonstrated a strong linear relationship between hearing ability and gray matter volume selectively within primary auditory cortex (Figure 1C). An exploratory whole-brain correlation analysis confirmed that a negative correlation was not present elsewhere.Together, these results suggest that even moderate declines in peripheral auditory acuity lead to a systematic downregulation of neural activity during the processing of higher-level aspects of speech, and may also contribute to loss of gray matter volume in primary auditory cortex.More generally they support a resource-allocation framework in which individual differences in sensory ability help define the degree to which brain regions are recruited in service of a particular task.

A15 Lexical Information Interferes with Phonological Processing in an Auditory Discrimination Task ***Robles-Aguirre, F.****, (1),* ***Torres-Agustín, A****.(1),* ***López-Tinajero, A.*** *(1),* ***ez-López, M.*** *(1); 1. Instituto Nacional de Neurología y Neurocirugía* – Under the base of experiments with event related potentials (ERPs) during phonological and lexical discrimination tasks, it has been proposed that auditory language processing occurs in a series of modular phases with no interactions between them until the latest phase (Friederici, 2002, 2004). To test that proposal, this study focused on the analysis of the N100 (associated to phonological auditory processing) and the N400 (associated to the semantic auditory processing) ERPs of 10 Mexican-Spanish speakers while performing a phonological and a lexical discrimination task of nominal phrases (NP). Each task consisted of 180 stimuli to be discriminated. Sixty stimuli consisted of a NP conformed by a definite article and a name, where the article was in agreement with the name. Names were 2-4 syllables length and from the same semantic category. Sixty stimuli consisted of the same NP but changed a vowel in the unstressed or the stressed syllable of the names, generating a pseudoword. The last sixty stimuli changed the syllables of the name, generating a non-word. For the phonological task, subjects were asked to discriminate the name from vowel-initiated or consonant-initiated. For the lexical task, subjects were asked to differentiate which of the names were Spanish words and which were not. According to Friederici (2002, 2004), interference was not expected between phonological and lexical processing, so we did not expect differences in the latency and/or the amplitude of the N100 or the N400. Subjects showed more difficulties to identify pseudowords than non-words ($t=2.85$; $p=0.019$) during lexical discrimination. There were no differences in the number of errors in phonological discrimination task ($F=1.61$; $p=0.22$). There were also no differences in the latencies to respond in the phonological ($F=1.93$; $p=0.17$) nor in the lexical ($F=3.01$; $p=0.074$) tasks. Amplitudes of the N400 did not differ ($q=3.56$; $p=0.2$) nor the latencies ($q=0.6$; $p>0.2$) during lexical discrimination task. About the N100 there were also no significant differences in the latencies ($q=3.37$; $p=0.2$) during the phonological task. However when comparing the mean amplitudes of the N100 during the phonological task it was found a significant increase in the words vs non-words ($W=5.0$, $p=0.01$). Such enhancement constitutes evidence that lexical information interferes with the phase of phonological processing, and questions the serial model of auditory language processing.

A16 Human brainstem plasticity to linguistic pitch patterns: distinct effects of auditory context and training ***Chandrasekaran, B.*** *(1),* ***Skoe, E.*** *(2),* ***Wong, P.C.M.*** *(2),* ***Kraus, N.*** *(2); 1. Institute for Neuroscience, The University of Texas at Austin; 2. Northwestern University, Evanston, IL* – While it is well established that the auditory brainstem undergoes experience-dependent plasticity even in adulthood, mechanistic aspects of such plasticity are poorly understood in humans. Invasive studies on animal models show two forms of brainstem plasticity— an immediate, stimulus probability-based plasticity, and a second form of plasticity that is training-dependent. Whether these kinds of plasticity have distinct manifestations in humans is still unanswered. Here we examine the onset and sustained components of the human auditory brainstem

response (ABR) to pitch patterns using a passive oddball design. Participants (n=13) listened to pitch patterns presented at a high probability of occurrence (standards) or a low probability of occurrence (deviants). They then underwent a 2-week sound-to-meaning training program during which they learned to use these pitch patterns to distinguish words. Post-training, the pitch patterns were presented again using the same passive oddball design. Results demonstrate the existence of two distinct forms of plasticity in the human auditory brainstem:a stimulus probability-driven plasticity that impacts the onset response (~7 milliseconds post sound-onset), and a training-dependent plasticity that alters the onset and sustained components of the ABR. Plasticity related to stimulus-probability is unaffected by auditory training; training-dependent plasticity is not influenced by stimulus-probability. These results establish, for the first time, multiple, distinct forms of plasticity concurrently operational in the adult auditory brainstem.

A17 Human inferior colliculus response to pitch patterns predict auditory learning success ***Bharath Chandrasekaran*** *(1),* ***Nina Kraus*** *(2),* ***Patrick C.M. Wong*** *(2); 1.Institute for Neuroscience, The University of Texas at Austin; 2. School of Communication, Northwestern University, Evanston, IL* – Animal models have defined a fundamental role for the inferior colliculus (IC), the primary auditory midbrain structure, in the processing of communicative signals and in auditory learning.Human IC function and role in auditory learning, however, is still poorly defined because the relationship between the IC neural signal, as measured by functional MRI (fMRI), and stimulus properties has not been clearly established. Here, we used multimodal (fMRI, EEG) imaging methods to examine the extent to which IC fMRI signal indices stimulus-related properties (pitch). Frequency-following responses (FFRs), reflective of phase-locked activity from neural ensembles within the brainstem, were used to index cycle-to-cycle neural encoding of stimulus features.Our results show a strong relationship between IC fMRI signal and FFRs, suggesting that the IC fMRI signal reflects stimulus-specific activity and that FFRs reflect neural sources originating in the IC. Individual differences in the IC representation of pitch patterns strongly relates to successful use of these pitch patterns to distinguish words with auditory training.Our results highlight the importance of the inferior colliculus in speech-sound representation as well as in auditory learning.We anticipate our findings using a combined fMRI-A/brainstem electrophysiology approach to be a starting point for more sophisticated understanding of human auditory midbrain processing to speech patterns.Such experiments could immensely benefit the development of auditory midbrain prosthesis for individuals with contra-indications for cochlear implants

A18 Phonetic encoding by intracranial signals in human auditory cortex ***Pasley, B.N.*** *(1),* ***Crone, N.E.*** *(2),* ***Knight, R.T.*** *(1),* ***Chang, E.F.*** *(3); 1. Helen Wills Neuroscience Institute, University of California Berkeley; 2. The Johns Hopkins University, Baltimore, Maryland; 3.University of California, San Francisco* – Speech comprehension requires mapping time-varying frequency representations onto categorical phonetic representations. How the auditory system decomposes complex sounds into elementary acoustic features and then pools these features to form invariant representations of auditory objects is unknown. To study auditory and phonetic representation, we recorded intracranial signals from epileptic patients, using subdural electrode grids placed over left or right superior temporal gyrus (STG). Patients listened passively to phonetically-transcribed English sentences from a variety of male and female speakers. We evaluated the ability of a phonetic-based neural encoding model to account for speech-induced high gamma (70-150 Hz) responses. We compared the predictive power of the phonetic model to that of linear and nonlinear spectro-temporal auditory models. The phonetic model is based on a set of categorical predictors, one for each of 58 distinct consonant and vowel phones from the TIMIT phonetic alphabet. The linear auditory model is based on the spectro-temporal envelope of the stimulus, while the nonlinear model is based on the modulation content. The models are fit to neural responses at each electrode site and predictive power is evaluated as the correlation between actual and predicted responses from a validation data set. For specific STG sites, the phonetic model provided equal or better predictions compared to the auditory models, with correlations up to r=0.5. Phonetic tuning in the fitted models exhibited selectivity for consonant-vowel sequences at specific sites. The results suggest that higher order auditory areas in human STG encode both auditory and acoustically invariant phonetic information. The pattern of phonetic tuning may be consistent with a role in lexical recognition.

A19 Rapid use of sentential context in spoken word recognition by young and older adults ***Revill, K. P.*** *(1); 1. Georgia State University/Georgia Institute of Technology, Atlanta, GA* – Activation of multiple lexical competitors during spoken word recognition (SWR) creates competition that must be resolved via continued activation of the target word and deactivation of non-target words. Previous research has demonstrated that constraining sentential contexts rapidly reduce competition from contextually inconsistent lexical competitors in young adults. This ability could be increasingly important for older adults, since they show larger lexical competition effects in both normal and challenging listening environments.Behavioral studies have shown that older adults readily use context to support SWR, but ERP studies of semantic integration have revealed reduced or delayed effects of context. In this experiment, we monitored the eye movements of young (18-30 years) and older adults (65-80 years) as they listened to sentences describing a character's actions while viewing a scene on a computer screen.We manipulated whether a phonologically related competitor was present among the items in the scene and whether the sentence's verb was constraining; that is, whether it could sensibly apply to only the target object or the object and its competitors. Like younger adults, older adults showed anticipatory fixations to

potential target objects after hearing a contextually constraining verb.When the verb was consistent with both the target and its cohort competitor, older adults showed larger competitor effects than the younger listeners.However, a constraining verb greatly reduced competition from contextually inconsistent cohort competitors for both groups.The time course of these effects did not differ between the younger and older groups. This data suggests that one mechanism underlying older adults' improved SWR performance with supporting contexts is a reduction in problematic lexical competition from semantically inconsistent competitors.We also demonstrate that older adults are able to use these simple contexts to make rapid predictions evidenced by anticipatory fixations to likely targets.Possible differences between these results and ERP studies showing delayed or reduced context effects include the strength of the contextual manipulation, the presence of both visual and linguistic contexts, and the absence of semantic violations that make predictive processing more costly.

A20 Phonological therapy in aphasic patients strengthens top-down connections within the auditory system ***Schofield, T.*** *(1),* ***Penny, W.*** *(1),* ***Stephan, K.*** *(1,2),* ***Crinion, J.*** *(3),* ***Thompson, A.*** *(4),* ***Price, C.*** *(1)* ***Leff, A.*** *(3,4); 1. Wellcome Trust Centre for Neuroimaging, University College London; 2. University of Zurich, Switzerland; 3. Institute of Cognitive Neuroscience, University College London; 4. Institute of Neurology, University College London* – **Methods:** We investigated the effects of rehabilitation on the auditory network of 22 aphasic patients with impaired language comprehension, using fMRI. A cluster analysis demonstrated that the patients fell into two clear groups of moderate (n = 13) and severe (n = 9) speech comprehension impairment. All had left hemisphere strokes; lesion size did not differ between groups (p = 0.9). The patients were randomized into a cross-over clinical trial with two interventions: a drug (donepezil) which was placebo-controlled, and a computer-based phonological therapy (Earobics ®). A speech-based fMRI task identified changes in brain activity related to improved language comprehension. Results: A) Behavior. The phonological therapy improved language comprehension (p = 0.04) with a trend interaction by group (p = 0.09): severe patients benefitted more. Donepezil had a borderline beneficial effect on speech output (p = 0.08), but not on language comprehension. B) fMRI pre-therapy. We used a Dynamic CaUSl Modeling analysis of the fMRI data to identify changes in the patients' auditory network. In the severe group, pre-therapy, there was task dependent activation of the left and right planum temporale (PT), right Heschl's gyrus (HG) and right medial geniculate body (MGB). Compared with moderate patients, two connections were significantly different: a feed-back connection from PT to HG, and a feed-forward connection from MGB to HG (both p = 0.03). This is consistent with the predictive coding account of brain function: weaker predictions about incoming sensory information (coded in the feed-back connections), lead to increased error signals being passed up the auditory hierarchy (coded in the feed-forward connections). C) fMRI post-therapy. Two connections changed significantly: the feed-back connection from HG to MGB became stronger (p = 0.05); the feed-forward connection from HG to PT became weaker (p = 0.04). We infer that therapy induced changes in language comprehension are mediated by increasing top-down influences within the auditory hierarchy that suppressprediction errors.

A21 Acoustic and phonemic factors determine the amplitude and laterality of mismatch fields in humans ***Teki, S.*** *(1,2),* ***Barnes, G.R.*** *(2),* ***Penny, W.*** *(2),* ***Griffiths, T.D.*** *(1,2),* ***Leff, A.P.*** *(3); 1. Newcastle Auditory Group, Medical School, Newcastle University, Newcastle-upon-Tyne, UK; 2. Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London; 3. Institute of Cognitive Neuroscience, University College London* – Objective: Perception of speech and language is an important biological function that is mediated by a distributed network in the primary (A1) and secondary (STG) auditory cortices that can be probed using mismatch paradigms (Schofield et al., 2009). We wished to investigate how network connectivity differed between normal subjects (n=16) and patients with chronic auditory perceptual deficits of speech caused by stroke (n=25), using a mismatch paradigm and magnetoencephalography (MEG). Stimuli: We used MEG and a standard paradigm to elicit mismatch responses (Nataanen, 1993) to a series of four vowels. The standard was of a 'vowel-consonant-vowel' word /bart/. The three deviants were created by varying the frequency of the first and second formant of the vowel to produce: (D1) an acoustically different but within-class deviant /baart/; (D2) /burt/, and (D3) /beat/. The last two deviants were perceived as being in a different vowel category to the standard and D1. Methods: Participants passively listened to the stimuli in an MEG scanner with 275 channels and third-order gradiometers (CTF Systems). The mismatch response typically occurs between 150 and 250 ms after stimulus onset and is considered an index of automatic change detection. The mismatch fields were fitted with a four dipole model with bilateral sources in A1 and STG using variational-Bayes equivalent current dipole model (Kiebel et al., 2008). Results: A single best source from each hemisphere was selected in a data-driven manner for the normal subjects. Responses from the fitted sources show a significant main effect of deviants and hemisphere such that the amplitude of response to D3 > D2 > D1 and the individual responses from the left hemisphere source were significantly greater than the corresponding responses from the right hemisphere source. The latency of the mismatch responses was significantly greater for D1 than D2 and D3 in both the hemispheres. These data will be modelled using Dynamic CaUSl Modelling (DCM; Friston et al., 2003) to investigate effective connectivity and flow of information between the selected sources. Conclusions: The present results from normal subjects suggest a strong left lateralization of the responses to deviant speech stimuli whose amplitude parametrically increases with the perceived

deviance from the standard. Results from stroke patients and DCM analysis will also be presented. References: 1. Schofield TM, Iverson P, Kiebel SJ, Stephan KE, Kilner JM, Friston KJ, Crinion JT, Price CJ, Leff AP (2009) Changing meaning causes coupling changes within higher levels of the cortical hierarchy. Proc. Natl. Acad. Sci. U.S.A 106:11765-11770. 2. Näätänen R, Jacobsen T, Winkler I (2005) Memory-based or afferent processes in mismatch negativity (MMN): a review of the evidence. Psychophysiology 42:25-32. 3. Kiebel SJ, Daunizeau J, Phillips C, Friston KJ (2008) Variational Bayesian inversion of the equivalent current dipole model in EEG/MEG. Neuroimage 39:728-741. 4. Friston KJ, Harrison L, Penny W (2003) Dynamic caUSl modelling. Neuroimage 19:1273-1302.

A22 Genome-wide linkage analysis of human auditory cortical evoked responses suggests distinct loci on chromosomes 2, 3 and 8 ***Renvall, H.*** *(1),* ***Salmela, E.*** *(2),* ***Vihla, M.*** *(1),* ***Leinonen, E.*** *(2),* ***Kere, J.*** *(2,3),* ***Salmelin, R.*** *(1); 1. Aalto University, Brain Research Unit, Espoo, Finland; 2. University of Helsinki, Helsinki, Finland; 3.Karolinska Institutet, Huddinge, Sweden* – Auditory evoked responses (AERs) as measured with magnetoencephalography (MEG) or electroencephalography (EEG) are widely used to probe human cortical functions both in healthy subjects and in clinical populations. Nevertheless, their underlying molecular mechanisms remain largely unrevealed. Genome-wide mapping of human traits provide tools to identify genetic loci involved in human cortical processes and, thus, a potential means of linking macroscopic cortical phenotypes with molecular-level processes controlled by specific genes. AERs are typically characterized by prominent and stable responses at ~100 ms (N100 in EEG and N100m in MEG), with neuronal sources located around the area of planum temporale. In the present study, we searched for the genetic basis of the N100m responses by using a genome-wide linkage analysis in healthy Finnish adults. The study group consisted of 113 sibling pairs (148 females, 64 males). Responses to 1-kHz tones, presented alternately to the left and right ear, were recorded in a magnetically shielded room with a 306-channel Vectorview neuromagnetometer. DNA was extracted from blood samples and genotyped with an Affymetrix 250K array that yielded genotypes for ~150000 single-nucleotide polymorphisms (SNPs) after filtering. The N100m responses peaked at 91 ± 1 ms (mean ± SEM) and 99 ± 1 ms for contra- and ipsilateral stimulation in the left auditory cortex and at 87 ± 1 ms and 96 ± 1 ms in the right auditory cortex. All four N100m amplitude values (left/right hemisphere, ipsi/contralateral stimulation) were highly heritable (h2 = 0.68–0.80). Regression analysis of the SNPs suggested genetic linkage for the right-hemispheric responses. Both the right contra- and ipsilateral N100m responses were linked to a locus on chromosome 2 (LOD=3.3), the contralateral responses additionally to a locus on chromosome 3 (LOD=2.6), and the ipsilateral responses to a locus on chromosome 8 (LOD=3.3); the loci are now under a more detailed analysis. In conclusion, our preliminary results suggest oligogenic regulation of right-hemispheric auditory cortical responses. Most importantly, identification of genetic variants of robust neurophysiological phenotypes provides an interesting platform for interpreting neuroimaging data, and for characterizing brain functions in general.

A23 Sensitivity to temporal structure in the human auditory system ***Overath, T.*** *(1,2),* ***McDermott, J. H.*** *(3),* ***Zarate, J. M.*** *(1),* ***Poeppel, D.*** *(1); 1. New York University, NY; 2. The UCL Ear Institute, University College London; 3. Center for Neural Science, New York University, NY* – Human speech is structured over multiple timescales. Phonemes, syllables and words carry information at scales ranging from a few tens of milliseconds to seconds, respectively (Rosen, 1999). Although cortical sensitivity to amplitude modulation is well-known, it is unclear how the complex temporal structure of speech and other natural sounds is encoded. Inspired by the use of image scrambling to study object recognition (e.g. Grill-Spector & Malach, 1998), we investigated sensitivity to temporal structure by measuring fMRI responses to speech signals scrambled at different timescales. We reasoned that mechanisms for encoding temporal structure might be tuned to the specific structures in familiar natural sounds such as speech, such that the unnatural signals produced by scrambling would evoke a lower response. Scrambling was accomplished with a "quilting" algorithm similar to those popular in computer graphics, in which pieces of a source image are rearranged and appended to create a new image. We divided a sound signal into fixed-length segments (30-960 ms) and reordered them pseudo-randomly. To minimize segment boundary artifacts, a segment order was selected that approximately matched the segment-to-segment envelope changes in the original signal; segments were then appended using pitch-synchronous overlap-add. The resulting signals shared the spectral structure of the original sound signal, but differed in temporal structure to an extent that depended on the segment duration. We used a localizer (960 vs. 30 ms) to define fROIs and then probed their responses to other stimuli. The fROIs were located bilaterally in the STS. Their response generally increased with segment length up to at least 480 ms, suggesting sensitivity to syllable-length structure. We found that the effect of scrambling was a) at least somewhat speech-specific (quilts from control sounds with speech-like modulation spectra failed to produce an effect), b) independent of pitch and prosody (quilts from noise-vocoded speech produced the effect), c) independent of lexical access and syllabic familiarity (quilts from familiar and unfamiliar spoken languages produced comparable effects), and d) consistent across and replicable within subjects. The results reveal pronounced sensitivity to temporal structure in human STS that cannot be explained simply in terms of amplitude modulation sensitivity. It remains to be seen whether the effect is fully specific to speech or whether the regions implicated are also sensitive to temporal structure in other natural sounds. References: Rosen (1992) Phil Trans Royal Soc B 336: 367-373. Grill-Spector & Malach (2001) Acta Psych 107: 293-321.

A24 A spontaneous ability of songbirds to discriminate syntactic rules in auditory information ***Abe, K.****(1,2)* ***Watanabe, D.*** *(1,3); 1. Kyoto University, Graduate School of Biostudies, Kyoto, Japan; 2. PRESTO, Japan Science and Technology Agency, Saitama, Japan; 3. Kyoto University, Faculty of Medicine, Kyoto, Japan* –Whether the computational systems in language perception involve specific abilities in humans is currently under debate. One of the unique features of human language communication is assumed to be the processing of grammar, the hierarchical rules of the ordering of elements such as words. The vocalization of passerine birds, or songs, share a number of features with human speech, but whether songbirds possess a similar computational ability to process auditory information as humans is unknown. In particular, whether the sequential orderings of syllables themselves in their songs contain any kind of information is not clear. The objective of our study was to found out whether songbirds can discriminate songs only by analyzing the sequential orderings of syllables in them. By analyzing the behavioral responses to the auditory stimuli, we assessed the spontaneous discriminative ability of Bengalese finches (Lonchura striata var. domestica). We found that the Bengalese finches can distinguish even a subtle modification of syllable sequences in their songs, and the processing of syntactic organization of syllables in the songs can be used to discriminate them. Notably, however, not all of the syllable sequence modifications could be distinguished, and the modifications that could be discriminated and those that could not were shared among the individuals, indicating the existence of a specific rule in the sequential orderings of syllables in their songs, shared within the social community. We also found that after a brief exposure to artificial languages composed of the syllables from Bengalese finches' songs, finches were also able to acquire the artificial grammatical rules from the synthesized syllable strings and to discriminate novel auditory information according to the rules. We further found that a specific brain region was involved in such auditory discrimination and that this ability to was acquired postnatally through the encounter with various conspecific-songs. Our results reveal that syntactic organization of syllables in birdsongs convey some information, and passerine birds have a spontaneous ability to process hierarchical structures, an ability that has previously been supposed to be human specific. These findings suggest that songbirds and humans have many similarities in their perception of auditory information, and thus offer a comparative animal model to examine the neurobiological basis of the complex information processing involved in language comprehension.

PROSODY

A25 Separate neural recognition pathways for word stress and phonemes in 3-month-old infants ***Becker, A.B.C.****,(1),* ***Schild, U.*** *(1),* ***Friedrich, C.K****. (1); 1. University of Hamburg, Germany* – Recent results revealed separate neural speech recognition pathways for word stress and phonemes in adults (Schild, Becker & Friedrich, this volume). Infants exhaustively rely on the sequence of stressed and unstressed syllables in their maternal language. Commitment to the typical stress pattern of the maternal language was observed even earlier than commitment to the phonemes used in the maternal language. Consequently, neural processing pathways for word stress and phonemes might be established independently in infancy. **Methods:** We tested neural correlates of stress priming and phoneme priming in infancy by means of Event-related brain potentials (ERPs). In a unimodal auditory priming paradigm spoken word onset syllables (primes) preceded spoken words (targets). Primes were either stressed syllables or unstressed syllables. They were the onsets of German nouns that are frequently used in infant-directed speech, like Puppe (Engl. doll). Stressed syllables were taken from correctly stressed words, like PUPpe (capitals indicate the stressed syllable). Unstressed syllables were taken from the same words spoken with incorrect stress, like pupPE. Stress priming was realized by combining stressed or unstressed primes with correctly stressed targets, e.g., PUP-PUPpe or pup-PUPpe. Phoneme priming was realized by combining primes with targets that shared or did not share initial phonemes, e.g., pup-PUPpe or ma-PUPpe. Stress Priming (stress match vs. stress mismatch) and Phoneme Priming (phoneme match vs. phoneme mismatch) were orthogonally varied. EEG Data of 30 three-month-olds infants from German speaking parents were analyzed. Results. ERP Stress priming and phoneme priming were independent. Both ERP effects showed different time courses and temporal distributions. This is evidence for separate processing of prosodic features and phonological features in infancy. Stress priming was more robust and longer lasting than phoneme priming. This might indicate that phoneme-based language recognition is restricted to early acoustic analysis, whereas stress-based language recognition activates more elaborated stress-based neural representations. Conclusion. Stress-based language representations are independent from phoneme-based language representations in infancy. There is a primacy of the stress-based language recognition pathway in early infancy.

A26 Patterns in Speech and Song ***Groh, J.*** *(1),* ***Sammler, D.*** *(1),* ***Bangert, M****. (2),* ***Goldhahn, D.*** *(1),* ***Lohmann, G.*** *(1),* ***Turner, R.*** *(1),* ***Friederici, A.D****. (1); 1. Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig; 2. Hochschule für Musik Dresden, Institut für Musikermedizin, Dresden, Germany* – Humans produce and perceive structured vocalization in two forms: speech and song. At the level of basic acoustic parameters they are in close correspondence, both show orderly variations of pitch and rhythm. On that basis, song exhibits more regular patterns according to the rules of Western music, i.e. in pitch contour (discrete pitch) and rhythm. Speech does not show this strict quantized quality, i.e. the pitch contour shows more continuous transitions and a more heterometric structure. From a perceptual perspective, humans do not seem to have major difficulties in distinguishing what is what. The present fMRI

study sought to investigate how the human brain processes and discriminates these differences and if perception of song and speech is mediated by different brain areas or non-identical operations in overlapping areas. Therefore, we compared the neural patterns evoked during passive listening to spoken (SPK) and sung sentences (SNG) on one hand, and hummed speech prosody (SPKm) and song melody (SNGm) on the other. All stimuli were derived from the same sentences. Uni- (UVA) and multivariate analyses (MVPA) were conducted on 21 data sets to tease out brain activity specific to spoken and sung sentences and their underlying pitch contour. The results of the UVA revealed a great overlap in auditory cortices and right premotor cortex (PMC). The SNG-SPK contrast showed activation clusters in anterior superior temporal gyrus (STG) bilaterally and the right PMC, the reverse contrast in left inferior parietal lobe. The SPKm-SNGm contrast revealed activation in left posterior superior temporal sulcus (STS), while no significant clusters were found in the reverse contrast. MVPA, however, showed that the bilateral STG/STS distinguish between both, SPK and SNG as well as SPKm and SNGm. SPK and SNG were also discriminated by left posterior cingulate, right primary somatosensory cortex and right supplementary motor area. A further differential information cluster for the SPKm and SNGm conditions was found in the right anterior intraparietal sulcus. The present study compared UVA and MVPA on song and speech perception. While results from UVA indicated rather shared neural substrates for speech and song processing than differences, the MVPA implied that spoken and sung information is encoded and processed differently even within the region of overlap in auditory cortices. These results most likely reflect the different acoustic features present in song and speech.

ACQUISITION

A27 Word learning from context: accuracy and reaction time in judgments of congruency ***Jackson, A.*** *(1) and* ***Bolger, D.J.*** *(1); 1. University of Maryland, MD* – **Objective:** Readers acquire most new vocabulary through incidental learning from discourse context (Nagy & Herman, 1987). The context variability hypothesis (Bolger et al., 2008) states that varying contexts will better support abstraction of a word's core meaning features than contexts that do not vary, and further states that definitions are a specific type of context consisting solely of core meaning features. It is expected that the abstraction of core meaning features will allow for better performance on tasks requiring knowledge of word meaning. This study examined the behavioral and neural correlates of learning novel words from high- and low-variability or limited contexts and definitions, and compared performance on these trained words in tasks requiring knowledge of word meaning to high- and low-frequency words as baseline measures for well-learned and unknown vocabulary. **Methods:** Participants were taught the meanings of sixty novel pseudowords through exposure to either sentence contexts or dictionary definitions. Following training, event-related potentials (ERP) were collected as participants read congruent and incongruent sentences that included the trained pseudowords, high-frequency words, or low-frequency words, and judged these sentences' congruence. Results: Participants were more accurate in judging congruent sentences that used words trained via varying contexts than on words trained via limited contexts or definitions; they were equally accurate in judging sentences that used words trained via varying contexts as sentences that used high-frequency words. Participants were more accurate on sentences using trained words than on sentences using low-frequency words, regardless of training condition. There were no differences in reaction time (RT) among training conditions, and no differences in RT between sentences using trained words and those using low-frequency words. Conclusions: These results support the context variability hypothesis by demonstrating better word learning through highly variable contexts than low-variability contexts or definitions, as measured by accuracy in a congruency judgment task requiring knowledge of word meaning. Performance on the congruency judgment task was equivalent between high-frequency words and words trained via varying contexts, indicating that the words trained via varying contexts were learned as strongly as very familiar known words. However, reaction times in this task suggest that while these novel vocabulary words have been learned as well as high-frequency words, their processing may not be as automatic, as far more time is required to produce highly accurate judgments of sentences using these trained words than sentences using high-frequency words.

A28 Event-related brain potential measures of the acquisition of grammatical constraints ***Boyd, J.K.*** *(1),* ***Federmeier, K.D.*** *(1); 1. University of Illinois, Urbana-Champaign, IL* – Transitive uses of verbs that cannot appear transitively—e.g. 'disappear' in *'The magician disappeared the rabbit'—are commonly attested in child language (Bowerman, 1982).These errors are eventually overcome, but the type of distributional evidence that promotes the acquisition of constraints against transitive use is a matter of much debate (Ambridge et al., 2008; Goldberg, 2006), with some researchers arguing that the relevant input data are intransitives ('The rabbit disappeared'), and others claiming that periphrastic caUStives are crucial (PCs; 'The magician made the rabbit disappear').The present experiment juxtaposes learning from both types of input as a means of illuminating the nature of the mechanisms that underlie the acquisition of grammatical constraints. In the experiment's exposure block, adult participants (n = 25) read and repeated 144 sentences containing different novel verbs: one that always occurred transitively (the control condition), and two others that always occurred intransitively or in PCs, respectively.In the test block, participants read 108 transitive sentences containing the same three verbs, and performed a grammaticality judgment task while their EEG was recorded at 26 electrode sites. Example stimuli are given below.Verbs were counterbalanced across conditions.Nouns were selected to be either novel or

vague so that any constraint learning that occurred would be based on distributional cues rather than meaning. BLOCK CONDITION EXAMPLE Exposure Control The yat decided to dack the object. Exposure Intransitive The yat tried to tam near the object. Exposure PC The yat made the object wug. Test Control The nid dacked the item. Test Intransitive *The nid tammed the item. Test PC *The nid wugged the item. If participants are able to infer constraints on transitive use from exposure to intransitive and PC verb uses, then they should be sensitive to the ungrammaticality that ensues at test.Further, given that all test sentences are transitive, the identity of the verb can be used to determine grammaticality.ERPs were therefore calculated starting at verb onset. Both the behavioral and electrophysiological results demonstrate that grammatical constraints on verb use were learned from the input.Relative to controls, intransitive and PC test sentences were significantly more likely to be judged ungrammatical, and showed significant frontally-distributed negativity from 400-1200 msec after verb onset.The behavioral and ERP measures disagreed, however, about which condition showed the strongest learning: the behavioral pattern favored intransitives, but the ERP negativity associated with ungrammaticality was larger for PC verbs.

These findings intimate that multiple learning mechanisms may underlie the acquisition of grammatical constraints.Analysis of participants' repetition accuracy during the exposure block indicates significantly better encoding of intransitive versus PC sentences into memory.This suggests that better explicit memory for intransitive verb uses may have driven the acquisition of stronger constraints against their transitive use, as measured in the grammaticality judgment task.At the same time, the ERP data indicate better implicit recognition of ungrammaticality in the PC condition.Note that 'make' always precedes PC verbs during exposure, so its absence at test may constitute an especially salient signal of ungrammaticality.

A29 Effects of Frequency and Imageability on N400 amplitudes in Adolescents with and without Specific Language Impairment ***Sizemore, M. L.**,(1,2), **Polse, L.**,(1,2), **Burns, E. L.**,(2), **Evans, J. L.**,(1,2); 1. SDSU/UCSD Joint Doctoral Program, San Diego, CA; 2. San Diego State University, San Diego, CA* – Children with Specific Language Impairment (SLI) have smaller vocabularies and slower/less accurate word retrieval than typical peers (CA; Leonard, 1998). In addition, even when children with SLI have learned words, their representations may be less well specified relative to typical peers (Mainela-Arnold, Evans, & Coady, 2008). The N400 component of event-related brain potentials (ERPs) is thought to reflect ease or difficulty of processing, with low N400 amplitudes reflecting facilitation (Kutas & Federmeier, 2000). Prior ERP studies in SLI found no N400 amplitude effects for semantic congruity, suggesting amplitude differences in SLI were due to reduced processing capacity (Sabisch et al., 2006). We examined N400 amplitudes during a lexical decision task using stimuli differing in word frequency (WF) and phonotactic probability (PP) but not conceptual imageability or phonological neighborhood density, in order to determine whether adolescents with SLI process high/low frequency words similarly to peers. Participants were 28 right-handed monolingual English-speaking adolescents (SLI ages 11;10-18;2, CA, ages 10;5-18;5), with normal Performance IQ, hearing, and speech-motor abilities. Adolescents with SLI had lower scores than CA on standardized language tests and reported a history of speech/language difficulties. Participants responded to each item by pressing a button (word/nonword). Both groups showed faster RT/higher accuracy for High WF/PP, though adolescents with SLI were significantly less accurate than CA (but no slower). A 128-electrode array (Electrical Geodesics, Inc.) recorded EEG data. Repeated-measures ANOVAs were conducted on mean N400 amplitudes (400-500 ms) on WF/PP (High, Low) on each group in Frontal, Frontocentral, Central, and Parietal regions. Significant effects of WF/PP (lower amplitudes for High) were found in CA in Right Central and bilateral Parietal, but significant effects in SLI were seen in Right Frontocentral only. Findings suggest that High WF/PP words are not as strongly represented for adolescents with SLI, and they may be using a different strategy than CA for lexical decisions. Ullman & Pierpont (2005) proposed that children with SLI have procedural deficits which could cause difficulty accessing word forms during lexical decision. In contrast, they proposed that children with SLI rely on declarative memory to process meaningful information, which suggests they may rely on conceptual knowledge during lexical decision. To determine whether adolescents with SLI rely on conceptual rather than lexical/phonological knowledge, we conducted a post-hoc median split of the stimuli based on imageability, resulting in lists that were not different in WF/PP, and re-analyzed the EEG data. Repeated-measures ANOVAs were conducted as before. Significant differences between High/Low Imageability words (lower amplitudes for Low) were found for SLI between 200-300ms in Frontal, but no imageability effects were seen for CA. Overall findings indicate that although adolescents with SLI show similar behavioral responses as CA, they may be using a different strategy. Specifically, adolescents with SLI seem to rely on imageability, while CA peers use lexical/phonotactic frequency during lexical decision. Imageability may be less efficient for language comprehension and could be one indication why adolescents with SLI continue to have difficulty comprehending language.

A30 Maturation of auditory processing in adolescents: Relationships to gamma power and reading fluency ***Escobedo-Quiroz, R.**,(1),**Warrier, C.**,(1), **Hornickel, J.**,(1), **Kraus, N.** (1); 1. Northwestern University* – **Study Objective:** The morphology of auditory evoked potentials (AEP) matures from a P1-N2 response seen in children to a P1-N1-P2-N2 response seen in adults.AEPs from 14-yr-olds were found to follow either the child-like or adult-like morphology. We hypothesized that these differences in morphology were related to maturation of the adolescents' auditory system and

predicted that other processing mechanisms would reflect these maturational tendencies.Because the gamma power of resting EEG is known to follow a predictable developmental trajectory, decreasing with age, we tested whether adolescents with child- or adult-like AEP responses would show a concurrent pattern of maturation of resting gamma power.Additionally, scores from a rapid-naming test, a skill which improves with development, were correlated with N1 amplitudes to assess the relationship between physiological maturity and reading fluency. Methods: Data were obtained as part of a larger study on the development of the auditory system during adolescence.A 32-channel electrode cap incorporating a subset of the 10-20 system was used to record AEPs in response to a /da/ stimulus and resting EEG from 73, 14-yr-old participants drawn from the Chicago area.Participants were divided into groups based on the morphology of their AEP response (child-like: n=35; adult-like: n=38).N1 amplitude was calculated for each participant by averaging response magnitude at CZ over the N1 time period (100-160 ms). Gamma power was calculated by summing activity in the 31-50 Hertz range for each subject from their resting EEG recording.The CTOPP rapid naming test, a measure of reading fluency and automaticity, was administered to all participants. Results: The two groups differed in N1 amplitude, with larger amplitudes in the adult-like group ($t = 3.4874$, $p = 0.0008$).A significant correlation was seen between N1 amplitude and resting gamma power, with larger N1 amplitudes (more mature response) relating to less gamma power (more mature response). This pattern was seen in two electrode groups; the left group consisted of F7,FT7,T7,TP7, P7 ($r = 0.385$, $p = 0.006$) and the right group consisted of F8,FT8,T7,TP8,P8 ($r = 0.367$, $p = 0.009$).CTOPP rapid naming scores also correlated with N1 amplitude, with larger N1 amplitudes associated with better test scores ($r = 0.287$, $p = 0.015$). Conclusions: Here we have shown that adolescents of the same age group can vary in the maturity of their auditory cortical response.More mature speech-evoked responses related to more mature gamma activity at rest.Additionally, higher scores on a rapid-naming task corresponded to more mature speech-evoked responses, indicating a relationship between auditory system maturity and reading fluency and automaticity.Fluent readers are better readers because they don't have to devote excessive resources to process each sound individually.They can recall words (here letters or numbers) quickly and accurately from memory.This study shows that adolescents of the same age can have auditory systems at different stages of development.Measurements of physiological maturity of this system relate to both other physiological measures and behavioral measures of maturity.

MANUAL & SIGN LANGUAGE

A31 Neural Basis of Action Understanding: Evidence from Sign Language Aphasia

***Hickok, G.**, (1), **Rogalsky, C.** (2), **Tomkovicz, V.**(2), **Batch, L.** (3), **Damasio, H.** (2), **Bellugi, U.** (3); 1. University of California, Irvine; 2. University of Southern California; 3. Salk Institute for Biological Studies* – The neural basis of action understanding is a hotly debated issue.The mirror neuron account promoted by Rizzolatti and colleagues holds that motor simulation in fronto-parietal circuits is critical to action understanding including speech comprehension, while others emphasize the ventral stream in the temporal lobe. Evidence from speech strongly supports the ventral stream account, but on the other hand, evidence from manual gesture comprehension (e.g., in limb apraxia) has led to contradictory findings.Here we present a lesion analysis of sign language comprehension in life long deaf signers with focal lesions.Sign language is an excellent model for studying mirror system function in that it bridges the gap between the visual-manual system in which mirror neurons are best characterized and language systems which have represented a theoretical target of mirror neuron research. As part of a large sign aphasia research program, sign comprehension was assessed in a group of 34 deaf, life-long signers with left or right focal brain injury by asking subjects to follow a set of commands adapted from the Boston Diagnostic Aphasia Examination (e.g., "point to the ceiling").This task was part of a larger language and spatial cognitive assessment battery.Lesions were transferred to a common space using the MAP-3 method.Subjects were excluded if the lesions were bilateral, unmappable, if available scans were acute, or behavioral assessment occurred less the 3 months post stroke. This resulted in a set of 14 left (LHD) and 10 right hemisphere (RHD) damaged subjects. The RHD group was used as a behavioral control group. Two analyses were conducted on the LHD cases. The first partitioned the set of 14 subjects into those within 1 s.d. of the RHD mean (n=4) and those more than 2 s.d. below the RHD mean (n=6) and then compared lesion maps of these two groups. The second partitioned the subjects on the basis of lesion location: those with fronto-parietal but minimal temporal lobe involvement (n=6) and those with substantial temporal lobe involvement (n=4). Both analyses suggest that left frontal damage is not associated with significant deficits in sign language comprehension and point instead to a more temporal or temporal-parietal focus. Behavioral performance of patients with lesions involving the left frontal cortex was comparable to control (RHD) participants (Figure 1).We conclude that the mirror system does not seem to be a critical site for action understanding in the form of sign language comprehension.

A32 The communicative style of a speaker can affect language comprehension? ERP evidence from gesture-speech integration

***Gunter, T.C.** (1), **Kelly, S.D.**, (2), **Obermeier, C.** (1); 1. Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig; 2. Colgate University, Hamilton, NY* – In face-to-face communication, speech is typically enriched by gestures thereby enhancing the transfer of information. Gestures have for instance been found to disambiguate homonyms (Holle & Gunter, 2007) and are important cues when speech is produced in a noisy environment (Obermeier

et. al, 2011). Clearly, not all people gesture in the same way, and the actual frequency of gesture use varies greatly between individuals (McNeill, 1992). The present study explores whether such individual differences in communication style are taken into account during the perception of gestures that accompany speech. To accomplish this, participants were presented with two gesturing speakers who had subtle differences in communication style. Before the start of the stimulus presentation, participants were introduced with two speakers on a video. One speaker gestured in a straightforward way, whereas the other also produced a lot of self-touch movements (i.e. meaningless grooming). Adding such grooming movements makes the gesture information a much shallower cue compared to that of the non-grooming speaker (Holle & Gunter, 2007). The two speakers could be identified by their position on the screen (left or right side) and the height of their voice (high or low voice), but not by their faces because they were covered with a nylon stocking (in fact, the two speakers were really the same person of which the voice-pitch was artificially heightened of lowered by the PRAAT software).Screen position and voice height were balanced across participants. EEG was recorded as participants watched videos of the two persons speaking. The experimental sentences contained an unbalanced homonym in the initial part of the sentence (e.g. She controlled the ball …) and were disambiguated at a target word in the subsequent clause (which during the game … vs. which during the dance …). Coincident with the initial part of the sentence, both speakers produced an iconic gesture that supported either the dominant or the subordinate meaning. For 16.6% of all the trials, the grooming speaker produced a grooming movement. ERPs were time-locked to the onset of the target word. The results showed that participants used gesture to disambiguate speech, but this effect was modulated by the presence of grooming movements. For the non-grooming speaker, the N400 at the dominant and subordinate target words was found to be smaller after a congruent gesture and larger after an incongruent gesture. For the grooming speaker, however, this N400 congruency-effect was found only for subordinate targets. The lack of an N400 at dominant targets suggests that the addition of grooming movements weakened the impact of gesture for this particular speaker. Thus, it is not just seeing grooming movements that impacts the integration of gesture and speech generally (as in Holle and Gunter, 2007). Rather, it impacts the integration only for the speaker who is producing those grooming movements. These data therefore show that sensitivity to the personal communication style of a speaker affects the extent to which gesture and speech are integrated in the brain during language comprehension.

A33 The neural processing of co-verbal gestures: The relevance of content and abstractness ***Straube, B.*** *(1),* ***Nagels, A.*** *(1),* ***Kircher, T.*** *(1); 1. Philipps-Universität Marburg, Germany* – **Objective:** Co-verbal gestures underpin verbal utterances with regard to shape, space or action information. However, speech-gesture utterances can also differ in their degree of abstractness. Until now it remains unclear how content (e.g., shape or space) and abstractness influence the neural processing of co-verbal gestures. The purpose of the current study aimed at the question in how far the processing of content and abstractness of co-verbal gestures is based on interacting neural processes. **Methods:** In a two-factorial design, we investigated the neural basis for the processing of descriptive gestures (D) and gestures containing spatial information (S) in reference to both, concrete (C) as well as abstract (A) sentence contents. During fMRI data acquisition participants were presented with short video clips of the four conditions (CS, AS, CD, AD) while performing an independent control task. Results: In line with previous findings we found for abstract (A) as opposed to concrete (C) utterances activation of the bilateral temporal lobes and the left inferior frontal gyrus (IFG) for both, descriptive (D) as well as spatial (S) utterances (AS>CS & AD>CD). However, the processing of speech and gesture was also affected by type of information (D vs. S), indicated by a significant interaction of information type and abstractness as activation in a more anterior part of the left IFG and inferior part of the posterior temporal lobe (pTL). Conclusion/Discussion: With this study we demonstrate the interaction of content and abstractness in the neural processing of speech-gesture utterances. Besides abstractness, the kind of communicated information seems to be relevant for the neural processing of speech and gesture and even interact with abstractness. These data suggest a functional subdivision of the pTL and left IFG and support the traditional categorization of co-verbal gestures with regard to content and abstractness.

A34 Language Representation for American Sign Language: Data from Implicit Sign Recognition ***Corina, D.P.*** *(1,4),* ***Lawyer, L.*** *(1),* ***Hirshorn, E.*** *(2),* ***Mendoza, M.*** *(1),* ***Williams, D.*** *(1), and* ***Hauser, P.*** *(3,4); 1. University of California, Davis; 2. University of Rochester; 3. Rochester Institute of Technology; 4. Gallaudet University Science of Learning Center on Visual Language and Visual Learning* – **Objective**: One goal of NSF's Science of Learning Center on Visual Language and Visual Learning (VL2) is to characterize the functional neuroanatomy of language representation across a heterogeneous population of deaf individuals who vary in ASL proficiency. A challenge faced by fMRI investigators interested in such assessments is to disentangle BOLD changes associated with task performance from signature patterns of activation related to linguistic processing. Tasks requiring implicit processing of written stimuli have been used successfully across ages to chart development of neural regions involved in reading (Price et al. 1996) while holding levels of behavioral performance constant. Method. We have developed an implicit sign recognition task suitable for testing signers of differing ages and backgrounds that avoids performance confounds related to explicit processing of sign stimuli. Our protocol requires subjects to monitor videotaped lexical signs and non-linguistic gestures for forms articulated

with one or two hands. This physical judgment of stimulus form provides a task that is readily performed even by individuals without knowledge of sign language. Importantly, the comparison of performance during lexical signs versus non-linguistic gesture recognition permits assessments of implicit lexical processing of sign language. In this paper, we present findings from profoundly deaf ASL fluent signers (n = 18). All subjects participated in off-line assessment of ASL competence (ASL-SRT, Hauser et al.) and were right-handed.Data were collected using 3 Tesla Trio using a gradient-echo planar imaging sequence sensitive to BOLD contrast (46 axial slices, 3.6mm thickness, TR = 3000 ms, TE= 30msec.) and analyzed using SPM 8 (Welcome Trust, 2009). Results. Activation in the Sign versus Gesture comparisons reveals a widely distributed set of activations in medial frontal regions, pre-cuneus, left-lateralized middle frontal gyrus and inferior parietal lobule. In contrast, activation observed in the Gesture versus Sign comparison were restricted to right hemisphere posterior inferior temporal regions associated with human form processing (Downing et al., 2001; Corina et al., 2007). On-going analyses examine how these patterns of activation vary as a function of linguistic proficiency. Conclusion. The use of an implicit language task to assess language representation in deaf signers permits an assessment of cortical regions subserving lexical processing that are largely uncontaminated by task effects. This study documents an important first step towards being able to document changes in language representation as a function of language experience across divergent populations while holding constant behavioral performance.

PATHOLOGY

A35 An aphasic patient with damage to the left STS but preserved McGurk effect ***Baum, S.****(1),* ***Nath, A.****(1),* ***Hamilton, C.****(2),* ***Martin, R.****(2),* ***Beauchamp, M.****(1,2); 1. University of Texas Health Science Center at Houston, TX; 2. Rice University, Houston, TX* – We examined a patient, SJ, who presented with language impairment following a stroke. SJ performed well on standard spoken comprehension tests without close phonological distractors but was mildly impaired on the Western Aphasia Battery (88 where 100 is best performance) and on discrimination of consonant-vowel minimal pairs (86%, controls 96% - 100%). A structural MRI (see figure) showed complete ablation of the left posterior superior temporal sulcus (STS). Because converging evidence suggests that the STS is important for multisensory integration of audiovisual speech, we investigated SJ's audiovisual speech perception. SJ was able to correctly identify A syllables with 70% accuracy and AV syllables with 80% accuracy (controls 100%). The higher accuracy for AV compared with A speech suggested that SJ might have some preserved ability to integrate A and V speech cues. To measure this, we performed behavioral experiments with a parametric manipulation of A and V syllables along the "ba" to "da" continuum with five steps per modality (Massaro, 1998). For an ambiguous A stimulus SJ's percept corresponded to the V stimulus 83% of the time and for an ambiguous V stimulus her percept corresponded to the A stimulus 70% of the time, significantly greater than chance and similar to controls (91% for V, 66% for A). Next, we examined SJ's perception of the McGurk effect, an illusion that depends on AV integration: A-ba/V-ga (canonical percept "da") and A-pa/V-ka ("ta"). Across three testing sessions, there was significant variation in SJ's McGurk susceptibility, ranging from 42% to 88% (any percept different from the A or V stimulus) or 0% to 53% (only canonical percepts). This variability was much greater than that observed in normal controls. In summary, a patient with complete ablation of the left STS showed multisensory integration of AV speech, including evidence for McGurk perception. Structural MRI shows that SJ's right STS is undamaged by her stroke. We hypothesize that SJ's right STS could be subserving her residual AV integration.

A36 Impaired auditory object processing in residual Landau-Kleffner Syndrome ***Stefanatos, G.A.*** *(1) and* ***DeMarco, A.T.*** *(1); 1. Temple University, Philadelphia, PA* – Landau-Kleffner syndrome (LKS) is a disorder of childhood onset characterized by an acquired aphasia that emerges in association with epileptic or epileptiform electroencephalographic (EEG) abnormalities. The aphasia is typically characterized by severe modality-specific impairment of auditory language comprehension resembling word deafness and is thought to result from functional disruption of posterior temporal cortex by the epileptiform EEG discharges.The syndrome is both clinically and theoretically important as it provides a unique opportunity to study word deafness in a developmental context. Long term outcome is highly variable, with most demonstrating residual lifelong deficits that implicate auditory processing and auditory working memory problems. In the acute phase, children with LKS demonstrate fundamental deficits in frequency modulation (FM) analysis, evident in grossly abnormal steady-state potentials to rapidly presented FM pulses (FM-SSAEPs) The deficit in FM analysis impedes phonological decoding (particularly stop consonants) and contributes significantly to their dense comprehension deficit. Children who recover from LKS secondary to successful corticosteroid treatment show resolution of the FM-SSAEP abnormalities. Little is known about the status of SSAEPs in individuals who show incomplete recovery.We therefore describe here the SSAEP findings in B.L., a partially recovered 9-year-old male with LKS. B.L.'s language regression began at 3 years 8 months, eventuating in a picture consistent with word deafness. At 4 years 6 months, he demonstrated the hallmark electroencephalographic feature of LKS -sleep-activated, continuous spike and wave during sleep (CSWS). This was accompanied by predominantly left centro-temporal sharp and slow waves. After unsuccessful trials with anticonvulsants, corticosteroid treatment was started at 6-years. At 9-years, his receptive language had significantly improved, but remained problematic. Though his comprehension of connected meaningful speech (sentences) was low average, in the absence of contextual cues his comprehension was poor. Substantial difficulties were

evident in phoneme discrimination. B.L.'s FM-SSAEPs were normal in amplitude but delayed in latency (Figure 1, top).While the typical FM-SSAEP peaks around 100ms, B.L.'s peak positivity occurred at approximately 150ms. To further characterize the residual auditory deficits, we utilized a new developed auditory-evoked-steady-state-oddball-potential "AESOP" paradigm which probes neurophysiological mechanisms involved in processing of auditory objects whose onset is cued by frequency changes. Normal responses to the AESOP paradigm are characterized by a negativity around 160ms after stimulus changes cue the onset of an auditory object, followed by a positivity at 270ms (Figure 1, bottom right). B.L.'s response was similar to controls' in the right hemisphere, but was attenuated in amplitude by 50% over the left hemisphere (Figure 1, bottom left). Despite the resolution of epileptiform EEG activity, deficits in phonological processing deficits persist in partially recovered LKS, implying limitations in neuroplasticity and response to intervention. Higher order aspects of language processing appear to help compensate for these deficits to some degree. In contrast tothe mildly abnormal FM-SSAEPs observed in this case,abnormalities using the AESOP paradigm were compelling. The findings suggest lateralized dysfunction in the utilization of transitional frequency information to identify auditory objects. The relevance to word recognition is discussed.

A37 Comparing auditory-motor interaction in static and time-varying articulation between stutterers and normal speakers ***Cai, S.*** *(1,3),* ***Beal, D.S.*** *(2),* ***Ghosh, S.S.*** *(1,3),* ***Tiede, M.K.*** *(1),* ***Guenther, F.H.*** *(2,3),* ***Perkell, J.S.*** *(1,2,3); 1. Massachusetts Institute of Technology, Cambridge, MA; 2. Boston University, Boston, MA; 3. Harvard-MIT Division of Health Sciences and Technology, Cambridge, MA* – **Objective:** Numerous empirical observations and theoretical considerations have led researchers to propose that auditory feedback (auditory self-perception when speaking) functions abnormally in the speech motor system of persons who stutter (PWS) (e.g., Max et al., 2004; Brown et al. 2005; Civier et al. 2010; Beal et al., 2010, 2011). However, evidence for this hypothesis is mainly from indirect sources, such as nonspecific alterations of auditory feedback (masked and delayed auditory feedback) and functional neuroimaging. Hence the support remains circumstantial and subject to alternative interpretations. The objective of this study is to use an improved method based on real-time manipulation of auditory feedback to directly investigate whether the speech motor system of a PWS utilizes auditory feedback abnormally during articulation, and if so, detail the specific deficits of this auditory-motor interaction. Methods: Fifteen otherwise healthy adult PWS (including 3 females) were recruited and screened by a speech-language pathologist (D.S.B.). Age- and sex-matched fluent speakers were recruited as controls. By using a short-latency (~11 ms) formant-perturbation system (Cai et al. 2010), we examined auditory-motor interaction in the speech production of the PWS and controls during both static and time-varying portions of stimulus utterances. In the static paradigm, participants produced the monophthong [ε] embedded in monosyllabic words (e.g., "head") as their auditory feedback of the first formant frequency (F1) of the vowel was shifted up or down by 20% in randomly selected 25% of trials. In the time-varying paradigm, participants produced the multisyllabic utterance "I owe you a yo-yo" while the auditory feedback of the second formant frequency (F2) was perturbed in two ways that specifically manipulated the magnitude or timing of the F2 trajectory. Results: Under the static perturbation and the time-varying magnitude perturbation, the controls made small but significant online compensatory adjustments to their produced formant values in the direction opposite to those of the perturbations. Controls also responded to the time-varying temporal perturbation by significantly delaying or advancing the timing of their productions in the same directions as the perturbations. The PWS showed compensating responses to the static and time-varying magnitude perturbations, and the magnitude and latencies of these responses were similar to those of the controls. However, the PWS showed timing adjustments significantly less than controls under the time-varying temporal perturbation. In particular, under a perturbation that slowed the evolution of the F2 trajectory in auditory feedback, PWS did not slow down their production as much as the controls. Conclusions: The results from the control participants indicate that auditory feedback is utilized in the online control of both the spatial and temporal parameters of articulatory movements. PWS appear to utilize auditory feedback normally for online articulatory motor control of spatial magnitudes, but show deficits in the adaptive timing component of the control process. These findings provide further insights into the dynamic nature of the speech-motor deficits in stuttering (Ludlow and Loucks 2003) and call for revisions and refinements to models of auditory-motor interaction for this disorder (Civier et al. 2010; Hickok et al. 2011).

A38 Auditory feedback masking in apraxia of speech: Neural correlates of increased speech fluency ***Jacks, A.*** *(1),* ***Haley, K.L.*** *(1),* ***Roth, H.L.*** *(1); 1. The University of North Carolina at Chapel Hill* – Apraxia of speech (AOS) is a disorder of speech motor programming, usually resulting from left posterior inferior frontal cortex damage. Evidence suggests that the critical deficit in AOS is one of feedforward motor control, with relatively spared feedback control, as conceptualized in the DIVA theoretical framework. One prediction from this model of AOS is that affected individuals excessively attend to auditory feedback of their own speech, attempting to self-correct speech errors and that this may be causing a halting, disfluent speech pattern. Masked auditory feedback is known to reduce disfluencies temporarily in persons who stutter. A handful of studies have tested speech masking in participants with "nonfluent" aphasia, with some showing positive responses (i.e. improved speech) and others showing no response. Discrepancies in the previous studies may have resulted from differences in participant selection, with a positive response for individuals with AOS, and no response for those without AOS. The purpose of the present study was to investigate the effects of auditory masking on speech production

in individuals with AOS and/or aphasia, and to investigate the relationship between the masking response, presence of apraxia, and structural lesion characteristics. Method. Six adults participated in the study, including three individuals with apraxia of speech, determined on the basis of a motor speech exam. Aphasia profiles were determined by administration of the Western Aphasia Battery. Masked auditory feedback was tested using an ABA single subject design paradigm, replicated across participants. Speech-shaped noise was delivered via foam-tipped earphones at 85 dB during the "B" phase. Digital images of previously acquired brain scans (T1, T2, and FLAIR) were obtained, deskulled, and registered to MNI space using FLIRT as well as unified registration via SPM. Initial lesion tracings were made by the first author (AJ) and confirmed by the third author (HR). Results. Four participants showed a positive response to masked auditory feedback, with two or more of the following changes: increased speech rate (syllables/second), decreased inter-syllable pause duration, and decreased ratings of disfluency. Three of the four responders had AOS, while the two participants without a positive response to masking had mild anomic aphasia and no AOS. Preliminary results of the MRI results show common lesion areas for all responders in a large area in left inferior posterior frontal cortex, including a large portion of anterior insula and extending to Brodmann's area 44, spanning inferior pre- and post-central gyri. The two non-responders had smaller lesions not affecting these areas. Discussion. At this stage of the research, results suggest that a positive response to masking is linked more to overall lesion load and possibly a lesion locus in left inferior frontal cortex. Continued research is needed, including a larger population of individuals without AOS to determine the specificity of this response to individuals with a particular behavioral diagnosis. Nevertheless, the current results are consistent with the hypothesis that masking reduces maladaptive cortical activation associated with excessive attention to errors, potentially freeing up neural resources for more fluent speech production.

A39 Neural substrates of short and long-term repetition priming of naming in aphasia ***MacDonald, A. D.*** *(1),* ***Heath, S.*** *(1),* ***McMahon, K. L.*** *(1),* ***Angwin, A.*** *(1),* ***Nickels, L.*** *(4), and* ***Copland, D. A.*** *(1); 1. The University of Queensland, Brisbane, Australia; 2. Macquarie University, Sydney, Australia* ry effect on subsequent naming in persons with aphasia (PWAs) and healthy adults, however, the neurocognitive mechanisms involved are unclear. We examined the neural correlates underpinning short and long-term naming facilitation on an overt picture naming task in 5 PWAs [mean age 55 (range 39-66)] at least 2 years post-stroke and 18 controls [age 54 (38-66)]. PWA stimuli consisted of two sets of pictures (Long-term facilitation, LTF; Unknown, UN) unable to be named at baselines, and one set (Known) consistently named at baselines. Prior to fMRI, all participants completed 2 sessions during which LTF items were presented on 3 occasions for overt naming. During fMRI, all stimuli were presented for overt naming, however, UN items were presented twice thus creating an additional set (short-term facilitation; STF). Uncorrected whole brain individual analyses for PWA ($p < 0.01$) and control groups ($p < 0.001$) are reported (voxels > 20). For controls, in comparison to Known items, LTF was primarily associated with increased bilateral precuneus activity and decreased left inferior temporal and left inferior frontal activity. STF was also associated with increased precuneus activity with additional increases in both right MFG and SMG; decreased activity was found in left DLPFC. These BOLD changes suggest that both LTF and STF involve increased engagement of precuneus-based visuospatial imagery, episodic memory, and attention while LTF may additionally involve semantic-phonological processes. For PWAs, in comparison to Known items, LTF was most consistently associated with increased (left) precuneus activity, similar to that seen in controls; no consistent decreases were observed across PWAs. Compared to unknown items, patterns of activation associated with LTF were mixed across PWAs: (a) increased PFC, precuneus and right middle-superior temporal activity, or (b) decreased bilateral temporal lobe activity. When directly comparing the first presentation of UN items with their second presentation, STF was associated primarily with increased inferior-middle temporal activity and increased precuneus activity. The results suggest similar visual object processing mechanisms may underpin LTF in PWAs and controls, however, such mechanisms may play a greater role for some PWAs than others, possibly due to variability in lesion location, and others may rely more on semantic mechanisms.The results for STF in PWAs suggest a combination of visual object processing and lexical-semantic mechanisms may underlie this effect.

A40 A neurocognitive perspective on Specific Language Impairment: New evidence and the Procedural Deficit Hypothesis ***Pullman, M. Y.*** *(1),* ***Pierpont, E. I.*** *(2),* ***Ullman, M. T.*** *(1); 1. Georgetown University, 2. University of Wisconsin-Madison* – In 2005 we advanced a brain-based conceptualization of Specific Language Impairment (SLI), a developmental disorder affecting language that occurs in about 5% of children. We proposed that SLI can be largely explained by abnormalities of brain structures underlying the procedural memory system, in particular frontal/basal-ganglia circuits, especially in Broca's region and the caudate nucleus (Ullman & Pierpont, 2005). We argued that this pattern of brain abnormalities, which may be caused by various etiologies, results in deficits of the various language and non-language functions that depend on these neural substrates, but that declarative memory and its neural substrates remain largely unaffected. Since 2005, a new body of brain and behavioral research has been published that tests this Procedural Deficit Hypothesis (PDH). Here, we present a systematic review of this recent evidence, focusing on neuroimaging and ERP studies, as well as behavioral experiments examining procedural memory and declarative memory. In particular, we present a quantitative analysis of the proportion of SLI subject groups, across all studies, that have shown abnormalities of major cortical and subcortical brain structures. Overall, the research

suggest the following. The basal ganglia and frontal cortex are particularly affected in SLI, especially left motor regions, Broca's region, and the caudate nucleus. ERP studies of language in SLI indicate that individuals with SLI often elicit abnormal anterior negativities (ANs), which reflect automatic syntactic processing, but show largely normal N400s, which reflect lexical/semantic processing, with a mixed profile for the P600, which is involved in controlled syntactic processing. Moreover, in some cases syntactic processing in SLI leads to N400s instead of ANs, suggesting compensation by lexical/declarative memory. Finally, behavioral studies of procedural and declarative memory show consistent impairments of procedural but not of declarative memory: all studies that have examined procedural memory in SLI find impairments; in contrast, tests of declarative memory consistently find normal performance in the visual domain, with impairments in the verbal domain disappearing when working memory and language deficits are controlled for. Overall, the evidence supports the PDH, and suggests further theoretical refinements as well as avenues for future research.

A41 ADHD and language impairment: A new perspective on comorbidity ***Tagarelli, K. M.*** *(1),* ***Pullman, M. Y.*** *(1),* ***Ullman, M. T.*** *(1); 1. Georgetown University, Washington DC* – Attention-deficit/hyperactivity disorder (ADHD), the most common developmental disorder in children, co-occurs with language deficits at rates as high as 90%. Various accounts have been posited for this high comorbidity of ADHD with language impairments (including Specific Language Impairment; SLI). These include behavioral links between the disorders (inattention to the input leads to language impairments), and even a lack of any caUSlity between them. While these and other explanations may help to partially account for the observed comorbidity, we argue that they are not sufficient. We suggest a new hypothesis: abnormalities in frontal/basal-ganglia and/or frontal/cerebellar circuits in ADHD affect not only those portions of the circuitry responsible for the core deficits of ADHD, but also likely extend to other, parallel, portions of the circuitry, including those involved in language. Specifically, we predict impairments of grammar, including of syntax and morphology (which are posited to depend on those portions of the circuitry that underlie procedural memory) and lexical retrieval (thought to depend on nearby circuitry), as well as other, non-linguistic, functions that depend on this circuitry. That is, just as Ullman and Pierpont (2005) posit that SLI is not specific to language, we posit that ADHD is not necessarily specific to attention or hyperactivity. To examine this hypothesis, we present a systematic review of previous evidence from a wide range of neural and behavioral studies of ADHD. Overall, the evidence appears to support the predictions of this novel hypothesis for ADHD, which can be viewed as an extension of the Procedural Deficit Hypothesis (PDH) proposed for SLI. That is, individuals with ADHD tend to have impairments of both grammar (in particular syntax) and lexical retrieval, as well as of non-linguistic aspects of procedural memory, such as motor functions. In contrast, just as in SLI, declarative memory appears to be largely spared, and may even be enhanced. Finally, we make a number of testable predictions for future research, and suggest that the PDH is a useful paradigm for the further study of ADHD.

A42 Neural basis for category-specific semantic memory impairment in Alzheimer's disease ***Grossman, M.*** *(1),* ***Smith, E.E.*** *(2),* ***McMillan, C.T.*** *(1),* ***Cook, P.*** *(1),* ***Dreyfuss, M.*** *(1),* ***Bonner, M.F.*** *(1),* ***Bonner, A.*** *(1),* ***Buckholder, L.*** *(1); 1. University of Pennsylvania; 2. Columbia University* – Semantic memory is frequently impaired in Alzheimer's disease (AD). This often manifests itself as a category-specific effect for worse performance with natural kinds (NK) than manufactured objects (MO). The cognitive and neural basis for this deficit is unclear.We examined 24 patients (13 with AD and 11 with Mild Cognitive Impairment) and 14 healthy seniors (CON) on a simple task requiring judgment of a shared visual-perceptual feature for two printed objects (e.g. LEMON – BANANA: COLOR). We assessed color and shape in pairs of NK and MO (160 total trials) matched for imageability, frequency and familiarity. An ANOVA revealed a group X semantic category X perceptual feature interaction [$F(2,35)=3.52$; $p<0.05$]. T-tests showed that color and shape features of NK were more difficult for AD than CON; color features of MO also were more difficult in AD than CON, but AD judgments for shape features of MO did not differ from CON. These findings were related to cortical thinning in voxel-based morphometry (VBM) analyses of volumetric T1 MRI in 14 AD and MCI patients. We also obtained BOLD fMRI monitoring regional cortical activity in 18 CON while performing the same task. We found that patients are impaired for NK because their performance depends on brain areas critical for the task but are diseased. Regression analyses thus showed that judgments of NK were related to cortical thinning in inferior and ventral left temporal-occipital cortex (TOC) for shape and color in patients. This overlapped with areas of significant cortical thinning in patients relative to CON, emphasizing that these diseased areas are implicated in the patients' judgment difficulties. Finally, these significant regressions were encompassed by areas of TOC BOLD fMRI activation during the same judgments in healthy adults, emphasizing that these areas are critical for NK judgments. Regressions also related patients' NK judgments to cortical thinning in left prefrontal cortex (PFC), these regressions overlapped with areas of significant cortical thinning relative to CON, and these regressions were encompassed by areas of PFC BOLD fMRI activation judgments seen in CON. Patients are better in their judgments of MO because their performance depends less on diseased areas that are in cortical regions critical for task performance. Thus, there were minimal regressions relating MO of to cortical thickness in TOC and PFC, there was little overlap with diseased areas in TOC and PFC, and the overlapping areas we did observe were minimally encompassed by activated areas in TOC and PFC. These findings provide a neurobiological basis for the category-specific effect of worse performance with NK than MO in AD.

A43 ERP evidence for both similar and distinct cortical networks underlying semantic integration in adolescents with Specific Language Impairment ***Polse, L.*** *(1,2),* ***Sizemore, M. L.*** *(1,2),* ***Burns, E. L.*** *(2),* ***Evans, J.L.*** *(1,2); 1. San Diego State University/University of California San Diego Joint Doctoral Program, San Diego; 2. San Diego State University, San Diego* – It has recently been suggested that the pattern of syntactic, morphological, and phonological deficits seen in children with Specific Language Impairment (SLI) is consistent with abnormalities in the brain structures that support procedural sequential learning and memory; whereas lexical knowledge and the supporting declarative-memory system is not only spared in SLI, but may function as a compensatory learning mechanism for these children (Ullman, 2004; Ullman & Pierpont, 2005). N400 studies of lexical processing of words in sentences suggest that lexical semantic processing may differ for children with SLI compared to typically developing peers, however, and suggest that they may experience greater effort integrating lexical semantic information compared to their peers (Neville et al., 1993; Sabisch et al., 2006; C. Weber-Fox et al., 2010). Children as young as 5;0 evidence clear modulation of the N400 in lexical processing of words in sentences with behavioral accuracy being greater than 95% in both visual and auditory modalities (Holcomb et al., 1992), yet children with SLI are significantly less accurate in judging whether sentences make sense as compared to normal language controls regardless of whether sentences are in written or spoken formats (Neville et al., 1993; Sabisch et al., 2006; C. Weber-Fox et al., 2010). Ullman and colleagues argue that children with SLI may appear to have lexical semantic processing deficits if experimental conditions provide little or no contextual support and/or force children with SLI to rely heavily on their impaired procedural memory system (Ullman & Pierpont, 2006). In this study we ask if the N400 is modulated in a similar manner for school-aged children with SLI and typically developing peers when they correctly comprehended the questions. To ensure that the words are in the lexicons of children with SLI, we used the same simple declarative sentences used in Holcomb et al. (1992) that were modeled after those used by Kutas & Hillyard (1980) but with vocabulary appropriate to readers in first and second grade. Fourteen children with SLI and 14 typically developing, chronologically age-matched (CA) peers ages 11;11 – 18;11 participated. The same stimuli and procedures were used as outlined in Holcomb et al. (1992), consisting of 160 highly constrained sentences ranging from 3 to 13 words in length (e.g. Giraffes have long NECKS/SCISSORS). Electroencephalographic (EEG) data were acquired with the Electrical Geodesics Inc. (EGI) high-density array 128 channel system (v 4.3.1 Electrical Geodesics Inc., Eugene OR). Both groups were able to understand the sentence stimuli and attend to the task (behavioral accuracy for CA M = 97.92, SD = .016; SLI M = 95.61, SD = .041). No differences were observed in the modulation of the N400 for the two groups between 500-800 msec in frontal, fronto-central regions. However, differences were observed in the N400 for the two groups between 300–500 msec in anterior regions, and 500-800 msec in central regions. Results suggest that, despite normal behavioral performance, children with SLI may rely on both similar and distinct cortical networks to process lexical semantic information in sentences as compared to CA controls.

A44 An investigation of lexical-semantics in the semantic variant of Primary Progressive Aphasia: Monitoring eye-movements in a word-picture matching task ***Race, D.*** *(1),* ***Hillis, A.*** *(1); 1. Johns Hopkins University School of Medicine, Baltimore, MD* – Primary Progressive Aphasia (PPA) is a neurodegenerative syndrome that is characterized by a deterioration of language during the first 2 years of impairment (Mesulam, 1982). In the semantic variant of PPA (PPA-SV) patients have difficulty with word comprehension (e.g. word-picture matching) and production (e.g. picture naming), although other aspects of language such as syntax and articulation are relatively intact. We conducted a word-picture matching experiment that involved eye-tracking (design similar to Yee, Blumstein, & Sedivy 2008), to compare lexical-semantic processing between PPA-SV patients, patients with other variants of PPA (PPA-nonSV), and normal Controls. Specifically, we investigated whether PPA-SV performance suffers, compared to PPA-nonSV and Controls, due in part to a greater amount of interference from lexical competitors. We presented participants with a display of four pictures on a computer monitor (e.g. bee, mosquito, chair, hat).Clicking on a dot in the center of the display presented a sound-file of the target picture that the participant was to select.For experimental trials the display consisted of: Target (bee), Competitor (mosquito), and two unrelated pictures (chair, hat). We manipulated the relationship between the Target and the Competitor in three conditions (Coordinate, Associative, Linguistic). In the Coordinate condition (bee, mosquito), the features of Target and Competitor overlapped in both visual form and function. In the Associative condition (cow, farm), the Target and Competitor often appear together (e.g. cows tend to live on farms). Finally, in the Linguistic condition (butter, fly), the Target and Competitor are associated because they appear together in compound words (i.e. butterfly). The dependent variables were accuracy and the proportion of fixations to each picture. Fixations to each picture are expected to increase if the auditory presentation of the Target activates its representation. Specifically, we tested whether activation of the Target also activated the Competitor significantly more than the two unrelated pictures. For each condition, we compared PPA-SV performance with PPA-nonSV patients and Controls. Accuracy scores were high across groups (controls: 98%, PPA-nonSV: 93%, PPA-SV: 91%). For each condition, all groups had more fixations to the Target than to the Competitor and Unrelated pictures ($p < .05$). Both Controls and PPA-nonSV patients had more fixations to the Competitor than the Unrelated pictures only in the Coordinate condition ($p < .05$). In contrast, PPA-SV patients had more fixations to the Competitor in both the Coordinate and Associative conditions ($p < .05$). These results suggest that the

deficits in PPA-SV at least partially stem from increased semantic interference over the time-course of processing.Normal lexical-semantic processing involves some amount of interference, as evidenced by the Controls and the PPA-nonSV group in the Coordinate condition. However, as semantic representations deteriorate it may become easier to activate related items and also harder to suppress them once they are activated. In addition, this study highlights how on-line methods such as eye-tracking can at times provide a more sensitive measure of processing performance than accuracy alone.

A45 Error patterns in the Semantic Judgment Test differentiate semantic variant primary progressive aphasia (sv-PPA) from Alzheimer's disease (AD) ***Rascovsky, K.,*** *(1),* ***Libon, D.J.,*** *(2),* ***McMillan, C.T.,*** *(1),* ***Cook, P.A.*** *(1),* ***Dreyfuss, M.,*** *(1),* ***Bonner, M.,*** *(1),* ***Moore, P.,*** *(1),* ***Grossman, M.*** *(1); 1. University of Pennsylvania School of Medicine, Philadelphia, PA; 2. Drexel University College of Medicine, Philadelphia, PA* – **Objective:** To distinguish profiles of semantic impairment in semantic variant primary progressive aphasia (sv-PPA) and Alzheimer's disease (AD). Background:We evaluated the extent and pattern of semantic loss in sv-PPA and AD using a simple Semantic Judgment Task (SJT), where subjects judge the category membership of photo and printed word materials from familiar categories (vegetables, tools). Half the stimuli are targets and half foils; half the foils are semantically-related (e.g. "apple" for the category "vegetable"), and half semantically-unrelated (e.g. "chair" for "vegetable"). Design/Methods: We evaluated 57 AD, 16 sv-PPA and 39 healthy seniors (HS) matched for age and education. Patient groups had comparable dementia severity (AD-MMSE=21.4, sv-PPA-MMSE=23.1, p>.05). We used VBM analyses of MRI in 14 AD and 9 sv-PPA patients to evaluate grey matter atrophy associated with SJT performance. Results: AD and sv-PPA patients had lower SJT total scores than controls (AD=.86, SD=.80, HS=.94, p<.01), but patient groups did not differ significantly (p>.05). ANOVA revealed a significant group-by-foil interaction (p<.001). While AD patients had difficulty rejecting semantically related foils (p<.01), they performed normally with semantically-unrelated foils. Sv-PPA patients had difficulty rejecting both semantically-related and unrelated foils (both contrasts p<.01). This foil performance pattern was statistically significant for both categories and materials. Relative to HS, sv-PPA patients showed significantly reduced gray matter density in ventral and anterior aspects of the left temporal lobe, while AD patients showed most prominent disease in postero-lateral and medial temporal lobes bilaterally. Conclusions: Despite similar levels of overall SJT performance, foil-type analysis suggests different semantic profiles in sv-PPA and AD. AD patients have difficulty distinguishing category exemplars from semantically-related foils, arguing for deficits in the fine-grained distinction of semantically over-lapping word and picture meanings. In contrast, sv-PPA patients have a more pervasive semantic breakdown that limits their ability to distinguish between radically different concepts. These semantic profiles are associated with different patterns of temporal degeneration.

SPEECH PRODUCTION

A46 Persistent developmental stuttering as a disorder of neural adaptation ***Gracco V.L.*** *(1,2),* ***Frost S.*** *(2),* ***Mencl E.*** *(2),* ***Max L.*** *(2, 3); 1. McGill University, Montreal, QC, Canada; 2. Haskins Laboratories, New Haven, CT; 3. University of Washington, Seattle, WA* – Persistent developmental stuttering (DS) is a disorder with apoorly understood neural mechanism.A number of consistent neural symptoms are associated with DS including cortical grey and white matter changes in the left IFG, over-activation in motor areas, reduced temporal cortical activity and anomalous right-laterality. However, descriptive differences are difficult to synthesize and integrate into a coherent explanatory framework. Behavioural studies have suggested that DS reflects a problem in motor learning (Max et al., 1997; Max & Baldwin, 2010) based, in part, on the increased fluency (less stuttering) associated with reading repeated stimuli compared to novel stimuli. Here we attempt to better understand the brain activation differences using fMRI adaptation or repetition suppression (RS) to assess the ability of DS and non-stutterers (NS) to engage experience-related cortical dynamics associated with repeated stimuli. RS is associated with the mechanisms for priming (Henson 2003), implicit memory (Schacter et al., 2004) and skill learning (Poldrack & Gabrielli, 2001) and increased processing efficiency (Grill-Spector et al., 2006).In adolescent readers with reading disability, RS differences has been used to suggest a reduction in neural circuitry for reading and as a basis for performance differences (Pugh et al., 2008). Here we take a similar approach to determine whether the speech circuitry in DS is differently and poorly organized relative to NS. Eleven DS (9 males, 2 females) and eleven age and gender matched NS participated in the present investigation. We examined RS differences using 280 mid-frequency nouns during word reading using repeated and novel words (see Pugh et al., 2008 for details). Eight functional imaging runs were used in an event-related paradigm. On each trial a word appeared in the center of the screen and subjects were instructed to read the word aloud. Functional images were acquired on the 3 T Siemens scanner at the Yale University MRRC. The functional data were subjected to standard preprocessing steps. For single-subject event-related analysis, a regression-based method was used with the parameters used to create subject activation maps. Linear contrasts for evoked response of each trial type, simple subtractions among trial types, main effects, and interactions were applied to the regression estimates to obtain contrast images for each subject. Across subjects the contrast images were tested with a mixed-model or repeated measures ANOVA. Overall, DS and NS showed opposite RS effects in a number of cortical areas. In the left hemisphere of the DS group, precentral, middle frontal, and inferior frontal (BA 44/45/47) cortical areas increased activation with repetition compared to a decrease for the NS. A similar reversal of the RS pattern was found bilaterally in MTG, in the left

SPL, the left and right somatosensory cortex, the left uncus and in the right middle and inferior occipital and fusiform regions. The results suggest DS is a problem with sensorimotor integration and processing efficiency leading to motor learning and consolidation difficulties and suggests a conceptual framework in which the aberrant neural adaptation explains and integrates a wide array of brain and behavioural differences associated with persistent DS. Max L, Caruso A, Vandevenne A (1997) J Fluency Dis, 22, pp. 17-34. Max L, Baldwin C (2010) J Fluency Dis, 35, pp. 33-43. Henson RN (2003) Prog Neurobiol, 70, pp. 53-81. Schacter DL, Dobbins JG, Schnyer DM (2004)Nat Rev Neurosci, 5, pp. 853-862. Poldrack RA, Gabrielli JDE (2001) Brain, 124, pp. 67-82. Grill-Spector K, Henson R, Martin A (2006) Trends Cog Sci, 10, pp. 14-23. Pugh KR, Frost SJ, Sandak R, Landi N, Rueckel JG, Constable RT, Seidenberg MS, Fulbright RK, Katz L, Mencl WE (2008) J Cog Neurosci, 20, pp. 1146-1160.

A47 Variable patterns of BOLD signal changes in the recovery of chronic anomia: An fMRI study ***Magon, S.**, (1), **Basso, G.**, (1), **Capasso, R.**, (1,2), **Gandolfi, M.**, (3), **Florio, E.**, (1), **Smania, N.**, (3), **Miceli, G.** (1); 1. Università di Trento, Italia; 2. Fondazione Santa Lucia IRCCS, Roma, Italia; 3. Università di Verona, Italia* – **Objective:** Residual language functions and the improvement of linguistic deficits in chronic aphasia, both spontaneous and induced by treatment, are increasingly studied in fMRI investigations, in an effort to provide a generalized account of the neural mechanisms underlying language recovery. The results of these investigations are heterogeneous, but there is consensus on the view that in chronic aphasia recovery correlates with perilesional activation, and that contralesional activity may be irrelevant, or even maladaptive. The present study investigates the BOLD signal changes observed in three subjects with chronic aphasia, who completed a phonological training procedure aimed at ameliorating pure anomia. Materials and Methods. Participants were strong right-handers, who had suffered from ischemic damage to the anterior branches of the middle cerebral artery at least 4 years prior to participation in the study. They presented with pure anomia (ie, with word retrieval failures in the face of normal comprehension for items they could not name) in the context of non-fluent, agrammatic aphasia. Before starting participation in the experimental training protocol, each subject was asked to name three times a set of 300 black-and-white drawings, on separate occasions. Based on performance on this preliminary task, a custom-made naming test was prepared for each participant. The test included 20 easy items, that the subject had always named correctly, and 40 difficult items, that the subject had consistently failed to name, but had consistently comprehended in the context of word-picture verification tasks. The 40 difficult items were divided in two subsets, matched for the main psycholinguistic variables. Twenty difficult items were trained, and 20 served as controls. The entire set of 60 drawings was presented before and after training, during fMRI sessions. The training procedure consisted of 10 speech therapy sessions (60-90 minutes each), during which the subject was asked to name color pictures of the 20 difficult items targeted by treatment, 10 times per session. During training, graded phonological cues were presented to facilitate naming. Results. Before training, in all subjects naming easy items activated perilesional regions. After treatment, in all subjects trained items were named with significantly greater accuracy, and yielded a significant increase of the BOLD signal relative to untrained items. However, different patterns of post-training activation were observed. In one subject, changes were entirely perilesional. In another subject, they occurred perilesionally and in midline structures (precuneus and posterior cingulate cortex). In the third subject, they were entirely contralesional. Conclusions. These results show that, even when subjects with similar lesions are selected, the neural correlates of recovery vary across a wide range, and that in different participants BOLD signal changes related to recovery can involve perilesional language areas; right-hemisphere homologues of language areas; and areas that are not part of the language network. In addition, data from our third participant show that the role of the right hemisphere is not necessarily maladaptive, even in chronic aphasia.

A48 Speech Mirroring to Treat Non-fluent Aphasia ***Fridriksson, J.** (1), **Hubbard, H.I.** (1), **Hudspeth, S.** (1), **Floyd, B.** (1), **Holland, A.** (2); 1.University of South Carolina; 2.University of Arizona* – **Introduction:** Non-fluent aphasia is marked by very limited speech output but relatively spared auditory comprehension. Once in the chronic stage, non-fluent aphasia rarely progresses to become fluent (and less severe) aphasia. This study examined the effect of a novel treatment approach, audio-visual script training (AV-ST), in a group of patients with non-fluent aphasia. AV-ST relies on providing an AV model in real time presented via an iPod where the mouth of a speaker can be seen on the screen and the speech is heard via attached headphones. What is striking about AV-ST is that most non-fluent patients whose speech repetition is very poor, even those with who are almost completely mute, can produce fluent speech while getting real-time AV feedback (coined here 'speech mirroring'). In addition to examining the therapeutic effect of AV-ST in non-fluent aphasia, we also examined the neural substrates of fluent speech production in the presence of AV-ST in the same aphasic patients and a group of normal controls. **Methods:** Twelve patients with Broca's aphasia underwent AV-ST for script training for six weeks where three separate scripts were trained. Each script lasted approximately 90 seconds and only the mouth of the speaker was visible on the iPod screen while the speech was heard via headphones. Participants practiced each script for 30 minutes per day. Script probes (with and without the iPod) were administered once a week during treatment as well as before and after the treatment period. An untrained script was also assessed to further probe generalization. Nine patients and 13 older normal control participants underwent fMRI. Each participant was scanned during three separate fMRI runs (using sparse sampling): 1) watching and listening to speech; 2) speech mirroring; and 3) watching real time speech but listening to

backwards speech while producing a speech at the same time ('free speech condition'). **Results**: All 12 patients completed all training aspects of the study. A comparison of pre- and post-treatment performance revealed that most patients improved production of the scripts with and without AV feedback. A subset of patients also improved their speech during production of the untrained script suggesting generalization that is not script specific. The fMRI results revealed widespread activation for the contrast 'speech mirroring'>'watching and listening only' as well as for 'free speech'>'watching and listening only' among both patients and normal control participants (Figure 1). The greatest difference between these two comparisons was found in the right anterior insula-BA47 junction for the patients (blue circle in Figure 1). The same comparison in the normal participants revealed similar results, albeit, in the left hemisphere (orange circle in Figure 1). Discussion. Our findings suggest that AV-ST is a promising approach to improve speech production in non-fluent aphasia. Moreover, it seems that speech mirroring, the foundation for AV-ST, relies on brain regions including the most rostral part of the insula and the inferior caudal part of BA 47.

A49 The Phonological Facilitation of Naming in Aphasia - Its Neurocognitive Mechanisms and Longevity

Heath, S.*(1),* ***McMahon, K.*** *(1),* ***Nickels, L.*** *(2),* ***Angwin, A.*** *(1),* ***MacDonald, A.*** *(1),* ***van Hees, S.*** *(1),* ***Copland, D.*** *(1); 1. University of Queensland, Brisbane, Australia; 2. Macquarie University, Sydney, Australia*

– **Objective:** Phonological tasks can facilitate subsequent picture naming in individuals suffering from aphasia post-stroke, however, the neural mechanisms underlying these techniques are not well understood. Although purportedly targeting the phonological stage of word retrieval, it is argued that both phonological and semantic processing may occur. Debate also surrounds the longevity of these effects and the role of the right hemisphere, particularly in the context of neural recovery and plasticity. The current fMRI study aimed to investigate the short and long-term effects of a phonological task on naming in healthy older adults and individuals with aphasia. Methods: Six individuals (5 female, AV 57.6 years) with chronic aphasia and fifteen controls (10 female, AV 56.5 years) participated. Three naming conditions of interest were presented during a single fMRI scanning session. One week prior to the scan, all participants completed two separate facilitation sessions, during which one set of pictures was presented simultaneously with its auditory name, requiring overt repetition. In the scanning session, this set of items was presented again for overt naming to investigate long-term facilitation (over days). A second set was presented in the scanner once with the auditory word form for repetition, and later for overt naming, to investigate short-term facilitation (over minutes). A third set of unfacilitated pictures was also presented during the scanning session. Results: For controls, both short- and long-term facilitated items were named faster and more accurately than unfacilitated items, with short-term items faster and more accurate then long-term items. Whole brain analyses ($p<0.001$ uncorrected) identified a decrease in activation for facilitated items in regions associated with both phonological and semantic processing. Decreased activation for long-term items was identified in bilateral superior temporal gyri (short-term > long-term) and in the left middle and inferior temporal gyri (unfacilitated > long-term). Decreased activation for short-term items was identified in the left inferior parietal region (long-term > short-term) and the left inferior temporal gyrus (unfacilitated > short-term). All participants with aphasia showed a significant positive change in accuracy performance following facilitation for both short- and long-term items when compared to unfacilitated items. The patient group whole brain analyses showed decreased activation for long-term items in the right inferior frontal gyrus (unfacilitated > long-term). A decrease for long-term items was also identified in the left inferior parietal region when compared to both short-term and unfacilitated items (surviving small volume correction). Conclusions: In controls, phonological facilitation over the short- and long-term modulated activity in temporal and parietal regions linked to phonological and semantic processing. Individuals with aphasia showed more targeted facilitation over the long-term with recruitment of neural regions known to be associated with phonological processing, in particular the inferior parietal region. This region was preserved in the majority of participants with aphasia and implicated in short-term facilitatory effects in the control group. These results suggest that enduring facilitation of naming by a repetition task may be driven by more efficient phonological processing in preserved left-hemisphere language-related regions in participants with aphasia.

A50 Neural Correlates of Improvisation, Autobiography, and Social Interaction: An fMRI Study of Narrative Production

AbdulSabur, N.*(1,2),* ***Xu, Y.****(1),* ***Erkinnen, M.****(3),* ***Braun, A.R.****(1); 1. National Institutes of Health, NIDCD, Bethesda, MD; 2. University of Maryland, College Park, MD; 3. Darthmouth Medical School, Hanover, NH*

– Spoken narrative production – storytelling – is a complex, common behavior the neural correlates of which are still poorly understood.In this study, we examine the patterns of cerebral activity associated with of some of its essential features including extemporaneity, sociality and autobiography.Sixteen healthy right-handed adult subjects produced a series of stories 40 seconds in duration while BOLD functional magnetic resonance imaging data were collected. All of the stories fit into three types: rehearsed fiction, improvised fiction, and autobiographical narratives.Each story type was further subdivided into versions that either did or did not involve social interaction between characters (i.e. two vs. one character stories). Nursery rhyme recitation (NR) was used a non-discourse baseline.Data were analyzed using general linear model (GLM) techniques after preprocessing to remove susceptibility artifact and global signal changes associated with continuous speech.When all narratives were contrasted with NR, we detected a pattern of activation that included left-lateralized, perisylvian brain regions traditionally associated with language, as well as extrasylvian areas and subcortical brain regions known to be recruited at the discourse level.When production of

improvised fiction was compared to retelling rehearsed stories we found that improvisation was associated with selective activation of the medial prefrontal cortex and concomitant deactivation of the dorsolateral prefrontal cortices in both hemispheres, a pattern also seen during spontaneous musical improvisation.In this case, activation of the MPFC was accompanied by activation of the posterior cingulate/retrosplenial cortex (PCC/RSC), bilateral medial temporal lobes, and bilateral inferior parietal lobule (IPL), regions typically linked to mentalizing, and often referred to as the default mode network (DMN).Additionally, the posterior portions of this network, the PCC/RSC and IPL, were significantly more active during stories that involved social interaction than those that did not.Interestingly, when improvised fiction was contrasted with production of autobiographical narrative the only difference detected was increased activity in a small focus in the left parahippocampal gyrus for autobiography. When both conditions were compared to rehearsed stories, the patterns were virtually identical suggesting that creation of fiction and autobiographical recall engage the same neural mechanisms. These findings constitute an initial step toward understanding aspects central to ecologically valid discourse production and suggest patterns of brain activity that may underlie creative behavior. Future studies should contribute to the development a more coherent model of these processes.

A51 Investigating the neural basis of individual susceptibility to speaking under delayed auditory feedback ***Agnew, Z.K.*** *(1),* ***McGettigan, C.*** *(1),* ***Banks, B.*** *(1),* ***Scott, S.K.*** *(1); 1. UCL ICN, Alexandra House, London* – Speaking under delayed auditory feedback results in dysfluent speech, which manifests itself in a range of speech errors. Neuroimaging studies have demonstrated that speaking under delayed auditory feedback (DAF) conditions elicits activity in bilateral dorsolateral temporal cortices, and motor regions. Many factors influence behavioral performance under DAF conditions, for example length of the delay. Interestingly there is considerable variability in how susceptible people are to the effects of DAF however, it is unclear what the cognitive or neural basis of this variability is. This is the first functional MRI study to look at the neural networks underlying individual variability in ability to cope with producing speech under delayed auditory feedback. Functional MRI was used to look at neural activity during speech production with (i) normal feedback (ii) a 200ms delay and (iii) 50ms delay. Speech produced under delayed auditory feedback was assessed for normality by naïve subjects. Performance ratings were used as parametric modulators in order to look at network activity associated with individual variability. Subject ratings of sentences provides a novel way to assess speech production and revealed a high level of variability across subjects. Speech produced under normal feedback conditions was rated as significantly different to that produced under DAF conditions. Reading aloud under both delayed auditory feedback conditions was associated with significant activity in superior temporal, inferior parietal and premotor cortices in both hemispheres. When compared to reading under normal conditions this activity was restricted to bilateral mid and posterior superior temporal gyri. Activity of cells in this region has previously thought to reflect the activity of error cells however, we demonstrate significant activity in superior temporal gyri even when performance was added in as a regressor of no interest. An effect of increased delay was seen in right superior temporal and inferior parietal cortex confirming previous data. Using individual performance ratings as a parametric modulator, these data indicate that an ability to produce normal speech under a 200ms delay was associated with increased activity in ventral motor cortex and superior temporal gyrus in the right hemisphere. These data demonstrate that both auditory and motor cortices are recruited in order to produce fluent speech under a temporal delay of 200ms. Implications for current models of speech production are discussed.

A52 Speech sensory motor transformations occur bilaterally in the dorsal stream ***Cogan, G. B****. (1),* ***Thesen, T.*** *(2),* ***Carlson, C.*** *(2),* ***Doyle, W. K.*** *(2),* ***Devinsky, O.*** *(2),* ***Pesaran, B.*** *(1); 1. New York University, NY; 2. NYU Langone Medical Center, NY* – An important goal of the speech perception/production system is achieving parity between acoustic sensory inputs and motor production outputs.This transformation to a common representation is important as both speech perception and production need to have access to a centralized language faculty.Recent models of speech perception have posited a distinct role for a left-lateralized dorsal processing stream: mapping input - sensory information (perception) onto output - motor plans (production).The most recent model (Hickok & Poeppel 2007) divides this stream into two components: an articulatory network for production itself (left posterior inferior frontal gyrus, left premotor cortex, and left anterior insula) and a sensory motor interface that performs transformations from the perceptual input to the production output in the left temporal parietal boundary (SPT). Here, using intracranial electroencephalography (iEEG), we demonstrate that sensory motor transformations occur throughout the dorsal stream and these transformations occur in the dorsal stream bilaterally. Seven patients with pharmacologically resistant epilepsy were sub-durally implanted with an 8 x 8 electrode array (1 cm spacing; Adtech) either in the left (3 subjects) or the right (4 subjects) temporal-frontal / temporal-parietal regions. Patients performed a simple listen-repeat task, with a delay between listen and repeat of 2 seconds. Stimuli were composed of 7 auditory CVC syllables. There were 2 control conditions: just listen, and listen and mime the words. The listen-mime condition was included to rule out effects due to the auditory output of the repetition on the neural signals. We found that significant activation occurred in the high gamma region (70-90 Hz) for sensory motor transformations and this activity occurred bilaterally (i.e. in all subjects - a total of 27 electrodes) in the posterior temporal region (bilateral posterior superior temporal gyrus, supramarginal gyrus and area SPT), in the premotor cortex and the somatosensory cortex, as well as the inferior frontal gyrus. Furthermore, for one subject (left implant),

strip electrode activation over the right premotor cortex also showed significant sensory motor activity (2 electrodes), giving stronger evidence for bilateral sensory motor transformations. For 25/27 (~93%) of these electrodes, there was also significant activity in the just listen condition, suggesting that these regions are also involved in speech perception. Taken together, these results demonstrate, for the first time, that the speech dorsal stream exists bilaterally and that sensory motor transformations occur throughout the entire dorsal stream. These results contrast with current models that posit a single left lateralized region (SPT) for sensory motor transformations and a lateralized dorsal stream and also validate a role for the dorsal stream as an interface between speech perception and production.Taken together, the distributed nature of sensory motor transformations could facilitate a broader interface with different aspects of language processing.

Poster Session B

Thursday, November 10 3:20 - 4:50 pm
Senate, Capitol C, and Capitol C Pre-Function

SPEECH PERCEPTION

B1 Acquisition of frequent syllabic sensory and motor patterns within a neurocomputational model of speech processing ***Eckers, C.*** *(1),* ***Kannampuzha, J.*** *(1),* ***Heim, S.*** *(1, 2),* ***Kröger, B. J.*** *(1); 1. University Hospital Aachen and RWTH Aachen University, Aachen, Germany; 2. Research Center Jülich, Institute of Neuroscience and Medicine (INM-1), Jülich, Germany* – **Motivation:** A neurocomputational model of speech processing is proposed. This model aims for a quantitative description of cognitive and sensorimotor aspects of speech production, speech perception, and speech acquisition. The model comprises two self-organizing neural maps (Fig. 1). A semantic map (S-MAP) is capable of activating semantic representations of words (mental lexicon, see [1]), while a phonetic map (P-MAP) is capable of activating phonological, sensory, and motor representations of syllables (mental syllabary, see [2]). An articulatory-acoustic model allows the acoustic realization of syllables, words, and short utterances. Hypotheses: It is assumed that the P-MAP is capable of acquiring the phonemic and sensorimotor representations of the most frequent syllables of a specific language (here: the 200 most frequent syllables of Standard German) using standard self-organizing map training procedures (standard SOM-training). Experiment: On the basis of a children's book data base for Standard German (6513 sentences, 70512 words in total), the 200 most frequent syllables were selected. 200 sentences comprising these syllables were uttered by one speaker (male, 35 years old) and imitated by the articulatory-acoustic model. The phonological and the resulting motor, somatosensory, and auditory representations were used as a basis for an associative standard SOM training. Syllable representations were applied to the SOM with respect to the frequency of their occurrence within the data base. Results: A 25x25 neuron-sized self-organizing P-MAP is sufficient in order to represent all 200 syllables. 5000 incremental training cycles were used and each syllable is represented within each training cycle with respect to its frequency. Within the P-MAP an ordering of syllables with respect to phonetic-phonological features emerged ("phonetotopy"; e.g. CV-, CCV-, CVC-syllables occur in different regions of the P-MAP; CV-syllables are ordered with respect to different consonant features like plosive or fricative; for one specific consonant, a CV-region also indicates an ordering with respect to vowel features, e.g. high vs. low, front vs. back etc.). Further work: Neuroimaging experiments are proposed (i) in order to identify the P-MAP, i.e. a brain region where syllable states are represented in a supramodal way and (ii) in order to underpin the hypothesis of the existence of a phonetotopic ordering of syllable states within the P-MAP. References: [1] Li, P., Farkas, I., and MacWhinney, B. (2004). Early lexical development in a self-organizing neural network. Neural Networks 17(8-9), 1345-1362. [2] Kröger, B. J., Kannampuzha, J., and Neuschaefer-Rube, C. (2009). Towards a neurocomputational model of speech production and perception. Speech Communication 51(9), 793-809. Figures: Figure 1: Structure of our neurocomputational model of speech processing. Light blue boxes indicate processing modules; dark blue boxes indicate self-organizing maps (S-MAP and P-MAP) and neural state maps (e.g. auditory or motor state map).

B2 Essential cortical sites for single word repetition in the posterior peri-Sylvian operculum identified by electrocortical stimulation ***Babiak, M.C.****(1),* ***DeLeon, J.*** *(1), and* ***Chang, E.F****. (1); 1. University of California San Francisco, CA* – **Background:** Classical disconnection theory in the Wernicke-Geschwind model posits that damage to the white matter tract, the arcuate fasciculus, disrupts communication between Wernicke's and Broca's area. While this is theorized to result in the selective inability to repeat words and phrases, known as conduction aphasia, little empirical data exists to support this claim. We directly test the hypothesis that repetition is cortically-mediated by inducing transient cortical inactivation by electrocortical stimulation mapping during awake neurosurgery. Methods. Seven patients undergoing awake craniotomy for speech and language mapping underwent a single word repetition task. Patients were instructed to repeat exactly what they heard (i.e., a word or pseudoword) following a short carrier phrase. A bipolar stimulating electrode was applied across successive perisylvian cortical sites (50Hz, 1.5-3mA,1-2 sec). Video recording of both the cortical stimulation and subjects' verbal responses was used for detailed analysis. Stimulation-induced errors were categorized as: no response, perceptual, speech arrest, motor-speech/phonetic, and phonological errors. Cortical sites that produced an error rate of 50% or more were deemed positive error sites. To further analyze phonological errors, words and pseudowords were broken into syllabic units and examined for substitution,

addition, and deletion of phonemes. Results. Fourteen discrete error sites (typically <1cm2 of cortical area) were identified, and were mostly clustered in the posterior perisylvian opercular region. Seven were in the superior temporal gyrus, two in the supramarginal gyrus (SMG), and five in the anterior inferior parietal lobe. A total of 188 stimulations were applied to the 14 positive error sites. Of these, 100 caused errors. Ninety-two percent of perceptual errors were within STG, while 80% of the phonological errors were within STG and SMG. The anterior inferior parietal lobe accounted for the majority of speech arrests. Motor speech and no response errors each accounted for less than 10% of overall errors. Thirteen of the 14 sites did not cause errors during counting, picture naming, or word comprehension tasks. Detailed analysis of phonological errors showed that as word length increased, percent correct of syllables decreased (~70% on syllable1, dropping to ~20-25% for each additional syllable). The percent of phonological substitutions (~15%) was similar across syllables, however the likelihood that an entire syllable was deleted substantially increased as syllable number increased (0, 26.9, 25.6, and 44.4% respectively). Multiple errors (i.e., substitution of both consonant and vowel phonemes) increased across word length and were maximal on syllable3 but then returned to the rate of syllable1 by the fourth syllable (11.5, 21.2, 25.6, and 11.1% respectively), suggesting an important role in processing greater word complexity or syllabic load. Conclusion. Our results provide direct evidence supporting selective processing for repetition in the posterior perisylvian cortex. These findings add to the growing evidence of a cortically-based etiology accounting for the repetition deficit in conduction aphasia.

B4 Visual Speech and Speech Production Rely on Separate Cognitive Networks: Evidence from Articulatory Suppression, the McGurk Effect and fMRI ***Matchin, W.**, (1), **Hickok, G.** (1); 1. University of California, Irvine* – Visual speech influences the perception of heard speech. A classic example of this is the McGurk effect, whereby an auditory /pa/ overlaid onto a visual /ka/ induces the fusion percept of /ta/. In addition to much work on the role of sensory systems and the posterior superior temporal sulcus on audiovisual speech, recent behavioral and neuroimaging research has highlighted the importance of motor speech representations and corresponding motor-related regions of the brain, particularly Broca's area. We investigated the role of motor speech representations in audiovisual speech integration in two experiments:1) A behavioral study that examined the effect of articulatory suppression on the McGurk effect, and 1) an fMRI study that examined, within subject the relation between activated networks involved in visual speech perception and motor speech articulation.The hypothesis regarding experiment 1 was that if articulatory representations are utilized in producing audiovisual fusion, then saturating the motor system with articulatory representations that are inconsistent with the fusion percept should prevent subjects from utilizing these representations for fusion. The results of experiment 1 showed that subvocal rehearsal of the syllables /pa/ and /ba/ during presentation of auditory /pa/, visual /ka/ resulted in no reduction (interference) of audiovisual fusion, suggesting that articulatory representations are not critical to produce the McGurk effect. Note that subjects articulated syllables either identical to or congruent in place of articulation with the auditory stimulus, presenting a strong test of the role of articulatory representations. The hypothesis of experiment 2 was that if the brain activation to visual speech in motor-related regions (such as Broca's area) represents the activation of articulatory representations, the patterns of activity for visual speech and subvocal rehearsal of speech sounds should be highly overlapping in this region. The results of experiment 2 demonstrate that while some of the activity for visual speech in motor speech regions can be accounted for by articulatory representations, much of the activity in Broca's area, particularly in anterior and superior regions of the inferior frontal cortex, does not overlap between the two conditions. The results suggest that visual speech and subvocal rehearsal activate different networks of brain regions, and that the activity generated in these regions to visual speech does not reflect the activation of a motor speech representation. The combined results suggest that speech production and the perception of visual speech are processed by separate mechanisms.

B5 On the role of the dorsal auditory stream: syllable onset complexity in speech perception and speech production ***Deschamps, I.** (1), **Gracco, V.** (1, 2), **Baum, S.** (1); 1. McGill University, Montreal, Canada; 2. Haskins Laboratories, New Haven, Connecticut* – In recent years, numerous neuroimaging studies have reported activation clusters surrounding the superior temporal plane in the vicinity of the parietal-temporal junction during both speech perception [1] and speech production [2] tasks.These findings have been interpreted as suggesting that this region is involved in the processing of sensorimotor information [3] associated with phonological codes [4].The objective of this study was to investigate the role of modality of stimulus presentation and phonological complexity during both speech perception and speech production within these regions.To this aim, we used both visual and auditory pseudowords that varied in terms of phonological complexity. We manipulated the sonority values associated with word initial consonant clusters.Pseudowords were used to eliminate lexical effects.Hypothesis: We hypothesized that regions within the posterior superior temporal plane associated with phonological processing would show similar patterns of activation for both visual and auditory stimuli as the processing of phonological codes should be modality independent.We also predicted an increase in activation within these regions for more phonologically complex stimuli during both speech perception and speech production. Data acquisition: Data were acquired on a 3T Siemens Trio MR scanner.A clustered sparse volume temporal acquisition paradigm was used in order to eliminate movement artifacts. A silent period (4.04s) was interleaved between each cluster of volumes

(TE=30ms, TR=8.08s, delay in TR 4.04s, whole brain coverage), during which participants were instructed to respond.Analyses: The results from the whole group analysis demonstrated an increase in activation for more phonologically complex stimuli in regions along the posterior superior temporal plane during both speech perception and speech production.To further investigate the role of these regions within the posterior superior temporal plane, anatomically-based ROIs will be defined.We will extract ROIs for the following regions: bilateral planum temporale, inferior parietal lobule, supramarginal gyrus and superior temporal gyrus.Our results will help clarify the role of these regions in processing phonological codes during both speech perception and speech production.References: [1] Binder, J. R., Frost, J. A., Hammeke, T. A., Rao, S. M., & Cox, R. W. (1996). Function of the left planum temporle in auditory and linguistic processing. Brain, 119 (Pt 4), 1239-1247. [2] Buchsbaum, B. R., Hickok, G., & Humphries, C. (2001). Role of left posterior superior temporal gyrus in phonological processing for speech perception and production. Cognitive Science, 25, 663-678. [3] Hickok, G., & Poeppel, D. (2007). The cortical organization of speech processing. Nature Reviews Neuroscience, 8(5), 393-402. [4] Okada, K., Smith, K. R., Humphries, C., & Hickok, G. (2003). Word length modulates neural activity in auditory cortex during covert object naming. Neuroreport, 14(18), 2323-2326.

B6 Feedforward vocal predictions characterized by speaking-induced suppression of auditory cortex ***Niziolek, C.*** *(1),* ***Nagarajan, S. S.*** *(1),* ***Houde, J. F.*** *(1); 1. UCSF, San Francisco, CA* –Speakers use auditory feedback to control their productions, making adjustments when the observed feedback fails to match what was intended.Evidence for the comparison of intended and observed auditory signals includes event-related potential studies showing a suppressed auditory response to self-generated speech compared with playback of the same speech signal.This speaking-induced suppression, or SIS, is thought to reflect a partial neural cancellation of incoming sensory feedback as it is matched to predicted feedback.The source of the auditory prediction, however, is still under debate: it could be generated by a forward model (motor efference copy), reflecting the expected sensory consequences of outgoing articulatory commands, or it could be represented by an internal vowel target, reflecting desired sensory consequences. Vowel production variability enables us to test these alternatives without using artificial formant perturbations, allowing for a more ecological assay of how potential errors are corrected in natural speech.In this study, we used magnetoencephalography (MEG) to examine how SIS varied over repeated productions of the same vowel. We compared the SIS of the productions nearest to the vowel's median formants with the SIS of the more outlying productions. If incoming sensory feedback is compared with an internal target, the two signals will match perfectly only for productions that hit that target; therefore, we should expect less SIS for outlying productions, which are farther from the hypothesized target (i.e., the median).However, if feedback is compared with a forward model prediction that encompasses production variability, we should expect no difference in SIS between near-median and peripheral productions. Subjects produced vowels in the MEG scanner.These productions were then played back to the subjects. Speaking-induced suppression was defined as a reduction in the amplitude of the M100 response to spoken vowels than to playback.In some individuals, SIS in near-median productions was greater than SIS in peripheral productions: in other words, vowel productions closer to the edges of the distribution appear more error-like.This result suggests that variation in speech output is not built into the prediction.This is consistent with an auditory target model, or with a forward model in which output variation is introduced after generation of the auditory prediction (e.g., from articulatory variability due to noise in subcortical and spinal motor neurons).We present data from individual subjects that show this pattern and investigate the effect on a broader scale. Support: NSF BCS-0926196; NIH R01-DC010145.

B7 Cortical regions involved in sensorimotor processing of syllable sequences ***Rong, F.****,(1),* ***Isenberg, A.L.****,(1),* ***Hickok, G.*** *(1); 1. University of California, Irvine* – Correctly ordering a sequence of speech sounds is a crucial aspect of speech processing both in terms of perception and production (e.g., the difference between 'cat' and 'tack' is simply the order in which the phonemes appear), as is the correct ordering of syllable sequences ('cat attack' is quite different from 'tack a cat'). A recent computational model of syllable sequence production has implicated frontal and subcortical motor-related structures (Bohland, Bullock, & Guenther, 2010); an earlier fMRI study that manipulated complexity reported activation that is consistent with this view (Bohland, et al. 2006). In this study we took a different approach to investigate the neural basis of syllable sequence processing. Rather than manipulating complexity we used fMRI to compare the response to covertly repeating the same syllables either individually or in a sequence. Each trial consisted of 8 bins.In the non-sequence condition, subjects heard different CV syllables in bins 1, 3, 5, and 7 and repeated each syllable once in bins 2, 4, 6, and 8.In the sequence condition, subjects heard different syllables in bins 1-4 and repeated the sequence during bins 5-8, one syllable per bin. Thus, over the course of the trial, the same items are heard and repeated in each condition.There were two trials in each block. Every participant was also tested in an overt behavior session using same tasks before the scanning session during which error rates and types were recorded. Analysis focused on the second trial in each block to minimize differences due to front-loading of acoustic stimulation in the sequence condition.In addition, the response to acoustic stimulation was explicitly modeled and used as a covariate to eliminate its influence.The contrast between sequence and non-sequence trials demonstrated increased (sequence>non-sequence) activity in left posterior STG/STS (Figure 1). No activity was noted in early auditory cortex in this contrast indicating that the activity in STG/STS is not driven by low level acoustic differences. These findings suggest a role

for posterior sensory-related phonological regions in syllable sequence processing. Figure 1. ROI shows stronger activity in covert syllable sequence repetition. Bohland, J. W., Bullock, D., & Guenther, F. H. (2010). Neural representations and mechanisms for the performance of simple speech sequences. J Cogn Neurosci, 22(7), 1504-1529. Bohland, J. W. & Guenther, F. H. (2006). An fMRI investigation of syllable sequence production. NeuroImage 32, 821-841

B8 A mediating role of the auditory-motor dorsal pathway in selective adaptation to speech ***Grabski, K.*** *(1),* ***Tremblay, P.*** *(2),* ***Gracco, V.*** *(3,4),* ***Sato, M.*** *(1); 1. CNRS & Grenoble Universités, Grenoble, France; 2. CIMeC, University of Trento, Trento, Italy; 3. CRLMB, Montreal, Canada; 4. Mcgill University, Montreal, Canada* – **Introduction:** Despite accumulating evidence that motor regions are activated in processing speech sounds, the question of whether articulatory processes mediate speech perception is still debated. In the present study, we tested by means of state-dependent transcranial magnetic stimulation (TMS) whether the left ventral premotor cortex (vPM), the inferior parietal lobule (IPL) and the posterior part of the superior temporal gyrus (pSTG) contribute to speech categorization. A selective adaptation paradigm was used in which repeated presentation of a particular syllable causes a reduction in the frequency with which that token is reported in a subsequent auditory categorization task. If the left vPM, IPL and pSTG are involved in syllable categorization, this adaptation procedure would modulate the initial activation state of these regions prior to application of TMS during the presentation of target syllables. Compared to a control condition without TMS, a modulation of the selective adaptation effect after TMS would demonstrate a caUSl contribution of the left vPM, IPL and pSTG in speech categorization. Methods: Twelve right-handed participants with no contraindications to TMS were recruited. They first performed a two-choice auditory decision task, with synthesized syllables varying along a /ba/-/da/ continuum. The three syllables (C-1, C0, C+1) ranging in the categorical boundary between /ba/ and /da/ were individually determined. Participants then performed three TMS sessions, one for each stimulation site with the order counterbalanced across participants. Each session consisted of a two- choice auditory decision task on C-1, C0, C+1 syllables. Four TMS and auditory adaptation conditions were contrasted: 1) no TMS – no adaptation, 2) no TMS – adaptation, 3) TMS – no adaptation and 4) TMS – adaptation. In the TMS conditions, a single-pulse TMS was applied at the onset of each target stimulus. In the auditory adaptation conditions, participants repeatedly and repeatedly listened to /ba/ syllable before performing the syllable decision task. In each session, a figure-of-eight TMS coil, driven by a magnetic stimulator, was placed on the stimulation site using frameless stereotaxy and individual MRI to-head co-registration. Stimulation sites were identified on individual brain reconstructions on the basis of macroanatomical landmarks. vPM was defined as the portion of the precentral gyrus posterior to the point where the inferior frontal sulcus meets the precentral sulcus. IPL was targeted over its dorsalmost portion, immediately ventral to the intraparietal sulcus. pSTG was targeted on the ventral region over the caudal end of the posterior branch of the sylvian fissure. In the TMS conditions, single pulse TMS were applied with stimulation intensity at 110% of individual resting motor threshold. Results: To specifically test the effect of various experimental conditions on selective adaptation, the proportion of /ba/ responses and the median RTs observed with prior auditory adaptation were subtracted from those observed without prior adaptation for each participant, each stimulation mode (TMS, no TMS), each stimulation site (vPM, IPL, pSTG) and each stimulus (C-, C0, C+). Three-way repeated-measure ANOVAs were further performed on these dependent variables with the stimulation mode, the stimulation site and the stimulus as within-subjects variables. Perceptual scores. A significant 'simulation mode x stimulus' interaction ($F(2,22) = 3.95$, $p = .05$) was observed. This interaction was due to a stronger selective adaption effect observed for c- and c0 stimuli after TMS compared to no TMS (average decrease of /ba/ responses, 23% vs. 9%, and 22% vs. 13%, all p's < .05). No other significant effect or interaction was observed. The fact that no other effect or interaction was observed suggests that this modulation equally affected vPMC, SMG and pSTG. Reaction Times. The main effect of stimulation mode was significant ($F(1,11) = 4.6$, $p = .05$), with faster RTs observed after auditory adaptation compared to no adaptation when no stimulation was applied (average difference of 21ms) while slower RTs were observed after auditory adaptation compared to no adaptation in TMS conditions (average difference of -24ms). No other significant effect or interaction was observed. Conclusion: The stronger criterion shift due to selective adaptation after stimulation applied over the left vPM, IPL and STGp demonstrate a mediating role of these regions in speech categorization. These results appear in line with recent neurobiological models of speech perception and production that postulate a crucial role of these regions in sensory-to-motor and motor-to-sensory speech interactions.

B9 Incongruence between low- and high-level speech perception within core production regions ***Elgie, B.*** *(1),* ***Baum, S.R.*** *(1),* ***Gracco V.L.*** *(1,2); 1. McGill University, Montreal, QC, Canada; 2. Haskins Laboratories, New Haven, CT* – Findings of overlapping speech production/perception neural activation, as well as a hypothesized mirror system for speech, give support to aspects of gestural theories of speech perception (Liberman & Mattingly, 1985; Rizzolatti & Arbib 1998, Wilson et al 2004).Within the literature, few authors distinguish among results found using phonemes, words, and sentences.This study investigated whether there is overlap in neural activation between word-level speech production and perception, and whether that overlap is present during perception of sentence-level speech. To accomplish this, we conducted two functional magnetic resonance imaging experiments.In Experiment #1, 10 participants (5 female, mean

age 22.6) were presented with 50 concrete nouns in auditory form and instructed to passively listen to, or to repeat, the stimuli aloud. In Experiment #2, 10 participants (5 female, mean age 26.0) were required to judge 60 affectively-intoned (30 angry, 30 happy) and 60 linguistically-intoned (30 question, 30 statement) sentences presented auditorily.A functional mask was created using the speech repetition condition from Experiment #1 (at p = 0.005 uncorrected), and used for group analyses of word listening in Experiment #1 and the sentence task from Experiment #2 (p = 0.01 corrected to p = 0.05, k = 12 voxels). The production mask contained clusters within bilateral ventral pre/post-central gyrus, bilateral dorsal post-central gyrus, bilateral pre-Supplementary Motor Area (pSMA)/SMA, bilateral putamen, bilateral cerebellum (Cbm), bilateral transverse temporal gyrus (TTG), and left posterior TTG.For word listening, significant clusters were found within bilateral ventral primary motor/somatosensory (M1/S1) regions, TTG, and dorsal M1/S1.Sentence-level speech perception was associated with significant clusters of activity in bilateral TTG, left premotor (PMv)/M1v (from the button-pressing response), left S1v, and right Cbm. Tremblay & Small (2011) suggest that for object-descriptive (as opposed to action-descriptive) speech perception, motor activity derives from activation of a range of potential motor plans.As our study did not show activity in PM/M1/S1 for sentences, a different explanation seems required for our findings.At lower levels of speech (e.g., phonemes/syllables), where articulation is perceptually relevant, it is possible that heard speech activates M1 in an articulator-specific manner, in the absence of other task demands.This accounts for findings of overlap between perception/production of syllables within M1 (Wilson et al 2004), and for studies where TMS modulated activity within M1 during effector-emphasized word perception (Fadiga et al 2002).Task demands which cannot be met by M1 may suppress/inhibit M1 in favour of other regions.At higher speech levels (e.g., sentences), articulation may be less relevant to interpreting the speech signal, and so motor regions only come online in the presence of specific task demands, accounting for conflicting findings of M1 activation during speech perception across investigations. Fadiga L, Craighero L, Buccino G, Rizzolatti G. (2002) Eur J Neurosci, 15, pp. 399-402. Liberman A, Mattingly I (1965). Cognition, 21, pp. 1-36. Rizzolatti G, Arbib MA. (1998) Trends Neurosci, 21, pp. 188-94. Tremblay P, Small SL. (2011) Cereb Cortex, 21, pp. 1166-77. Wilson SM, Saygin AP, Sereno MI, Iacoboni M. (2004) Nat Neurosci, 7, pp. 701-2.

B10 Source space analysis of cortical responses to auditory feedback perturbations: An MEG study

Kort, N. *(1),* ***Houde, J.F.*** *(1),* ***Nagarajan, S.S*** *(1); 1. University of California, San Francisco* – The role of sensory feedback in speech is complex and remains poorly understood.Sensory feedback, particularly auditory feedback, is essential when children are learning to speak. Adults do not need sensory feedback to speak intelligibly, but alteration of their auditory or somatosensory feedback does cause systematic changes in their speech. Thus, experimental manipulation of auditory feedback during speaking offers a unique window to understand the neural substrates of speech motor control. In this study we used perturbed auditory feedback and magnetoencephalography (MEG) to explore the neural correlates of feedback processing during the production of single vowel utterances. MEG data was collected using a 275-channel biomagnetometer.The analysis consisted of stimulus-locked analysis of the sensor data, synthetic aperture magnetometry (SAM), virtual sensor analysis, and time-frequency beamforming using the NUTMEG software package. Subjects produced utterances of the single vowel /a/ and heard their voice in real time through headphones in the MEG. The onset and offset of phonations were cued with a visual stimulus.During phonation the subjects heard a 100cent pitch perturbation lasting 400ms. Across the trials of the Speaking condition, this perturbation was pseudorandomly alternated between a positive and a negative pitch shift. In a separate Listening condition, subjects passively re-listened to their perturbed audio feedback that was recorded in the Speaking Condition. The subjects were eleven healthy right-handed volunteers with normal hearing and speech. Analysis of the temporal MEG sensors showed bilaterally a greater response in the Listening condition than the Speaking condition at speech onset.This result is consistent with the results of speaking-induced suppression (SIS) seen in other studies.Analysis of the right temporal MEG sensors at the perturbation onset showed a peak around 80 ms that was greater in the Speaking condition than the Listening condition. The left temporal MEG sensors showed a broader enhancement in the Speaking condition than the Listening condition around 150ms.The neural structures underlying these effects seen in the sensors were further distinguished with a source-based analysis.A latency difference was found in the m50 peak with the Speaking condition peak following the peak in the Listening condition in right superior temporal gyrus (STG)/ Brodmann area 21/22. Left Brodmann area 40, the superior parietal temporal/parietal temporal area (spt/pt) showed a greater response in the Speaking condition than the Listening condition at 150ms.Left pre-motor (Brodmann area 6) and left STG (Brodmann area 21/22) then showed a greater response in the Speaking condition than in the Listening condition around 180ms.These results can be explained by a state feedback control (SFC) model of speech motor control: The initial right-lateralized STG enhancement in the Speaking condition as compared to the Listening condition reflects recognition of an error in auditory feedback. This feedback error is then propagated to area spt/pt and continues to pre-motor cortex where a compensatory response is generated. As a result, a motor response is initiated around 200ms, when the subject changes pitch to oppose the perturbation. Support: NSF BCS-0926196; NIH R01-DC010145, Alzheimer's Assoc. ETAC-09-133596, Bay Area Consortium of Affective Science

B11 A longitudinal study on the neural development of English vowel processing: Comparing monolingual

versus bilingual children ***Shafer, V.L.****(1),* ***Yu, Y.H.****(1),* ***Tessel, C.*** *(1),* ***Gerometta, J.****(1),* ***Garrido-Nag, K*** *(1,2); 1. City University of New York; 2. Gallaudet University* – Many studies have demonstrated that considerable changes in speech perception occur during the first few years of life and that these changes are strongly influenced by the ambient language. The current longitudinal study examined the development of neural correlates of vowel discrimination in a sample of monolingual (English)- and bilingual (Spanish-English)-exposed children at multiple time-points between three months and four years of age.A larger, cross-sectional study using Event-Related Potentials (ERPs) showed increased positivity to a vowel contrast at frontocentral sites (positive mismatch response, pMMR) in infants, which declined in amplitude and latency with increasing age.Towards three-years of age, monolingual (MO)-exposed infants showed an emerging negativity (mismatch negativity, MMN).The bilingual (BI)-exposed group (particularly females) showed a different pattern, with greater negativity at earlier ages. We suggested that these different patterns are at least partially related to attentional affects as another study from our lab revealed that drawing the infant's attention to the speech change led to a negative MMR. The goal of the current analysis was to determine whether individual participants showed a linear or curvilinear pattern of development for the MMRs and whether behavioral language and background measures correlated with the ERP findings. Fourteen MO (6 girls) and 14 BI (5 girls) children were tested at least twice between three and 47 months of age. Testing consisted of standardized language and cognitive measures, a language background questionnaire and ERPs recorded from 65-sites to the vowels [I] and [E] presented in an oddball paradigm.The results revealed that the majority of MO children showed greater negativity of the MMR between 300 and 400 ms at older ages (18-48 months) compared to each child's data at an earlier age (three to eight months).However, of the eight children who were also tested between 12 and 15 months of age, six showed more negative MMRs than for the later testing ages.The BI children showed a different pattern, with half of the group (most who were females) showing negative MMRs at six months of age, and less negativity at older ages.Only five of the 14 BI infants showed a negative dip in amplitude (the MO pattern) relative to the earlier and later ages.The amount of English versus Spanish exposure was not related to this finding within the BI group. We suggest that these different patterns are at least partially related to attentional effects. It is unlikely that the increased negativity of the MMR at six months for many BI children and at 12 months for many MO children indicates the development of robust discrimination because the same child often showed more positive MMRs at the subsequent visit (18 or 24 months).By four years of age, there is evidence that the negative MMR (or MMN) does indicate robust discrimination because it is seen in almost all MO children.These results indicate a less straightforward relationship between the MMRs in infants and language development at older ages than suggested in some studies, and that attention is a factor.

B12 Language-Specific Tuning of Audiovisual Integration in Early Development ***Depowski, N.*** *(1),* ***Flynn, J.*** *(1),* ***Baart, M.*** *(2),* ***Bortfeld, H.*** *(1); 1. University of Connecticut, Storrs, CT; 2. Tilburg University, Tilburg, The Netherlands* – Perceptual narrowing is one way to characterize the age-related changes observed in infants' ability to perceive phonemes from non-native languages (Werker, & Tees 1984, 2005). In this line of research, infants are typically tested with single phonemes presented auditorily and with no accompanying visual stimuli (Werker & Tees, 1983; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992). Understandably, this allows researchers to focus on sensitivity to the speech signal itself while removing all other perceptual influences.From a perceptual standpoint, however, broad multisensory abilities are selectively narrowed according to infants' environmental experience. Thus, infants' sensitivity to all forms of environmentally irrelevant information decreases while sensitivity to environmentally relevant information increases (Lewkowicz & Ghazanfar, 2009; Pons, Lewkowicz, Soto-Faraco, & Sebastián-Gallés, 2009; Scott, Pascalis, & Nelson, 2007). At least for typically developing infants, the emergence of phonemic sensitivity happens in the context of multimodal speech. The goal of the present study is to determine whether infants demonstrate perceptual narrowing for their native language relative to an unfamiliar language (here, Spanish) in the context of fluent audiovisual speech. Twelve infants (6 female) ranging in age from 8-16 months were tested using a serial audiovisual presentation looking time paradigm. The broad age range was included to capture individual differences in emerging sensitivity to audiovisual speech using this novel paradigm. In the procedure, infants sat on their guardians' laps while viewing a video consisting of randomized blocks of the four audiovisual speech conditions. Stimuli were manipulated systematically to include either phonetically congruent or incongruent audio and visual speech in either the infants' native or a non-native language (see Figure 1). Meanwhile, synchronicity between the audio and visual signals was matched across conditions. Sessions were video-recorded and infants' looking behavior was coded off-line. Overall, there was a significant negative relationship between age and looking time for incongruent speech, indicating that infants tended to look proportionally less at incongruent speech than at congruent speech as they got older. Infants looked proportionally more at blocks in which audiovisual stimuli were congruent than to those in which they were incongruent. In particular, infants looked longer towards congruent English relative to the two incongruent conditions; no such effect emerged for Spanish. These results suggest that perceptual narrowing characterizes infants' sensitivity to audiovisual speech as well as the auditory-only signal. This work extends the concept of perceptual narrowing to the domain of fluent audiovisual speech. Ongoing studies are examining the specificity of the narrowing process to either the auditory or visual signal in this bimodal context.

B13 Elucidating neural mechanisms for speech perception development: An MEG study with children

with autism, their clinically typical siblings, and typically developing children ***Gage, N.*** *(1),* ***Isenberg, A.*** *(1),* ***Fillmore, P.*** *(2),* ***Osann, K.*** *(1),* ***Spence, M.*** *(1); 1. The University of California, Irvine; 2. The University of South Carolina, Columbia* – Language impairment is a defining feature of autistic disorder (AD) however its etiology is unknown. Early language acquisition involves largely implicit learning processes that underlie stages of speech perception such as phoneme discrimination, syllabic stress pattern detection, and word boundary perception that are essential to language development. The neural mechanisms that underlie these learning processes in typical and disordered language development have not been elucidated. We used magnetoencephalography (MEG) to acquire auditory evoked responses to sinusoidal tones of varying frequency and consonant-vowel syllables that varied in distinctive features in a sample of 18 children with AD and 18 typically developing (TD) controls 7-14 years. Six of the TD children were clinically typical siblings (SIB) of the children with AD. We focused on the M100, a component that reflects perceptual processing mechanisms in auditory language cortex. We used a passive listening paradigm, with sounds presented as the child watched a silent video, to assess the time course of neural resource allocation for speech (CV) vs. non-speech (tones) sounds in left (LH) and right (RH) auditory language cortex. M100 amplitude variation over the 4-m scans was our dependent variable. Since the children were being distracted with an entertaining video, we hypothesized that M100 amplitude variation over the scan would elucidate intrinsic neural resources allocated for encoding these sounds without voluntary attention. Our overarching goal was to determine if speech sounds were processed in a fundamentally different way for children with developmental language disorder vs. controls, and if this difference was evidenced in any of their clinically typical siblings. Results: for tones, TD children showed a slight decrease in M100 amplitude in both hemispheres that was larger in RH. For children with AD, this finding was reversed with an increase in both hemispheres that was larger in LH. This was not the case for CVs: TD children showed large (~30%) increases in M100 amplitude in both hemispheres while children with AD showed a sharply different effect with slightly decreasing responses in both hemispheres. For SIB, LH showed an amplitude increase similar to TD, and no change in RH, similar to their siblings with AD. Thus TD children – without conscious attention – had neural resources that were 'ramped up' – tuning in? -- over a few minutes to speech. This was not the case for the children with AD. Our findings provide evidence that children with AD allocate neural resources in a fundamentally different manner than TD, with a dynamic shift of resources away from speech and toward less salient tonal sounds. Our results for SIB show a hemisphere asymmetry for speech not found in TD or AD, nevertheless they developed language in a clinically typical (that is, without a diagnosis of language delay) manner. Cumulatively, results suggest that these intrinsic processes, reflected in the M100 and underlying speech perceptual mechanisms, may provide a candidate neural basis for at least some of the developmental language disorder observed in AD.

B14 Neural specialization for speech at birth: Comparing native and non-native language ***May, L.*** *(1),* ***Gervain, J.*** *(2),* ***Carreiras, M.*** *(3),* ***Werker, J.F.*** *(1); 1. University of British Columbia, Vancouver, BC; 2. CNRS and Université Paris Descartes, Institut Neurosciences Cognition, Paris, France; 3. Basque Centre on Cognition, Brain and Language, Scientific Director, Donostia-San Sebastián, Spain* – Researchers have long known that the adult brain responds specially to the native language, but a debate continues as to how much this specialization is driven by experience versus an innate predisposition (Perani et al., 1996; Dehaene et al., 1997). Recent research has weighed in on this debate by showing that some neural specialization for language is present from the first days of life: newborn infants show stronger and more left-lateralized brain activation to forward versus backwards native language (Dehaene-Lambertz et al., 2002; Peña et al., 2003).This work has been taken as evidence that the human brain is wired to acquire language. However, this conclusion is currently unwarranted. Research to date has thus far only explored the neonate brain response to the native language, leaving open the question as to how prenatal experience may have shaped the neural response to speech at birth. As infants enter the world having been exposed to the prosodic structure of the native language heard in utero, it is possible that neonate neural processing for speech might be different depending on the language familiarity. In the current study we take the first steps in addressing this question, by using Near Infrared Spectroscopy (NIRS) to examine the relative strength and location of neonates' brain activation to native language, non-native language, and non-linguistic backwards language. English-exposed neonates (0-3 days old) were presented recordings of English (familiar language) and Spanish (unfamiliar language), as well as backwards English and backwards Spanish. The backwards language recordings served as matched non-linguistic controls. Neural activation, as indicated by changes in oxygenated and deoxygenated hemoglobin, was measured over 12 channels covering the temporal regions on each hemisphere (24 channels in total). We found no significant results for either language (English versus Spanish) or hemisphere (left versus right). However, our results showed a significant interaction between language direction and frontal versus posterior temporal regions. For both forward English and Spanish, activation was significantly greater in the frontal versus posterior areas, while no location differences were seen for backwards language. In frontal areas, the difference between forward and backwards language was marginally significant, while no such effect was found in the posterior region. Our results point to several interesting conclusions. First, our results confirm that the newborn brain responds strongly to forward versus backwards language. We specifically found heightened activation to forward speech across both languages in frontal temporal channels. We believe this activation likely corresponds to well-known language regions such as Broca's area, and demonstrates that their role in language

processing is active soon after birth. However, the activation that we observed was consistently bilateral, unlike the neural response to language in adults. Finally, our results did not show any overall difference in neural activation to forward English versus forward Spanish, suggesting that the neonate brain responds similarly to different languages at birth. These results indicate that early in life, neural processing of language does not rely entirely on language familiarity, but on language-universal biases.

B15 Subcortical correlates of pattern detection ***Skoe, E.**, (1), **Spitzer, E.**, (1), **Kraus N.** (1); 1. Northwestern University, Evanston, IL* – **Objective**: The ability to extract patterns from continuous sound sequences is fundamental to music as well as native and second language learning.In light of recent research showing that auditory brainstem activity is sensitive to simple, highly-repetitive patterns and stimulus context,we seek to elucidate if (and how) subcortical structures are involved in this generalized form of pattern detection, the time course over which learning-related subcortical plasticity can be observed, and the degree to which behavioral and neural measures of pattern detection are linked to performance on a commonplace, complex auditory task like listening to speech in background noise. We have chosen to examine speech in noise perception because real-world listening conditions are generally noisy, and because pulling out a signal from noise depends on the ability to learn the patterns associated with the target voice and the noise. **Methods:** In a group of normal hearing young adults, we evaluated auditory brainstem responses to eight complex tones presented in a patterned and an unpatterned sequence. In the patterned condition, the eight tones were grouped into four doublets, such that the tones forming a doublet were always presented in immediate succession.In the unpatterned condition, the eight tones were presented in pseudo-random order.In both conditions, the time interval between tones was identical and each tone had a 12.5% probability of occurrence; what differed between conditions was the transitional probability between successive tones.We measured the auditory brainstem response to the pitch of each tone and calculated the extent to which the response changed between the patterned and unpatterned conditions. **Results:** Preliminary results show a relationship between temporal discrimination ability and neural pattern enhancements, such that subjects with greater neural enhancements in the patterned condition were better at discriminating two sounds occurring in rapid succession, as assessed by a backward masking task. **Conclusion:** Our results suggest that poor temporal resolution might compromise the brain's ability to segment the auditory sequence into temporally distinct patterns.Our findings are noteworthy given that backward masking thresholds, which were found to correlate with the ability to hear speech in noise, are (1) elevated in children with language impairments, a group demonstrating impaired speech perception in noise and impaired pattern learning; and (2) lower in musicians, a group with an exceptional ability to understand speech in noise.

B16 Bilinguals show enhanced subcortical representation of sound ***Krizman, J.**, (1), **Marian, V.**, (1), **Shook, A.**, (1), **Skoe, E.**, (1), **Kraus, N.** (1, 2); 1. Northwestern University, Evanston, IL; 2. Northwestern University, Chicago, IL* – **Objective:** While bilingualism is known to impact cortical function, the effect of multiple language experience on subcortical processing is unknown. In the current study, we aim to investigate whether bilinguals and monolinguals process sounds differently at the subcortical level, and if these differences relate to cognitive abilities associated with executive function. **Methods:** To assess the impact of bilingualism on sound processing and cognitive abilities, auditory brainstem responses and behavioral measures of auditory processing and executive function were obtained in 60 adolescents of varying second language proficiency, matched on IQ and socioeconomic status. **Results:** Bilinguals, when listening to the syllable 'da' presented in six-talker background babble demonstrated more robust encoding of the stimulus compared to monolinguals. Subcortically, the spectral amplitude of the fundamental frequency (F0), a feature known to underlie pitch perception and grouping of auditory objects, was more robust in bilinguals compared to monolinguals. Behaviorally, bilinguals demonstrated perceptual advantages in the sensory processing of basic acoustic components, such as timing and frequency, which are fundamental to accurate speech perception. Specifically, bilinguals showed enhanced discrimination of simple, non-linguistic sounds as assessed by a measure of temporal resolution (backward masking) and a measure of frequency discrimination. Relative to monolinguals, cognitive advantages were seen in bilinguals in both the auditory and visual domain on a behavioral measure of executive function (i.e. sustained, focused attention). Performance on both the visual and auditory measures of executive function was correlated with subcortical F0 amplitude. Conclusions: The brainstem response to complex sounds was more robust in bilinguals than monolinguals. This enhanced neural encoding related to better performance on tests of executive function and is consistent with the notion that enhanced executive function may drive the strength of subcortical stimulus representation. Significance: The present findings suggest an enhancement for bilinguals in the neural processing of specific sound elements that relate to auditory perception and cognitive abilities. The subcortical strength of F0 encoding is known to be influenced by sensory and cognitive processes.An interaction among cognitive, sensory, and subcortical functions may provide bilinguals an advantage in listening situations where enhanced auditory acuity and cognitive control are essential to communication.

B17 Response bias modulates motor system activity during speech discrimination ***Venezia, J.H.** (1), **Saberi, K.** (1), **Hickok, G.** (1); 1. University of California, Irvine* – Recent evidence suggests that the speech motor system may play a significant role in speech perception. Repetitive transcranial

magnetic stimulation (TMS) applied to a speech region of premotor cortex impaired syllable identification but not color discrimination, while TMS stimulation of motor areas for different articulators selectively facilitated identification of phonemes relying on those articulators.However, in these experiments the speech stimuli were embedded in noise and performance was not corrected for response bias.It may be that speech motor networks are preferentially taxed under conditions of stimulus degradation. Moreover, it is not currently known whether or how response bias modulates activity in these networks.Thus, the present functional magnetic resonance imaging experiment was designed to systematically manipulate response bias in a speech perception task using degraded speech stimuli.Minimal consonant-vowel stimulus pairs were presented between volume acquisitions for same-different discrimination.Speech stimuli were embedded in Gaussian noise at the psychophysically determined threshold level (2-down, 1-up staircase).We manipulated bias by changing the ratio of same-to-different trials: 1:3, 1:2, 1:1, 2:1, 3:1.Ratios were blocked by run and subjects were cued to the upcoming ratio at the beginning of each run.Response bias (signal detection criterion measure, c) was measured in individual subjects for each ratio condition.Group mean bias varied in the expected direction while sensitivity (d') did not differ significantly across conditions. We predicted that activation in speech motor regions would co-vary systematically with bias.Two separate analyses confirmed our initial hypothesis. 1) We constructed a linear contrast at the individual subject level by taking the absolute value of c in each condition and subtracting out the mean across conditions.The remaining values were entered as contrast weights on activation in each condition, and the individual subject contrast coefficients were entered into a random effects group analysis.This analysis revealed voxels that co-varied with overall bias in each condition within individual subjects.We identified a motor network that demonstrated decreased activation for higher levels of measured response bias.The network included significant clusters in left ventral premotor cortex, left dorsal premotor cortex/middle frontal gyrus, and bilateral supplementary motor area (pictured; $p < 0.005$, minimum 20 voxels).2) We performed a simple linear regression of c on percent signal change across all conditions and all subjects.In this analysis, we removed the overall direction of bias prior to regression in order to identify voxels that co-varied with task-related bias across subjects.Again, we identified a motor network in which activation correlated negatively with measured bias.This left-lateralized network included inferior frontal gyrus, ventral premotor cortex, cerebellum and basal ganglia (not pictured; $p < 0.001$, minimum 20 voxels).Overall, we can conclude that activity in speech motor brain regions was significantly modulated by our experimental manipulation, which selectively targeted decision-level components of a speech perception task.

B18 Neurophysiological indices of Mandarin lexical tone processing: Effect of language experience and memory load ***Yu, Y. H.**, (1), **Shafer, V.L.** (1); 1. Graduate School and University Center, City University of New York* – Behavioral studies suggested that speech discrimination can operate at the acoustic/phonetic level when the interstimulus interval (ISI) is relatively short, but must rely on the phonemic information stored in long-term memory when ISI is longer because short-term memory traces of a speech sound decay over time (Werker & Logan, 1985). According to Automatic Selective Perception Model (ASP) account,non-native speech processing is challenged when the cognitive demands of the task and the complexity of the stimuliincrease due to lack of automatic Selective Perceptual Routines (SPRs) (Strange & Shafer, 2008). To date, few neurophysiological studies have directly compared speech discrimination under different memory loads, and the relationship between the role of memory load and psychoacoustic saliency on speech processing is yet to be investigated. Also, a few studies on the neural responses of lexical tone processing have led to contradictory findings. The goal of this study is to understand how speech discrimination of lexical tones and vowel segments is modulated by memory and to identify neural correlates of these processes in native compared to non-native listeners. We collected event-related potential (ERP) responses using 65-electrode nets via a passive listening oddball paradigm. The two ISI conditions are 500 ms (short) and 3000 ms (long). The stimuli consist of two lexical tone contrast pairs (Tone one versus Tone three & Tone two versus Tone three) and two vowel contrast pairs (/u/ versus /y/ & /u/ versus /i/) in Mandarin. Participants with native Mandarin and monolingual American-English (AE) backgrounds were tested. We predicted that MMN will be observed to both easy and hard tone contrasts and vowel contrasts for Mandarin listeners for both ISI conditions, and the amplitude of MMN will remain the same, or be slightly decreased in the long ISI compare to the short ISI condition. For native AE listeners, a significantly smaller MMN will be generated for the easy contrast (tone 3-tone 1 or, T1-T3) in the long ISI condition, compared to that found in the short ISI condition and, no MMN or greatly reduced MMN for the hard contrast (tone 3-tone 2, or T2-T3) compared to the short ISI. Preliminary results show that both language groups showed sensitivity to ISI manipulation. Clear MMNs were generated for vowel contrasts for majority of subjects, but the response patterns for lexical tones were somewhat inconsistent. Reasons for lack of consistent ERP response patterns for lexical tone contrast will be discussed. Findings from the currentstudy will shed light on the cognitive load effect in nonnative speech processing and also the neural mechanism of lexical tone processing.

B19 Attending to the unpredictable: contextual constraint modulates early perceptual processing of word onsets in natural speech ***Astheimer, L. B.** (1) **Sanders, L. D.** (2); 1. York University, Toronto, ON; 2. University of Massachusetts, Amherst* – Previous event-related potential (ERP) evidence demonstrates that listeners direct attention to word onsets in continuous speech in a manner that affects early perceptual processing. Attending to word-initial segments may be an effective listening strategy since these sounds are

less predictable and therefore more informative than segments at the ends of words. Although there is ample evidence that predictability affects later processing, as indexed by the N400, it is unclear whether predictability also influences attentional allocation and the differential processing of speech segments at the earliest perceptual stages. To test the hypothesis that listeners use predictability to modulate attention during speech processing, we compared ERPs elicited by auditory attention probes presented concurrently with word onsets following highly constraining (e.g., The woman took the warm cake out of the …) and unconstraining (e.g., The man walked over to the …) contexts. Both types of sentences were continued with a word that, based on the constraining context, was either expected (e.g., oven) or unexpected (e.g., pantry). Each participant heard each critical word only once to avoid repetition effects, and items in the four conditions were balanced across participants. This design allowed for the comparison of ERPs elicited by physically identical words in different contexts, thus controlling for acoustic properties that affect the amplitude of auditory evoked potentials. Consistent with previous cloze probability manipulations, unexpected words in constraining contexts and both types of words in unconstraining contexts elicited a larger negativity over posterior regions (N400) than expected words in constraining contexts. Context affected early processing of the "expected" words; probes presented concurrently with these word onsets in unconstraining sentences elicited a larger negativity over anterior electrodes in the P1-N1 time window than the same words in unconstraining sentences. These results indicate that listeners direct more attention to the times at which word-initial segments are presented when the identity of these segments cannot be predicted from the preceding context. However, there was no difference in the response to probes presented with unexpected words in either type of context. This finding suggests that listeners allocate similar amounts of attention to low-cloze probability words regardless of whether they are unable to make a prediction about upcoming information (i.e., unconstraining contexts) or detect that their prediction was wrong (i.e., unexpected words). In addition, analysis of mean amplitude in the 200 ms time window prior to critical word onset revealed differences in a broad negativity resembling the contingent negative variation (CNV) across conditions. This result raises the hypothesis that contextual constraint affects attentional preparation as soon as predictions are formulated, which likely occurred well before the onset of a critical word in the current study. Taken together, these results indicate that listeners do not allocate attention equally to all word-initial segments in speech, but instead selectively attend to the times at which unpredictable segments are presented. Listeners therefore use temporally selective attention to preferentially process the most informative segments of speech.

B20 Neural correlates of interindividual differences in children's audiovisual speech perception ***Beauchamp, M.****(1,2),* ***Nath, A.****(1); 1. University of Texas Medical School at Houston, TX; 2. Rice University, Houston, TX* – Children use information from both the auditory and visual modalities to aid in understanding speech. A dramatic illustration of this multisensory integration is the McGurk effect, an illusion in which an auditory syllable is perceived differently when it is paired with an incongruent mouth movement. However, there are significant interindividual differences in McGurk perception: some children never perceive the illusion, while others always do. Because converging evidence suggests that the posterior superior temporal sulcus (STS) is a critical site for multisensory integration, we hypothesized that activity within the STS would vary depending on susceptibility to the McGurk effect. To test this idea, we used blood-oxygen level dependent functional magnetic resonance imaging (BOLD fMRI) in seventeen children aged 6 to 12 years. Independent functional localizers were used to identify the left and right STS, auditory cortex, extrastriate visual cortex and the fusiform face area (FFA). The response in each region was measured to three stimulus categories: audiovisual McGurk, non-McGurk incongruent and congruent syllables. The STS of McGurk perceivers responded significantly more than non-perceivers to McGurk syllables, but not other stimuli, and perceivers' hemodynamic responses in the STS were significantly prolonged. In addition to the STS, the FFA and extrastriate visual cortex were also more active in McGurk perceivers. This suggests that both visual and multisensory components of the speech network contribute to variability in audiovisual speech perception in children.

B21 Psychophysical and physiological studies of synthetic vowel harmonic structure ***Jenkins, Julian III****(1),* ***Simon, J. Z.****(1),* ***Poeppel, David****(2),* ***Idsardi, William J.****(1); 1. University of Maryland, College Park, MD; 2. NYU, New York* –While real speech tokens are spectro-temporally complex in a way that exceeds our current understanding, progress can be made by utilizing synthetic signals that include specific, essential features of ecological signals, i.e. their harmonic and spectral envelope structure. The experiments presented quantify the timbre of synthetic steady-state vowel formant and source waveform structure, using an AX task and magnetoencephalography (MEG). The goal of the two experiments is to examine the ability of an observer to resolve differences in harmonic and formant structure behaviorally and physiologically. The signals employed were synthesized in accordance with source-filter theory. Filters were the transfer functions for the American English vowels /a/, /i/ and /u/; these vowels were chosen due to their linguistic properties and their being relatively unchanged when completely steady-state. The main source waveform was a sawtooth wave approximating the glottal excitation pattern. Timbral differences within each vowel category were created by selectively removing harmonics (from every 6th to 2nd) in the source waveform. The source waveforms cover a continuum from an ecological signal to sine wave speech. Signals with the sawtooth wave with every 2nd harmonic removed and the square wave as the source waveforms are metamers: physically different but perceptually identical signals. Discrimination comparisons were done within

each vowel category and physiological assessment of the signal was performed preattentively. The experimental hypotheses focused on how formant and harmonic structure interact to affect signal discrimination and preattentive processing. For the discrimination experiment, we hypothesized that the metamers would be confused most often, while the discrimination of the other signals would be easy.Hypotheses for the MEG experiment were that the evoked response component profiles would reflect both vowel structure and harmonic content of the signals.Data from the discrimination experiment supported the hypothesis concerning the metamers; there was however, an unexpected asymmetry: the /a/ signals exhibited a much lower proportion correct overall than the others.The asymmetry arose from signals in the middle of the /a/ continuum. There were three evoked components:the M50 and M100 in addition to the sustained field.MEG data showed that the M100 reflected fundamental frequency and vowel category in both amplitude and latency.However, the M100 did not have the resolution to reflect differences in harmonic structure within vowel category. M50 generation was larger and more consistent in the LH, but M50 and sustained field functional significance is unclear from the data.Together, the experimental data suggest that formant structure rather than harmonic content is more important for categorizing differences between vowel categories behaviorally and physiologically.

B22 Featural encoding of speech sounds and hemispheric differences in speech perception: an fMRI-adaptation study ***Lawyer, L.*** *(1),* ***Corina, D.*** *(1); 1. University of California Davis, CA* – **Objective:**fMRI adaptation paradigms have been commonly used to explore the low-level featural composition of visual processing in humans (Grill-Spector and Malach (2001)). In phonology, a long tradition of research suggests speech sounds may also be grouped into hierarchical representations (cf. Jakobson et al. (1952), Hayes (1999)).If this is so, a primary goal of speech perception must be to parse acoustic input into abstract categories to facilitate lexical access and comprehension.The methods of fMRI adaptation are well suited to explore this issue, yet they have not been widely applied to speech processing research.This study uses an adaptation paradigm to address two areas:first, whether speech-activated regions are sensitive to adaptation effects; and second, whether the featural composition of syllable pairs can modulate degree of recovery from adaptation. **Methods:** Subjects (n=6) listened to a number of CV syllables ('adapters') repeated 8-14 times, followed by a single CV test item which differedparametrically from the adapter by 0-3 major feature nodes (as per Clements (1985)).A region of interest analysis (Marsbar, Brett et al. (2002)) was employed to define voxels that were sensitive to three separate comparisons: speech compared to noise, the beginning compared to the end of adaptation, and those showing a response graded by number of feature contrasts. Data was collected on a Siemens 3T Trio Tim scanner and analyzed using a standard SPM8 random-effect model.**Results:** Speech stimuli produced bilateral activations in primary and secondary auditory cortices.The data shows adaptation is found in speech areas, but is predominantly restricted to the right superior temporal gyrus (STG).Activation for test items based on the degree of feature similarity to preceding adaptation strings is found bilaterally in left middle temporal gyrus (MTG) and right STG, including the concomitant adaptation area.Discussion.These gradiently-responding voxels suggest the possibility that regions in auditory cortex are specifically sensitive to the featural content of speech below the level of the segment.This may be representative of a level of articulatory or acoustic feature encoding in speech. Further, lateralization of the adaptation effect may be indicative of dual processing streams.Right-hemisphere speech areas may be adapting to larger prosodic cues, or non-linguistic information such as speaker identity (Belin and Zatorre (2003)).Left-hemisphere areas, including those which encode featural content, fail to show adaptation effects.This may be taken as evidence for differentiation of speech processing streams, as suggested by the 'asymmetric sampling in time' hypothesis (Poeppel (2003)).

PROSODY

B23 Influence of Music Aptitude on Metrical Expectancy during speech perception ***Magne, C.*** *(1),* ***Jordan, D.*** *(1),* ***Gordon, R. L.*** *(2); 1. Middle Tennessee State University, Murfreesboro, TN; 2. Vanderbilt University, Nashville* – **Objective:** Speech meter, the pattern of stressed and unstressed syllables, is generally acknowledged to play a role in language in both infants and adults. English-learning infants develop an increased sensitivity to the common trochaic stress pattern during the second half of their first year, and rely on this early sensitivity to discriminate word boundaries within the continuous speech stream. In adults, speech meter also guides other aspects of language comprehension such as lexical expectancy. While meter is known to be an important aspect of speech perception, its neural basis has been largely understudied. The present study investigates the electrophysiological correlates of metrical expectancy in American English and the influence of music aptitude on speech meter sensitivity. **Methods:** ERPs were recorded in 18 participants (9 musicians) while they were listening to sequences of four bisyllabic words. The first three words were either all trochaic or all iambic. Metrical expectancy was manipulated by varying the stress pattern of the last word of each list, so that it had either the same or different stress pattern as the previous four words. The log HAL frequency was used to ensure that all the words within each sequence have similar lexical frequencies, while a pseudo-random inter-word interval was used to prevent temporal expectancy of successive stressed syllables. After each sequence, an additional word was presented and participants were required to decide whether it was a new word or a repetition of one of the previous words. This memory task was used as a distractor to ensure that participants attentively listened to each word of the sequences without having explicit knowledge of the metrical manipulation. Prior to the ERP session,

the participants' music aptitude was assessed using the Advanced Measures of Music Audiation. **Results:** Fourth words that did not match the stress pattern of the previous words elicited a larger negative component between 250 and 650 ms following the word presentation, over the fronto-central regions of the scalp. Moreover, individuals with high music aptitude displayed a larger negativity than individuals with low music aptitude over the left-hemisphere. In addition, for unexpected iambic words, positive correlations were also found between the amplitude of the negativity over the left hemisphere and the participants' score on the AMMA rhythm subset, and between the amplitude of the negativity over the right hemisphere and the participants' score on the AMMA tonal subset. **Discussion and Conclusion:** The results suggest that word sequences with a regular stress pattern elicit expectancies about the stress pattern of upcoming words, even when the time-interval of the successive stress syllables is irregular. This finding is also in line with previous studies showing that incorrect or unexpected metrical cues in speech are reflected by an increased negativity in the N400 latency range, and that this effect is task independent. Finally, our results suggest that music aptitude enhanced speech meter sensitivity, particularly for the less common iambic stress pattern. Overall, they extend previous finding showing a positive influence of musical expertise on various aspects of language processing.

B24 Stress and phonemes are processed independently in neuronal word form recognition

Schild, U. *(1),* ***Becker, A.*** *(1),* ***Friedrich, C. K.*** *(1); 1. University of Hamburg* – Recent results revealed separate speech recognition pathways for word stress and phonemes in infants (Becker, Schild & Friedrich, this volume). Although there is evidence for separate identification of phoneme-relevant information and word stress-relevant information at the neural level in adults, behavioral research did not point to independent word recognition routes for both types of information. Here we tested independent word recognition via stress and phonemes in adults from a neural perspective. **Methods:** In a unimodal auditory priming paradigm spoken word onset syllables (primes) preceded spoken words (targets). The primes were taken from German noun-pairs for which the first syllables only differed in stress like MANdel or manDAT (Engl. almond or mandate; capital letters indicate the stressed syllable). Stress priming was realized by combining stressed and unstressed primes with initially stressed and initially unstressed targets, e.g., MAN-MANdel or man-MANdel. Phoneme priming was realized by combining primes with targets that shared or did not share initial phonemes, e.g., man-MANdel or dok-MANdel. Stress Priming (stress match vs. stress mismatch) and Phoneme Priming (phoneme match vs. phoneme mismatch) were orthogonally varied. Participants made lexical decision to the targets. Event-related potentials (ERPs) for the targets were obtained from 76 electrodes. Eighteen right-handed native speakers of German participated in the study. **Results & Discussion:** We observed behavioral facilitation for phoneme overlap, but no behavioral effect for stress overlap. Nevertheless, we found independent stress-priming and phoneme-priming in the ERPs. The phoneme-priming effect occurred over the left hemisphere in an early time window (100-250 ms after the target word onset). The stress-priming effect occurred over anterior sites in a later time-window (between 300-600 ms). The different time courses of activation for neural phoneme-based representations and neural stress-based representations might contribute to the behavioral data. Stress-based representations might be activated to late to modulate the behavioral responses in the present and previous priming studies. **Conclusion**: Word stress is a cue for neural spoken word recognition, which is used independently from the phonemes. Phoneme-based language recognition dominates the behavioral responses observed in priming experiments with adults.

B25 The word order processing is modulated by rhythmic pattern during silent reading: ERP evidence

Luo, Y. *(1),* ***Zhou, X.*** *(1); 1. Peking University, Beijing, China* – **Objectives:** Syntactic processes can be observed in electrophysiological recordings of brain activity, with syntactic violations typically elicit P600 effects (Hagoort et al., 1993). These processes interact with prosodic features like intonation and metrical structure, captured by the variations on the P600 effect (Eckstein & Friederici, 2005; Schmidt-Kassow et al., 2009). The processing of word order information is also manifested in P600 (Hagoort & Brown, 2000; Weyerts et al., 2002). In Chinese, word order is constrained by rhythmic pattern, i.e., the combination of words with different syllabic lengths. A verb-object (V-O) phrase could modify a noun by simply preceding it, forming a V-O-N pattern; when the verb is disyllabic, however, the word order has to be O-V-N and the object has to be disyllabic as well (Luo & Zhou, 2010). This study was to investigate to what extent the brain activity and the P600 associated with word order processing are modulated by rhythmic pattern in Chinese. **Method:** EEGs of fourteen native Mandarin speakers were recorded while they were reading sentences, each embedding a critical noun phrase. This phrase could be in the correct, O-V-N order or the incorrect, V-O-N order. Moreover, the object could be disyllabic (correct for the rhythmic pattern) or monosyllabic (incorrect for the rhythmic pattern). The two factors crossed, forming four types of sentences (Fig. 1). Each sentence was presented on the screen word by word, with each word appearing for 400 ms, followed by a blank for another 400 ms. In principle, rhythmic pattern violation can be detected when both the verb and the object appear, and word order violation can be detected only when the following noun appears. We analyzed two epochs, with the first time-locked to the verb in O-V-N sentences and with the second time-locked to the head noun in all conditions. **Results:** The first epoch. Compared with correct sentences, sentences violating rhythmic pattern elicited a larger positivity (about 1 μV) in the 190-230 ms (P200) window and a larger negativity (about 2 μV) in the 390-440 ms (N400) window. The second epoch. A similar P200 effect was found for rhythmic pattern

violation. This effect interacted with word order, as sentences with incorrect word order elicited a larger P200 than correct sentences, but only when sentences were correct in rhythmic pattern. In the 500-700 ms window, a classical P600 effect was found for word order violation, but this effect was significant only when sentences were correct in rhythmic pattern. **Conclusion:** The P600 effect associated with word order processing in Chinese is modulated by rhythmic pattern, suggesting that the reanalysis/repair process driven by incorrect word order could be weakened after an earlier detection of incorrect rhythmic pattern. Moreover, consistent with our previous study (Luo & Zhou, 2010), the P200 and the N400 effects elicited by rhythmic pattern violation (on the first epoch) demonstrated that the brain processes prosodic information very efficiently and the violation of rhythmic pattern causes difficulties in semantic integration.

MULTILINGUALISM

B26 Emergent MMN response in Spanish learners as a result of high variability training ***Herd, W.*** *(1),* ***Fiorentino, R.*** *(1),* ***Jongman, A.*** *(1),* ***Sereno, J.*** *(1) 1.University of Kansas, Lawrence, KS* – Previous research suggests that auditory training produces changes in neural activation when measuring MMN (mismatch negativity) responses (Tremblay et al., 1997; Tremblay, Kraus & McGee, 1998).However, these studies trained and measured responses to a noncontrastive distinction (prevoiced vs. voiced stops) for the monolingual English participants.It remains to be seen whether an allophone in the L1 can be reclassified as a phoneme in the L2, thus the current study trained American English learners of Spanish, for whom the tap is an allophone of /d/, to distinguish the phonemic tap - /d/ contrast in Spanish, as in coro 'choir' vs. codo 'elbow'.This contrast is difficult for American English speakers to produce and perceive (Waltmunson, 2005; Face, 2006; Herd, 2011).During six high variability perceptual training sessions, participants completed forced choice identification tasks.For example, after hearing coro, the participant would mouse click the word they heard, "coro" or "codo". Participants would then hear the word a second time and receive immediate feedback.The objective of this study was to determine if training, which improved Spanish learners' perception and production, also produced changes in MMN responses to naturally-produced [ede] and [e-tap-e] tokens presented in an oddball paradigm.Seven repetitions of each stimulus were selected from twenty repetitions produced by a native Spanish speaker based on visual and auditory inspection using Praat (Boersma & Weenink 2005).The amplitude of all tokens was adjusted to 70 dB.Paired samples t-tests confirmed the different token types did not differ significantly in total duration, first vowel duration, amplitude, fundamental frequency, or vowel formants.The experiment was presented in two blocks, with a 7:1 [ede] standard to [e-tap-e] deviant in block one and a 7:1 [e-tap-e] standard to [ede] deviant in block two. Blocks contained eight hundred binaurally-presented stimuli and were counterbalanced across participants, who watched a silent video while EEG (Electroencephalogram) was recorded from 29 scalp electrodes using a Neuroscan SynAmps 2 system. First, preliminary results for native Spanish speakers indicate the amplitude of the response to deviant [ede] was significantly more negative than to standard [ede] [t(8)=2.784, p=0.024] and the response to deviant [e-tap-e] was significantly more negative than to standard [eɾe] [t(8)=3.594, p=0.007]. This establishes that tap and /d/, separate phonemes in Spanish, yield an MMN in our experimental paradigm and that canonical MMN responses can be elicited using naturally produced stimuli.Second, Spanish learners did not exhibit a significantly different response to deviant [e-tap-e] and standard [e-tap-e] at pretest, indicating that tap and /d/ were categorized as the same phoneme [t(8)=0.125, p=0.904].Crucially, this was not the case at posttest.After training, Spanish learners, like native Spanish speakers, exhibited a significant MMN response when presented with deviant [e-tap-e] compared to standard [e-tap-e] [t(8)=2.520, p=0.036].The emergence of an MMN response in Spanish learners clearly indicates neural plasticity still exists in adult learners: it is possible to recategorize L1 contrasts when learning an L2.[Research Supported by NSF: 0843653]

B27 Language discrimination in monolingual and bilingual infants of Spanish and Basque ***Monika Molnar*** *(1),* ***Judit Gervain*** *(2), and* ***Manuel Carreiras*** *(1); 1. Donostia, Spain; 2. CNRS & Universite Paris Descartes, Paris* – It has been established that newborns use rhythmical properties as a cue for discriminating between languages they have never heard before (i.e., Ramus, 2002), and monolingual infants by 5 months of age are able to distinguish their own native (or familiar) language from an unfamiliar (non-native) one even when they belong to the same rhythmical class (i.e., Nazzi et al., 2000). However, for bilingual infants, both languages are familiar; therefore, they must develop strategies different from those of their monolingual peers to succeed in language separation. The few studies on bilingual infants show that at 4 months they are equally adept at recognizing and discriminating their two native languages as their monolingual peers (i.e., Bosch and Sebastian-Galles, 1997); however, one study suggests that bilingual-to-be 4 –month-olds do not attend to language differences in the same way as their monolingual peers (Bosch and Sebastian-Galles, 2001). In order to investigate what cues might be crucial to guide bilingual infants toward the development of language separation, we carried out a set of infant and adult perceptual experiments, in addition to the acoustic analysis of Spanish and Basque. Language discrimination of Spanish-Basque monolingual and bilingual infants in two age groups (3-4 months, and 4-5 months) were measured using the visual habituation and eye-tracking procedures in response to Japanese vs. Polish (unfamiliar and rhythmically different languages), and Spanish vs. Basque (familiar and rhythmically different languages). Preliminary results pooling together all age groups and language backgrounds suggest that all infants succeed in the discrimination of Japanese and Polish. However, discrimination performance across the familiar languages (Basque

vs. Spanish) has been shown to be affected by the language experience (Spanish dominant vs. Basque dominant infants) and the age of the infant. Further implications of the overall findings will be discussed.

B28 The effect of cognates on the perception of English vowels by late Spanish-English bilinguals ***Tessel, C. A.*** *(1),* ***Gitterman, M.*** *(1),* ***Shafer, V. L .*** *(1); 1. City University of New York* – Research in second language (L2) acquisition has yielded overwhelming evidence that acquiring a second language later in life will result in less accurate production and perception of speech sounds in the second language.These effects are a result of interference from the already formed phonetic categories shaped by early exposure to the first language (L1).Phonetic categories from L2 will at least initially be mapped onto phonetic categories from L1.Shared storage of similar lexical items from L1 and L2 may also take place.It is unknown whether lexical items that differ only in an L2 phoneme contrast are processed as homophones (e.g., sit/seat). The bilinguals may perceive changes in the cognates more easily due to their familiar nature, or they may perceive them less easily assuming a shared storage of these items. This study examined adult late L2 learners' ability to discriminate phonemic differences in stressed vowels in their L2 in words that are cognates (having similar meaning and phonology in L1 and L2) and non-cognates (L2 words that are not phonologically similar to their L1 translation equivalents). Event Related Potential (ERP) responses were recorded to auditory English (L2) words presented in pairs. Stimuli were recorded by a bilingual speaker who was asked to produce the words in standard English and then again with the stressed vowel in an 'accented' manner.Half of the L1 words had Spanish (L1) cognates (e.g., 'system' in English translated as 'sistema' in Spanish) and half had non-cognates (e.g., 'sister' in English translated as 'hermana' in Spanish). Half the word pairs consisted of two tokens of the same word pronounced similarly by the same speaker. The other half of the pairs consisted of two words that differed by a mispronunciation of one vowel phoneme (e.g.,'s/I/ stem' vs. 's/i/stem'). The mispronunciation was a Spanish phoneme (e.g., /i/, /e/, or /a/).ERP responses (in particular, N400 and/or the late positive component (LPC)) are expected to reveal the robustness of perception, as well as the timing of this processing. Monolingual English speakers and native Spanish speakers who learned English after the age of 15 years old were tested. ERPs were obtained from 64 sites using a geodesic net in a 45 minute session.Participants were instructed to press one button to indicate that the two stimuli were the same and a second button to indicate that one was different. Preliminary results suggest that monolingual and bilingual participants processed the changes in these vowels differently.The monolinguals demonstrated responses with greater positivity (LPC) at fronto-central sites starting at 450ms lasting until 650ms for the different trials. Bilinguals demonstrated a late positive component which was longer and more widespread at fronto-central sites, but only for cognate words.Bilinguals did not recognize the changes as easily for non-cognates words indicating that they may be processing these words as homophones. Implications of this finding for pedagogy include that cognates may provide a useful L2 teaching tool for phonological-lexical learning.

B29 Language experience modulates perception of phonemic categories ***Harvey, P.*** *(1),* ***Zevin, J.*** *(1); 1. Sackler Institute for Developmental Psychobiology, Weill Cornell Medical College, New York* – Functional magnetic resonance imaging (fMRI) studies have demonstrated that areas of the tempoparietal junction (TPJ) respond more strongly to experimental conditions containing stimulus change.This stronger activation is attributed to the sensitivity of these regions to the differences between phonemic categories.This apparent selectivity for speech sound categories may reflect a preference for behaviorally relevant stimulus dimensions.Language experience is a contributor to behavioral relevance.In the current study, we examine the role of language experience in this sensitivity to phoneme categories. In a passive listening block-design fMRI study, eighteen native-Japanese speakers were presented with auditory native and non-native phoneme contrasts. The native condition being the syllables /da/ and /ga/ and the non-native condition containing the syllables /ɹa/ and /la/.In each condition (native and non-native), participants were presented with "standard" and "deviant" trials."Standard" trials contained different tokens of the same phoneme (i.e. da – da – da – da) and "deviant" trials contained stimuli that alternated between two phoneme categories(i.e. da – da – da – ga). Each four stimulus trial was 15 s long with a 12 s inter-trial interval.Participants watched a muted movie with sub-titles as the sounds were presented.English fluency was determined by scores on the Peabody Picture Vocabulary Test (PPVT). Four contrasts were investigated (1) Speech vs. Silence; (2) "Deviant vs. Standard" which was then evaluated at the (3) native and (4) non-native level.Compared to silence, speech resulted in bilateral activations in traditional speech areas such as superior temporal gyrus (STG)."Deviant" trials as compared to "standard" elicited bilateral activation in the inferior temporal lobe, specifically the angular gyrus (AG). However, when this comparison is further analyzed between native and non-native contrasts, it is shown that type of contrast has an effect on this activation.Both contrasts elicit activity in the left STG, but only the native contrasts contribute to the bilateral AG activations. These results demonstrate activations in the inferior temporal lobe during passive tasks reflect change detection.Furthermore, the activity in the AG appears to be modulated by language experience.Activity in the AG was shown to occur only in trials reflecting change detection of the native contrasts.This behavioral relevancy component demonstrates that the change detection effect found in this region is a result of learned behavioral relevancy as opposed to some neural correlate for sound categories.Previous studies demonstrate a role of behavioral relevancy in the TPJ, specifically the supramarginal gyrus, which is adjacent to the AG.Finally, as left STG was found to be active for both native and non-native change detection,

activity in this area may be less influenced by language or behavioral experience.

B30 Bilingualism: characteristics of intensive language training in the adult brain ***Jennika Soles*** *(1),* ***Megan Callahan*** *(1),* ***Jen-Kai Chen*** *(1),* ***Kate Watkins*** *(2),* ***Denise Klein*** *(1); 1. Montreal Neurological Institute; 2. University of Oxford* – Training-induced plasticity in associated brain regions has been related to various skills, such as navigation (Maguire et al., 2000), music (Bermudez et al., 2009) and juggling (Draganski et al., 2004). It has also been suggested that the functional and structural architecture of the human brain can be modified by the acquisition of a second language (L2) (Mechelli et al., 2004; Perani et al., 1998). The objective of this study was to investigate whether the brain may change as a function of increasing language proficiency after intensive training. Seven right-handed, English monolingual participants were assessed at two time points, one at the beginning of an intensive French course and one after 12 weeks of training. Behavioural (speech samples), anatomical (aMRI) and functional magnetic resonance imaging (fMRI) data were acquired at two time points. BOLD fMRI activation analysis was performed using fMRIstat based on a linear model with correlated errors. On a behavioural level, participants showed increasing levels of proficiency as measured on a number of variables, including subjective proficiency ratings and changes in sentence complexity produced during the speech samples. The participants also showed changes in BOLD fMRI activation, especially in the basal ganglia, from time 1 to time 2. Our results show that even with a task as complex as learning a second language, changes in both behaviour and brain organisation can be detected after as little as twelve weeks of intensive language training. These results further confirm that neuroplasticity can be observed even in adult brains.

B31 Priming Tip-of-the-Tongue States in Poor and Good Foreign Language Learners ***Borodkin, K.****(1),* ***Faust, M.*** *(1); 1. Bar Ilan University, Ramat Gan, Israel* – Some individuals with seemingly intact linguistic skills experience severe difficulties in foreign language (FL) learning. Previous research demonstrated that poor FL learners might have mild deficits in native language processing. For example, we previously found that poor FL learners experience more tip-of-the-tongue (TOT) states than good FL learners while naming in native language. Uncovering the locus of this naming difficulty might advance our understanding of the type of linguistic deficit that the poor FL learners might have. To this end, we studied the effects of phonological priming on TOT resolution in poor and good FL learners. Participants named pictures of rare objects and, following TOT and don't know responses, read aloud a list of pseudowords, which sometimes contained a phonologically related prime. Resolution of don't know responses was not related to priming in both groups. In contrast, phonologically related primes increased TOT resolution in good FL learners, but not in poor FL learners (see Figure 1). These results are inconsistent with studies in older , whose naming difficulties are reduced, provided phonological cuing (James & Burke, 2000). The naming difficulties in older adults were previously attributed to weakened connections between phonological and semantic representations (Burke, MacKay, Worthley, & Wade, 1991). According to the account, phonological priming improves naming by strengthening these connections. On the other hand, individuals with dyslexia, like poor FL learners, experience more TOTs than linguistically intact controls and show no benefit from phonological cuing during naming (Faust & Sharfstein-Friedman, 2003). The lack of phonological facilitation effect in both individuals with dyslexia and poor FL learners is comprehendible in terms of the quality of phonological representations (Elbro, 1996) rather than weakened connections. If phonological representations are impaired, excitation of the connections should not have an effect on naming. The findings of this study show an indirect association between FL learning outcomes and quality of phonological representations of native language words. Further research is required to explore how impaired phonological representations might hinder FL learning.

B32 Sensorimotor plasticity when learning to produce non-native speech ***Simmonds, A. J.*** *(1),* ***Wise, R. J. S.*** *(1),* ***Iverson, P.*** *(2),* ***Leech, R.*** *(1); 1. Imperial College London, UK; 2. University College London, UK* – Articulatory movements necessary for producing native speech sounds are highly over-learned and automatic. In contrast, those necessary for non-native phonemes are unfamiliar. Our hypothesis was that this would result in greater dependency on the function of sensorimotor systems, and that activity in part of this network would decline with practice. Our previous work has shown that regions involved in integrating motor feedforward signals with sensory feedback are more active during non-native speech production, even in proficient bilinguals, relative to native speech. This study used a prospective training fMRI paradigm to explore the functional importance of increased sensorimotor activation for producing non-native speech sounds, and the plasticity within this system with a short period of training. The 22 subjects were monolingual native speakers of English. They were scanned both before and after a week of training in producing these non-native phonemes. The experimental tasks in each fMRI scanning session required subjects to listen to and repeat a range of non-native words, as well as native non-words. The out-of-scanner training consisted of self-paced, computer-based training, which was carried out for approximately one hour a day over five days in between the two scanning sessions. The training introduced subjects to articulatory anatomy in general, before focusing on the non-native speech sounds specifically. Audiovisual material enabled the subjects to listen to and observe native speakers producing the words and were instructed how to move their articulators specifically in order to produce each sound, and the training required them to practise saying the words repeatedly. Subjects were not taught the meaning of the words. These novel sounds varied systematically in place of articulation and in level of

difficulty relative to English phonemes. All the words were bisyllabic and each language group manipulated only one aspect of articulation, by using Spanish consonants, German vowels and Mandarin tones. Subjects' speech was recorded on-line during the two fMRI scanning sessions, as well as throughout the training process, and the speech recordings were assessed by native speakers of the languages included in the study. This allowed us to observe how the sensory regions of the brain changed their activity with training, and whether the amount of measured brain activity faithfully reflected the actual proficiency achieved. Familiarity with non-native speech sounds led to modulation of activity within the network of regions involved in the motor feedforward and sensory feedback production of speech. Non-native speech resulted in higher activity than native non-words and this difference reduced after training. Region of interest analyses revealed dissociation of activity across the three groups of speech sounds. The data from this study have revealed the plasticity within cortical and subcortical regions that are central to acquisition of non-native speech production.

READING & WRITING

B33 fMRI Masked Transposed Letter Repetition Suppression and VWFA Localization

Eddy, M. *(1),* ***Grainger, J.*** *(2),* ***Holcomb, P.H.*** *(3),* ***Del Tufo, S.*** *(1),* ***Gabrieli, J.*** *(1); 1. Massachusetts Institute of Technology, Cambridge, MA; 2. Aix-Marseille University & CNRS, Marseille, France; 3. Tufts University, Medford, MA* – The existence of the putative visual word form area (VWFA) has been highly debated in the past years. The aim of the current studies was to isolate processing specific to word forms. We used two different tasks to examine the amount of overlap in VWFA localization across two different experiments. One paradigm combined masked repetition priming in orthographically overlapping transposed letter prime-target pairs (barin-BRAIN) compared to non-overlapping pairs (bosin-BRAIN) to examine brain regions involved in rapid processing of word stimuli. Sixteen typical reading adults, 18-30 years old, took part in this event-related fMRI experiment where they performed a go, no-go semantic categorization task. A second paradigm, a localizer, comparing words, objects, faces and scrambled stimuli that controlled for low level stimulus characteristics was collected in the same participants. In this paradigm participants performed a low level task where they were instructed to detect an occasionally occurring target trial (anytime the stimulus was green in color – all other trials were black on a white background). In the masked priming experiment, repetition suppression was observed for the orthographically overlapping stimuli compared to the non-overlapping stimuli in an area near the canonical VWFA as well as in bilateral inferior frontal regions. In the localizer paradigm, when comparing words greater than objects, we observed a very similar pattern of activity as in the masked priming paradigm. Activations for words greater than objects were localized to left ventral temporal cortex and inferior frontal region. These activations for the localizer were very close to those areas showing repetition suppression in the maskedpriming paradigm, specifically the VWFA and inferior frontal regions. These results suggest even across different tasks and stimuli, consistent areas emerge as playing an important role in processing word form.

B34 Early decomposition effects during visual processing of past tense verbs: An MEG study using masked priming and single-word lexical decision tasks

Fruchter, J. *(1),* ***Stockall, L.*** *(2),* ***Marantz, A.*** *(1); 1. New York University, New York; 2. Queen Mary, University of London, UK* – **Objective:** To what extent does morphological structure play a role in early processing of visually presented English past tense verbs? Previous masked priming studies have demonstrated obligatory form-based decomposition even for pseudo-affixed words; for example, "brother" is decomposed into "broth" + "-er" (Rastle, Davis, & New, 2004). Additionally, MEG studies of derivational morphology have demonstrated that the transition probability from stem to affix modulates an early evoked response known as the M170 (Solomyak & Marantz, 2010 and Lewis et al., in press, for parallel findings for pseudo-affixed words). Surprisingly, an MEG study of masked identity priming did not provide evidence of an M170 effect, instead finding a later effect at ~225 ms (Monahan, Fiorentino, & Poeppel, 2008). Here we performed two MEG lexical decision experiments: (i) a masked priming experiment with identity, regular, and irregular conditions; and (ii) a single-word experiment with past tense verbs. (i) is designed to test for an M170 priming effect, confirming this as the locus of decomposition for both regular and irregular verbs since a behavioral masked priming study with irregular verbs indicated that they prime their stems more than orthographically matched controls (Crepaldi et al., 2010). (ii) aims to verify that the transition probability between stem and inflectional affix modulates the M170, as in derivation (Solomyak & Marantz, 2010).If masked priming for irregulars modulates the M170 and if irregulars show a transition probability effect, form-based decomposition must be more abstract than previously understood. Methods: Twelve right-handed native English speakers participated in the two experiments. The masked priming experiment included four conditions: identity ("car"-"CAR"), regular ("jumped"-"JUMP"), irregular ("fell"-"FALL"), and pseudo-irregular ("bell"-"BALL", controlling for orthographic sub-regularity in "fell"-"FALL"). The single-word experiment included regular and irregular past tense verbs. Cortically-constrained minimum norm estimates were generated in MNE. Neural activity in source space was investigated via anatomical regions of interest (ROIs) in the left temporal lobe. Results: In masked priming, there was significant RT facilitation for the identity, regular, and irregular conditions. At ~150-200ms, there was a masked priming effect on activity in left temporal ROIs for the identity, regular, and irregular conditions. For the single-word experiment, at ~100-130ms, there was a transition probability effect in the left fusiform ROI for the regular verbs, but not the irregular verbs. Conclusions: Our study reveals an earlier MEG masked priming effect than previously reported, and it confirms the existence of inflectional transition

probability effects for regular verbs. The masked priming for irregular verbs at the M170 suggests that they are decomposed into their stems for lexical access, but their lack of a transition probability effect indicates that this decomposition is not simply form-based. This is not surprising, given that irregular verbs cannot be visually segmented into stems and affixes in the same way as regular verbs. Nonetheless, the masked irregular priming results argue for decomposition, in agreement with previous results demonstrating that irregular verbs prime their stems in a morphological identity relation (Stockall & Marantz, 2006), but problematize the nature of the masked priming effect.

B35 Number of meanings and number of senses: An ERP study of sublexical ambiguities in reading Chinese disyllabic compounds ***Huang, H.W.****(1),* ***Lee, C.Y.****(2); 1 University of Illinois, Urbana-Champaign; 2 Institute of Linguistics, Academia Sinica, Taiwan* – In English, behavioral and neuropsychological evidence suggest that homonymy (many distinct meanings) and polysemy (many related senses) may be represented, retrieved, and processed differently in the human brain. In Chinese, most of the words are compounds and the constituent character within a compound word can carry different meanings and/or related senses (sublexical ambiguity). This study aims to examine how two types of sublexical ambiguity affect Chinese word processing. Both the number of meanings (NOM) and the number of senses (NOS) corresponding to the first character of Chinese compounds were manipulated in a lexical decision task. Behavioral result showed a main effect of NOS advantage and an interaction between NOM and NOS, in which NOM disadvantage effect was found for few-senses words only. Similarly, NOM and NOS interaction also showed on N400, words with ambiguous, few-senses characters (NOM>1, few-senses) elicit a more negative N400 than words with unambiguous, few-senses characters (NOM=1, few-senses), but there was no such tendency for words with many-senses. On the other hand, the NOS effect was significant for words with ambiguous constituent characters (NOM>1) - words with many-senses showed a less negative N400 than few-sense words. No NOS effect for words with unambiguous constituent characters (NOM=1). The ambiguity disadvantage suggested that semantically unrelated morphemes are represented as separate entries. For characters with multiple meanings, one orthographic form is linked to more than one morphemic representation. This one-to-many mapping from form-to-meaning slows down the process of a morpheme. On the other hand, the sense advantage can be interpreted as that semantically related senses shared a morphological root and are represented within a single entry. The more senses listed in a morphological root the richer or stronger semantic relatedness will be formed.

B36 Interhemispheric effective connectivity increases during processing of Japanese Kanji ***Keith J. Kawabata Duncan*** *(1,2),* ***Tae Twomey*** *(3),* ***Parker Jones*** *(1),* ***Mohamed Seghier*** *(1),* ***Katsuyuki Sakai*** *(2),* ***Cathy J. Price*** *(1),* ***Joseph T. Devlin*** *(3); 1. Wellcome Trust Centre for Neuroimaging, UCL, London, UK; 2. University of Tokyo, Japan; 3. UCL, London, UK* – The Japanese writing system is composed of multiple scripts and, uniquely, both morphographic (Kanji) and syllabographic (Hiragana) are in everyday use. Kanji characters (e.g., "和紙" [Japanese paper]) are semantically rich but phonologically impoverished. They are also visually complex. Hiragana characters (e.g., "みりん" [Japanese sweetener used in cooking]), on the other hand, are semantically impoverished but phonologically rich and are visually simple. Because of these opposing characteristics, it has long been suggested that the two scripts are processed differently by the brain. However, in general studies have found that Kanji and Hiragana activate the same network of regions. Where there are differences, they tend to be quantitative rather than qualitative; in particular, Kanji show more bilateral activation. To further explore processing differences between scripts, we used fMRI with dynamic caUSl modelling (DCM) to investigate effective connectivity within bilateral areas of the language network. 34 native Japanese readers made lexical decisions on visually presented Japanese compound Kanji and Hiragana words. To examine the connectivity in the language network, we first identified cortical regions that were commonly activated for both Kanji and Hiragana items. To capture potential hemisphere differences, these regions comprised bilateral ventral occipitotemporal (vOT) cortex and bilateral dorsal pars opercularis (d-pOp). Second we used these regions in DCM analyses, investigating the intrinsic connectivity in the network common to both Kanji and Hiragana and importantly, the modulatory connectivity in the network for Kanji relative to Hiragana. We found that for Kanji and Hiragana, all intrahemispheric connections were significant (Figure). Both forward connections (vOT -> d-pOp) were positive, whereas both backward intrahemispheric connections (d-pOp -> vOT) were negative. In other words, both scripts resulted in vOT driving activity in, while itself being suppressed by, d-pOp. The posterior interhemispheric connections (LH vOT <-> RH vOT) were both significant. These posterior interhemispheric connections were both positive, meaning that increased activity in one reciprocally increased activity in the other. In contrast, neither anterior interhemispheric connection (LH d-pOp <-> RH d-pOp) was significant. In addition to this pattern of connectivity common to Kanji and Hiragana, Kanji significantly increased the strength of the LH vOT -> RH vOT connection, relative to Hiragana. Consistent with standard GLM analyses of neuroimaging data, we found that Kanji and Hiragana share a common bilateral network. Crucially however, the effective connectivity for Kanji differed significantly from that of Hiragana, with Kanji increasing flow of information from left vOT to right vOT. This increase in connection strength is consistent with a decrease in left hemispheric asymmetry for Kanji and may reflect an increased demand on visual form processing.

B37 Neuronal Interactions for Words and Pseudowords during Lexical Decision ***Kielar, A.*** *(1),* ***Mack, J.*** *(1),* ***Meltzer-Assher, A.*** *(1),* ***Wali, E.****, (1), Thompson, C. K.(1); 1. Northwestern University* – **Introduction:** The neural

processes that underlie lexical decision are shaped by word type. Pseudowords activate both dorsal (BA 44) and ventral (BA45/47) parts of the left inferior frontal gyrus (IFG) more strongly than words, reflecting increased phonological processing and more extensive lexical search, respectively (Fiebach et al., 2002; Heim et al., 2005). In contrast, words elicit greater activation in the left angular gyrus (AG), reflecting lexical-semantic processing (Binder et al., 2003, 2005; Davis & Gaskell, 2009; Fiebach et al., 2002; Henson et al., 2002; Ischebeck et al., 2004). In the present study, we used DCM to investigate the neural dynamics underlying these effects. In particular, we tested whether lexical status influences interactions between frontal and posterior regions. Methods: Neural responses from 11 healthy volunteers were measured using fMRI while they performed a lexical decision task. Direct comparisons of words to pseudowords revealed stronger activation in the left AG for words, and left IFG and fusiform gyrus (FG) for pseudowords. Word-type dependent interactions between these areas were then investigated using DCM. For each participant four DCMs were estimated that included four left-lateralized ROIs identified in the group GLM analysis: BA44, BA47, FG and AG. For all subject-specific models bidirectional intrinsic connections were specified between all four regions, with words and pseudowords serving as direct inputs to the FG. Additionally, words and pseudowords were entered as modulatory parameters to examine changes in connectivity as a function of word type. At the second level Bayesian Model Selection was used to identify the best-fitting model. The parameter estimates of the winning model (driving inputs, intrinsic connections, and modulations) from all participants were entered into one-sample t-tests. Results: According to the winning model bidirectional connections between the FG and BA47, as well as between FG and BA44, were significantly greater than zero (all ps < .01), as was the forward connection between BA 47 and BA 44 ($t(10) = 10.84$, $p < .01$). In addition, the coupling between BA 47 and the AG was significantly less than zero ($t(10) = -3.50$, $p < .01$), as was connection between FG and AG, ($t(10) = -3.25$, $p < .01$). The influence of driving inputs (words + pseudowords) on the FG was significantly greater than zero (words: $t(10) = 6.37$, $p < .01$; psw: $t(10) = 16.60$, $p < .01$). The forward connection between the FG and BA 47 was strengthened by pseudowords ($t(10) = 4.80$, $p < .01$) and weakened by words ($t(10) = -4.13$, $p < .01$). The forward connection between BA 47 and BA 44 was likewise weakened by words ($t(10) = -2.87$, $p < .05$). Conclusion: The results indicate that during lexical decision coupling between the FG and IFG is influenced by word type (cf. Mechelli et al., 2005): pseudowords strengthen the connection to ventral IFG, consistent with its hypothesized role in guiding lexical search and selection. The finding that words negatively modulate the forward connection between BA47 and BA44 is in line with the assumption that BA44 is involved in phonological processing.

B38 The role of left frontal regions in phonological assembly: Insights from a novel paradigm ***MacSweeney, M.*** *(1,2),* ***Waters, D.*** *(2),* ***Kherif, F.*** *(3),* ***Woll, B.*** *(2).,* ***Price, C.J.*** *(4); 1. Institute of Cognitive Neuroscience, London; 2. ESRC Deafness, Cognition and Language (DCAL) Research Centre, London; 3. Université de LaUSnne, Suisse; 4. Wellcome Trust Centre for Neuroimaging, London* – **Objective:** The aim of this study was to examine the role of left frontal regions in phonological assembly during reading. The ability to pronounce novel words, and thus learn new words, is supported by knowledge of the relationship between grapheme combinations and their related sounds. This involves retrieving sublexical phonology and holding the sounds in memory while assembling the sounds into whole words. A popular approach to identifying the brain areas associated with phonological assembly has been to compare activation for reading novel (pseudo) words with reading real words. This has consistently shown increased activation in left inferior frontal and premotor areas (e.g., Mechelli et al., 2005). However, the interpretation of increased activation for pseudowords than words is confounded by differences in lexicality and familiarity. Left inferior frontal activation for pseudowords has thus been accounted for by some in terms of decreased familiarity and increased reading time, rather than phonological assembly (see Binder et al., 2005). In the current study, we use a novel approach to explore the regions involved in phonological assembly by manipulating the presentation of the same stimulus identities. We compared activation for words and letter strings that were presented either sequentially – with individual letters appearing in fluid sequence, or simultaneously – as globally emerging text. Since the same stimuli were presented both simultaneously and sequentially, lexicality, familiarity and response times were matched across conditions. Methods: Participants performed a visual lexical decision task during fMRI data collection. Lexicality (words vs. letter strings) and Presentation Context (sequential vs. simultaneous) were orthogonally manipulated, resulting in a 2 x 2 factorial design. A mixed design was used such that letter strings and words were presented randomly (event-related), whereas presentation context (sequential vs. simultaneous) was blocked. These blocks were interleaved with null events (fixation cross) of variable duration. Participants made a speeded, forced-choice button-press response to each stimulus item, indicating whether or not the item was a word. Results: There was no main effect of Presentation Context observed in the accuracy or reaction time data. However, a significant main effect of Lexicality and a Lexicality x Presentation Context interaction demonstrated that responses to letter strings were slower during the sequential than the simultaneous condition. The fMRI data indicated greater activation for sequential than simultaneously presented words and letterstrings in two left frontal regions: dorsal premotor cortex and pars opercularis. Conclusions and significance: By manipulating presentation context rather than word type, this study demonstrates a role for left inferior frontal and premotor regions in phonological assembly. A role which, in this case, cannot be attributed to differences in response times, lexicality or familiarity. References: Binder et al., 2005, Neuroimage Mechelli et al., 2005, J Cogn Neurosci

B39 Learning to read a new language shapes the neural activities associated with reading in the native language ***Leilei Mei*** *(1),* ***Gui Xue*** *(2,3),* ***Zhonglin Lu*** *(3),* ***Qi Dong*** *(2),* ***Chuansheng Chen*** *(1); 1. University of California, Irvine, CA; 2. Beijing Normal University, Beijing, China; 3. University of Southern California, Los Angeles, CA* – Learning to read one or more foreign languages is essential for social and economic success in this era of globalization. One fundamental issue is how the native language interacts with the second language. Decades of research have provided accumulative evidence on the effect of native language (L1) on second language (L2). However, much less attention has been paid to the influence of L2 on L1, especially in terms of neural organization. Here, we adopted an artificial language training paradigm and fMRI technology to examine whether learning to read a new language affects the neural organization of L1 and the level (i.e., orthographic, phonological, and semantic) at which such effects occur. The artificial language was created by adopting the visual forms and sounds of 60 Korean Hangul characters, and was assigned arbitrary meanings. To disentangle the effects of phonology and semantics, two matched groups of subjects were recruited to learn the artificial language either with or without semantics for eight days, one hour per day. A naming task was used at the end of each day to collect behavioral data on learning performance. Before and after training, subjects were scanned when performing a perceptual task, during which subjects were asked to carefully view 60 Chinese words (CWs) and 60 artificial language words (ALWs). It should be noted that, except for semantics, the intervening variables such as the number of repetitions and overall learning time were controlled for across the two groups. Behavioral results showed that training significantly improved naming accuracy and reduced reaction times for both groups of subjects, suggesting that our training was effective, although the performance of the semantic group was a little poorer than that of the phonological group. Imaging data showed that training resulted in increased activations for ALWs in both groups. Specifically, training-related increases were found in the bilateral inferior frontal gyrus (IFG) for the semantic group, and in the anterior cingulate cortex, left IFG, occipitotemporal (OT) areas, and bilateral occipitoparietal (OP) areas for the phonological group. Surprisingly, we found that, in the CW condition, semantic training on ALWs resulted in decreased activations in several regions, including the left IFG, middle temporal gyrus, and bilateral OT as well as the OP areas. In contrast, no significant neural changes in the CW condition were found in the phonological group. Taken together, using an artificial language paradigm, this study demonstrated that learning to read a new language shaped neural activities of word reading in the native language and this occurred only at the semantic level.

B40 Reading faces: Investigating the use of a novel face-based orthography in acquired alexia ***Moore, M.W.*** *(1),* ***Brendel, P.C.*** *(1), and* ***Fiez, J.A.*** *(1); 1.The University of Pittsburgh, PA* – A left lateralized fusiform area, the visual word form area (VWFA), is involved in the orthographic-to-phonological transformation in reading. A widely accepted role of the VWFA is its function in processing the letter-like qualities of English graphemes (e.g., line segments; McCandliss, Cohen, & Dehaene, 2003), though its specific role has been disputed. The purpose of this study was to further examine the nature of the VWFA using a single case study of a patient with acquired alexia who had damage to this region of the brain. Specifically, we asked if she would be able to learn a novel alphabetic orthography that consisted of non-letter-like graphemes (i.e. faces); in our previous work (Moore, Durisko, Perfetti, & Fiez, Submitted), we have shown that the 35 face-phoneme pairings that comprise the "FaceFont" orthographic system can be readily acquired by healthy, young adults in a single, 2-hour training session. The patient (AA1), a female who was 68 years old at the time of initial testing, presented with the classic letter-by-letter reading observed in patients with acquired alexia, such that she exhibited a steep, linear increase in reading latencies as words increased in length. She performed age-appropriately on other general measures including intelligence, verbal working memory, spatial working memory, memory for faces, verbal paired associative learning, auditory phonological processing, and reading comprehension for simple stories. In an initial testing session based upon our standard training procedures, AA1 learned only 2/35 of the FaceFont grapheme-phoneme associations. In subsequent training sessions, she completed a reduced training protocol in which two subsets of five grapheme-phoneme associations were introduced one at a time. The training protocol for each subset was followed by a decoding task involving word and nonword items comprised of the trained graphemes. Compared to age- and gender-matched control participants, AA1 demonstrated a markedly decreased ability to acquire the grapheme-phoneme associations as well as decreased ability to decode items comprised of the graphemes that she did acquire. These findings indicate that the VWFA's contribution to reading is not bounded by the visual perceptual qualities of the orthographic stimuli, and that the region plays a general role in mapping visual stimuli to stored speech sounds. It remains an open question whether the deficits observed in AA1 are specific to phoneme-level associations, or whether the ability to form associations involving larger phonological units (e.g., syllables, words) is affected as well. References: McCandliss, B.D., Cohen, L. & Dehaene, S. (2003). The visual word form area: Expertise for reading in the fusiform gyrus. Trends in Cognitive Science, 7, 293-299. Moore, M.W., Durisko, C., Perfetti, C.A., & Fiez, J.A. (Submitted). Reading faces: Examining the effects of a novel face-based orthography. Abstract submitted to the 2011 Annual Meeting of the Society for Neuroscience, Washington, D.C.

B41 Abstract letter identity representations revealed through multi-voxel similarity analysis ***Rothlein, D.*** *(1),* ***Rapp, B.*** *(1); 1. The Johns Hopkins University, MD* – **Objective:** Literate adults effortlessly recognize that r and R refer to the same letter. A common explanation is to assume a representational

level that encodes a letter's abstract letter identity (ALI) in a case-invariant manner. Previous fMRI studies investigated case-invariance by identifying regions exhibiting cross-case word priming (e.g. dog facilitating DOG) (Dehaene, 2001; 2004), or by comparing brain responses for alternating and single-case words (e.g. OrAnGe vs. orange) (Polk and Farah, 2002). Their findings indicated case-invariant responses in the left mid-fusiform gyrus. The present fMRI study is also concerned with investigating the neural representation of abstract letter identity, however it is different from previous studies in that: (1) we used single letter stimuli to minimize the possible influence of lexical or sub-lexical processes; (2) we explicitly tested if evidence of case-invariant representation could be explained by letter-name representation (e.g. b and B are both pronounced /bi/); (3) we used a multi-voxel analysis approach that allowed us investigate the neural responses to letter stimuli in ways that are difficult for univariate methods. Methods: The present study evaluated the ALI claim by examining the multi-voxel pattern of BOLD responses from 9 participants viewing single upper and lower case letters. To do so we developed a searchlight application of Representational Similarity Analysis (Kriegeskorte, 2008). We examined if the similarity of the neural response of voxels to different letters was predicted by: pixel-overlap, cross-case identity (a/A), and letter-name similarity. Pixel-overlap was used to identify brain regions sensitive to low-level visuospatial properties of the letter by predicting higher correlated patterns of BOLD activity for letter-pairs that had a greater degree of pixel-wise similarity. Cross-case identity was used to identify ALI representations by predicting identical patterns of BOLD activity for cross-case identity pairs (a/A) and uncorrelated activation patterns for all other cross-case pairs (a/B). Case-invariant response patterns are also consistent with responses to letter names. To distinguish between these possibilities, we used a letter-name confUSbility matrix (Hull, 1973) to identify brain regions that were sensitive to the names of letters (e.g. confUSble letter-pairs like "b" and "e" should have more similar patterns of activation than non-confUSble pairs like "b" and "r"). Results and Conclusions: A brain region that represents ALIs should have activation similarity that is predicted exclusively by cross-case identity, and not letter-name similarity or pixel-overlap. Consistent with previous literature, we found such a region in the left-mid fusiform gyrus. Pixel-overlap, on the other hand, matched with activation similarity for low-level visual regions within the posterior occipital cortex. These results affirm the validity of the methodology. We found letter-name sensitivity in bilateral regions along the middle/superior temporal gyrus and in the left anterior inferior frontal gyrus. Importantly, however, within the fusiform gyrus, letter-name sensitive areas did not overlap with substrates showing case-invariant ALI responses. These results constitute the strongest evidence to date for the neural representation of ALIs in the left-mid fusiform gyrus and demonstrate a novel approach to identifying the format and location of letter representations throughout the brain.

B42 Functional network elements in patterned hand movements and writing ***Saarinen, T.*** *(1),* ***Kujala, J.*** *(1),* ***Jalava, A.*** *(1),* ***Laaksonen, H.*** *(1),* ***Salmelin, R.*** *(1); Aalto University, Espoo, Finland* – The left hemisphere of the human cortex is crucial for both right-handed tool use and linguistic expression, abilities that come together in the acquired skill of handwriting. We investigated the left-hemisphere interareal functional connectivity supporting motorically comparable linguistic and non-linguistic hand movements. The tasks included regular and simplified handwriting, and varied and monotonous pattern drawing; they were contrasted with rest. Magnetoencephalography (MEG) was used for real-time tracking of cortical activity and electromyography (EMG) of the right upper limb for registering the arm muscle activity. Cortical nodes of corticomuscular and corticocortical coupling were identified with Dynamic imaging of coherent sources (DICS), at the prominent coherent frequencies of the movement rate (~2-5 Hz) and in the low and high 10-Hz band. Coherence reflects dependencies in the frequency domain and it is thought to indicate the efficiency of information transfer between oscillating neuronal assemblies. A fully data-driven search revealed a task-related network of coupled areas that mainly covered frontal and parietal cortex but also included language-related areas of temporal and temporo-occipital cortex. This connectivity pattern matched earlier activation and stimulation findings markedly well. For instance, specific premotor and parietal nodes fell close to areas that have been assigned an important role in writing (Exner's area) and tool use. Synchronization index showed subtle but significant task-modulations for three functional connections: middle and superior frontal areas were more synchronized in monotonous than varied drawing, whereas the linguistic aspect of the tasks enhanced synchronization between parietal and inferior frontal as well as between superior temporal and inferior temporo-occipital nodes. The present findings show how oscillatory coupling between brain areas can reveal functional connectivity pattern supporting the linguistic-motor function, without a need to select specific seed regions. We found a multi-node network that was largely shared by both linguistic and non-linguistic hand movements, but with the synchronization in a subset of connections modulated by the linguistic content of the graphomotor task.

B43 Orthographic learning in real-time: Differential contributions of the fusiform gyrus and the hippocampus ***Schubert, T.*** *(1),* ***Rapp, B****. (1); 1. Johns Hopkins University, Baltimore, MD* – **Objective.** Research has identified the role of the left mid-fusiform gyrus in reading (Cohen et al., 2002) and spelling (Rapp & Lipka, 2011). Furthermore, this region –often referred to as the VWFA (Visual Word Form Area) --has been implicated in the acquisition of literacy (Dehaene et al., 2010)and also shows increased processing efficiency with increasing word frequency (Rapp & Lipka, 2011) and with repeated presentations of written words (Pugh et al., 2008). However, the functional properties of the VWFA have not been examined during real-time orthographic learning. The current study examined the involvement of the

VWFA and the hippocampus in the learning of orthographic representations by normal adults. Methods. Participants learned mappings between auditory pseudowords and arbitrarily-designated "to-be-learned" spellings.The learning task involved repeated trials in which participants heard a pseudoword and selected from four visually-presented spelling choices. All spelling choices were phonologically plausible; the to-be-learned spelling was predetermined by random selection and indicated through feedback. For example, the pseudoword /tʃejkǝ/ was presented with: CHAKA CHAICA CHACA CHAIKA, with CHAIKA was the to-be-learned response. 24-48 hours before an fMRI scanning session, participants learned four pseudoword spellings as Reference items for comparison to items learned during the scanning session. Over the course of four scanning runs, participants learned twenty additional pseudowords in two sets of ten items. Eight Learning trials for each item were randomly intermixed with perceptual-motor Baseline trials and eight presentations of Reference items. To identify substrates generally involved in learning, whole-brain analysis identified areas more active for Learning trials than Baseline trials. Additional volume-of-interest analyses involved a functionally localized VWFA cluster, its right hemisphere homologue, and neuroanatomically-identified bilateral hippocampi. The first learning trial for each item, representing processes involved in initial exposure and novelty, was coded separately. For analyses designed to examine changes in neural response throughout the time-course of orthographic learning, Learning trials were categorized by: (a) presentation number, with a different predictor for each presentation (1-7) collapsed across items (Pugh et al., 2008), and (b) memory strength, with a different predictor for each of five memory strengths determined by categorizing each trial based on the probability of a correct response (Law et al., 2005; Smith et al., 2004) Results/Conclusions.Whole-brain analysis revealed that orthographic learning recruited neural areas traditionally associated with reading and spelling tasks, including the left mid-fusiform gyrus, left inferior gyrus/junction, and left supramarginal gyrus. Small-volume analysis revealed that in the VWFA and its homologue, activation decreased with increasing presentation number, with a steeper slope over earlier presentations than later ones. In contrast, the VWFA response did not change systematically with increasing memory strength. Conversely, activation in the bilateral hippocampi increased as a function of memory strength but was highly variable over presentation number. These results provide novel evidence of the distinctive roles played by the VWFA and hippocampus in the learning of orthographic representations, with the VWFA sensitive to the number of repetitions and the hippocampus sensitive to the strength of the memories being formed. References. Cohen, L., Lehéricy, Chochon, F., Lemer, C., Rivaud, S. & Dehaene, D. (2002). Language-specific tuning of visual cortex?Brain. 125, 10954-1069. Dehaene, S., Pegado, F., Braga, L., Ventura, P., Nunes Filho, P., Dehaene-Lambertz, G., Kolinksy, R., Morais, J., and Cohen, L. (2010). How learning to read changes the cortical networks for vision and language. Sciencexpress. Law, J. R., Flanery, M. A., Wirth, S., Yanike, M., Smith, A. C., Frank, L. M., … Stark, C.E.L. (2005). Functional magnetic resonance imaging activity during the gradual acquisition and expression of paired-associate memory. The Journal of Neuroscience, 25, 5720-5729. Pugh, K. R., Frost, S. J., Sandak. R., Landi, N., Rueckl, J. G., Constable, R. T., … Mencl, W. E. (2008). Effects of stimulus difficulty and repetition on printed word identification: An fMRI comparison of nonimpaired and reading-disabled adolescent cohorts. Journal of Cognitive Neuroscience, 20, 1146-1160. Rapp, B., & Lipka, K. (2010). The literate brain: The relationship between reading and spelling. Journal of Cognitive Neuroscience. DOI: 10.1162/jocn.2010.21507. Smith, A., Frank, L., Wirth, S., Yanike, M., Hu, D., Kubota, Y., Graybiel, A., Suzuki, W., & Brown, E. (2004). Dynamic analysis of learning in behavioral experiments. Journal of Neuroscience, 24, 447-461.

B44 Spatial specification in Chinese character recognition: The role of structural configuration and radical similarity ***Su, I.-F.*** *(1),* ***Lee, R.H.-M.*** *(1),* ***Law, S.-P.*** *(1); 1. The University of Hong Kong, Hong Kong* – **Introduction:** About 34% of 4-letter words in English and French can form other words by rearranging their letters. Therefore, spatial specification of letter position is vital to correct word recognition and production (see Grainger & Van Heuven, 2003). The orthographic form of Chinese characters differs dramatically from alphabetic scripts as character components (radicals) are arranged in a square shape of constant size. Whether spatial information of these components is necessary in the Chinese lexicon can also be asked given the existence of transposable characters, e.g. 呆 and 杏 (Taft, Zhu, & Peng, 1999). Hence, how characters are structurally represented has led to at least two proposals. The Multilevel Interactive-Activation model (Taft & Zhu, 1997) postulates that radicals are specified for position of occurrence within a character (e.g. 嫁 constitutes of a left radical 女 and right radical 家). In contrast, the Lexical Constituency model (Perfetti, Liu, & Tan, 2005) assumes a role of structural configuration in characters. This refers to the relative spatial relationship among radicals in a character and is conceptualized as 'spatial slots' that radicals occupy (e.g. left-right: 嫁; top-bottom: 爸; enclosing: 鬧or困). While the former finds evidence from facilitative priming effects on lexical decision latency when prime and target share the same radical in the same position, unambiguous support for the latter is lacking. Methods. Thirty-three right-handed Cantonese speakers performed a lexical decision task where each trial began with a prime (48ms) sandwiched between a forward (100ms) and backward (16ms) mask, followed by the target character. Targets were 30 low frequency (<80 per million, Leung & Lau, 2011) characters with left-right configuration and 30 filler pseudo-characters. Primes were pseudo-characters related to corresponding targets by Radical Similarity (same vs. different radical) and Configuration (same vs. different), giving four prime types: (1) same configuration-same radical, (2) different configuration-

same radical, (3) same configuration-different radical, and (4) different configuration-different radical. Same radical primes never shared the same position to their targets. All pseudo-characters were stroke matched to their corresponding real word targets. Electrophysiological data was collected simultaneously with the behavioral reaction time and accuracy data. Results and Discussion. Behavioral results showed facilitative effects for shared radicals whereby participants were faster to identify targets that shared the same radical as the prime. A radical-by-configuration interaction was also found where radical similarity facilitation was observed when the prime and target shared the same configuration. ERP results reflected a greater contribution of configuration as significant effects of configuration were found at the N1 component (80-140ms) for all electrodes in the occipital region. Targets sharing the same configuration as their primes elicited a more negative N1 than ones with different configuration. In contrast, the radical similarity effect was only observed in the left occipital electrode, where greater negativity was found for targets that shared the same radical as their primes (Figure 1). The findings suggest that configuration plays an early role in Chinese character recognition and challenges models that do not assume such features in the orthographic lexicon.

B45 Eye Movement Modulation of Word Processing ***Temereanca, S.*** *(1),* ***Hamalainen, M.S.*** *(1),* ***Kuperberg, G.*** *(1,2),* ***Stufflebeam, S.M.*** *(1),* ***Halgren, E.*** *(3),* ***Brown, E.N.*** *(4,5); 1. Harvard Medical School, Martinos Center for Biomedical Imaging, Charlestown, MA; 2. Tufts University, Medford, MA; 3. University of California, San Diego, CA; 4. Massachusetts General Hospital, Boston; 5. Harvard/MIT, Cambridge, MA* – Reading is an active process that requires coordination between frequent eye movements (saccades) and short fixations on the visual target. Yet, the impact of saccades on word processing remains unknown, as previous work has focused on stimulus processing during constant eye fixation. Here we investigate the effects of saccades on word recognition processes employing anatomically-constrained magnetoencephalography (MEG), psychophysical measurements and eye movement detection in real time. Word recognition was slower and brain responses were reduced to words presented early vs. late after saccades, suggesting an overall transient impairment of word processing after an eye movement. Response reductions occurred in early visual as well as language regions, where they were co-localized with repetition priming effects implicated in lexical and semantic processing. Similar effects occurred when words were presented early vs. late after background movement that mimicked saccades, suggesting an inhibitory contribution to postsaccadic effects from retinal image motion. At the same time, significant differences in the degree of postsaccadic and background movement modulation of word processing are consistent with additional central postsaccadic influences mediated by brain regions that control eye movements and attention. Together, our results suggest complex peripheral visual and central postsaccadic influences on word processing that alter perception and reading performance.

B47 Dissociating visual form from frequency using Japanese ***Twomey, T.*** *(1),* ***Kawabata Duncan, K. J.*** *(2,3),* ***Hogan, J. S.*** *(1),* ***Morita, K.*** *(3),* ***Umeda, K.*** *(3),* ***Sakai, K.*** *(3)* ***Devlin, J. T.*** *(1); 1. University College London, UK; 2. University College London; Wellcome Trust Centre for Neuroimaging, London, UK; 3. University of Tokyo, Japan* – Of all the world's languages, only Japanese relies on multiple written orthographies for its everyday use.The ability to write the same word in either morphographic Kanji or syllabographic Hiragana means that Japanese offers a unique opportunity to disentangle the frequency of a word from the frequency of its visual form.This is particularly relevant to theories of ventral occipitotemporal (vOT) contributions to reading as previous studies have shown greater vOT activation for low than high frequency words.If the effect is due to lexical frequency, then it speaks directly to "visual word form area" accounts that posit neuronal specialization for written words.If, on the other hand, activation is modulated by visual familiarity rather than word frequency, this would be consistent with the hypothesis the region plays a more domain-general role in representing visual patterns, of which written words are only one example. The objective was to evaluate these hypotheses using functional magnetic resonance imaging (fMRI) and a visual lexical decision task in Japanese. Participants decided whether or not visual stimuli represented real Japanese words.Stimuli were written in either Kanji or Hiragana and fully crossed with visual familiarity.In other words, each word appeared twice in the course of the experiment, once in Kanji and once in Hiragana.Half of the words were more commonly written in Kanji and the other half, in Hiragana.This design allowed us to look for main effects of Visual Familiarity (high vs. low) and Script (Kanji vs. Hiragana) as well as their interaction.A second analysis recoded all the words into quartiles according to lexical frequency (independent of script) and looked for effects of lexical frequency.In this fashion, we could independently evaluate the effects of visual familiarity and lexical frequency on vOT. As expected, there were strong behavioural effects of both visual familiarity and lexical frequency, independent of script.Critically, the imaging results showed that activation in vOT was modulated by visual familiarity (low > high) but not by lexical frequency (Figure).Instead, increased activation for lexical frequency (low > high) was observed in frontal regions including left pars opercularis, left pars orbitalis and the bilateral frontal opercula (not shown). These findings suggest that previously reported frequency effects in vOT were driven by visual familiarity rather than lexical frequency.This can be understood within a predictive coding framework in which vOT receives bottom-up information encoding complex visual forms and top-down predictions from regions encoding nonvisual attributes of the stimulus such as its sound and meaning.Less familiar visual patterns increase the prediction error between the bottom-up and top-down signals, resulting in greater processing demands in vOT.Lexical frequency, on the other hand, increased processing demands in amodal language regions.

B48 Hierarchical processing effects support reading

of words and false fonts ***Woodhead, Z.*** *(1),* ***Barnes, G.*** *(1),* ***Penny, W.*** *(1),* ***Teki, S.*** *(2),* ***Price, C.*** *(1), and* ***Leff, A.*** *(3); 1. Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London, UK; 2. Newcastle Auditory Group, Medical School, Newcastle University, Newcastle-upon-Tyne, UK; 3. Institute of Cognitive Neuroscience, University College London, UK* – **Introduction:** The N170 shows a category-specific response to familiar visual objects such as words or faces, and is localised to the fusiform gyrus (Maurer et al. 2008; Mercure et al. 2011). We explored the latency and amplitude of this component in a magnetoencephalography (MEG) study of word reading in order to identify hierarchical processing effects along the occipito-temporo-frontal axis. Methods and results. Nine right-handed volunteers with no history of reading disorders participated in the study. In an event-related design, participants viewed 200 words and 200 meaningless false font stimuli over four runs. Catch trials (10 per run), consisting of common names such as "James", were included to maintain subjects' attention. To identify sources in an unbiased way, we fitted the sensor space data to the m170 of the average across both stimulus types. Source space dipoles were fitted to this peak using the Variational Bayes Equivalent Current Dipole (VB-ECD) method in SPM8 (Kiebel et al. 2008), which finds the optimal locations of a set of anatomically-defined dipoles for each subject, and uses Bayesian statistics to describe how well these dipoles explain the sensor data. Four anatomical models were tested: (1) A two dipole model, with sources in the left and right V1; 2) A four dipole model, with sources in left and right V1 and ventral occipitotemporal cortex (vOT); (3) A five dipole model, as 2, plus the left inferior frontal gyrus (IFG); (4) Another five dipole model, as 3, plus the right IFG; (5) A six dipole model with bilateral sources in V1, vOT and IFG. All subjects showed the highest model evidence for the six-source model, with a random-effects group analysis using Bayesian Model Averaging (Penny et al. 2010) confirming an exceedance probability of the winning model of 0.997. Having identified each subject's optimal set of dipoles using averaged data, the data were then split into words and false font conditions to examine the effects of stimulus type on latency and amplitude of the M170. Repeated-measures ANOVAs were calculated with the factors stimulus (words or false font), region (V1, vOT or IFG) and hemisphere (left or right). This showed a main effect of region on M170 amplitude ($F(1,8)=2.1$, $p<.05$), with stronger responses in more posterior regions, and a trend towards a stimulus by hemisphere interaction ($F(1,8)=3.0$, $p=.1$) due to stronger left lateralisation for words than false font. The M170 responses occurred significantly earlier in the left hemisphere than the right ($F(1,8)=20$,$p<.005$) and there was a trend towards an interaction of region and hemisphere ($F(2,18)=2.9$, $p=.08$), as the temporal advantage towards the left hemisphere was stronger in the V1 and vOT regions than the IFG. Conclusion. These results support a hierarchical organisation of the reading network with stronger activation in posterior visual areas, and earlier activation in the left hemisphere. The data will be further investigated using Dynamic CaUSl Modellingto infer whether early visual areas are influenced by top-down effects from the vOT or IFG, and how stimulus type modulates connection strengths within the network.

SOCIAL & EMOTIONAL PROCESSING

B49 Understanding speaker meaning: Neural correlates of pragmatic inferencing in discourse comprehension ***Basnakova, J.*** *(1),* ***Weber, K.*** *(2),* ***Petersson, K.-M.*** *(1),* ***Hagoort, P.*** *(1),* ***van Berkum, J.*** *(1,3); 1. Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands; 2. Radboud University, Donders Institute (RU/DI-BCB), Nijmegen, Netherlands; 3. Utrecht University, Utrecht, Netherlands* – **Objectives:** Although the explicitness of words and phrases often suggests otherwise, natural communication is to a large extent inferential. Depending on the context, an utterance like It is hard to give a good presentation for this audience can convey very different messages, for example "You'd better submit a poster!" or, alternatively, Your talk was a mess! The recovery of such context-dependent speaker meanings is absolutely central to communication. However, most neuroimaging studies of language comprehension to date have focused on the comprehension of rather simple coded meaning, or on relatively context-free pragmatic enrichment (e.g. metaphors). To examine the neural systems involved in inferring context-dependent speaker meaning, and the extent to which they overlap with neural systems involved in relatively context-free semantic analysis, we focused on the comprehension of indirect replies, in an fMRI experiment involving spoken dialogue. Methods. Native listeners of Dutch listened to dialogues ending in a question-answer pair. The final and critical utterance, e.g., "It's hard to give a good presentation", had different meanings depending on the dialogue context and the immediately preceding question: It was either a direct reply (e.g. to "How is it to give a good presentation?"), or an indirect reply (e.g. to "Did you like my presentation?"). One of the indirect conditions involved a socio-emotional aspect, as the reason for indirectness was to 'save one's face' (as in excuses or polite refUSls). We used the same critical utterance in all conditions. Results. Relative to direct replies, the indirect replies activated brain structures associated with theory of mind and inferencing: right temporo-parietal junction and bilateral dorso-medial prefrontal / frontal cortex. Both types of indirect replies also activated the insula, known to be involved in empathy and affective processing. Moreover, they recruited bilateral inferior frontal gyrus (IFG), and right middle temporal gyrus, which play a role in semantic selection and semantic integration of inferential information. Interestingly, the comparison between neutral and face-saving indirect replies revealed that the presumed affective load of the face-saving replies activated additional areas in the right hemisphere: anterior cingulate cortex and insula, associated with empathy and affective processing, but also superior temporal gyrus and IFG, involved in inferencing and contextual integration. Discussion and conclusions. The findings of the first fMRI study on the comprehension of indirect replies reveal that the areas used to infer the intended meaning of an implicit

message are partly different from the classic language network. Our results are consistent with the idea that inferring hidden meanings requires taking the speaker's perspective, on both affective and cognitive levels. Interpreting face-saving replies adds not only a social-emotional aspect, but ultimately leads to more complex discourse model building. One of the implications of this study is that currently popular "simulationist‟ accounts of language comprehension are incomplete at best. Finally, our study testifies to the importance of studying language understanding in richer contexts in which we can tap aspects of pragmatic processing, beyond the literal language code.

B50 Is it over-respectful or dis-respectful? Differential brain responses in perceiving pragmatic violation of social status during language communication ***Xiaoming Jiang*** *(1),* ***Yi Li*** *(1),* ***Xiaolin Zhou*** *(1); 1. Peking University, Beijing, China* – **Introduction:** A central issue in the study of pragmatic aspect of language communication is how extra-linguistic information, such as social status of the communicators in social interaction, is taken into account in language comprehension (Grice, 1975). Communicative meanings can be perceived very quickly (Regel et al., 2010; Van Berkum, 2009). In Peking Mandarin, such pragmatic constraints can be manifested in terms of the use of second person pronouns (you/your), whose communicative forms (the respectful forms Nin/Nin-de vs. the less respectful forms Ni/Ni-de) are used differentially according to the relative social status between the speaker and the hearer. The respectful pronouns are used by a speaker of lower status to address a hearer of higher status, whereas the less respectful pronouns are used by a speaker of higher status to address a hearer of lower status. Violation of the status constraints on pronoun USge would lead to perception of over-politeness or impoliteness. The aim of this study was to investigate how information of social status affects the brain activity in pronoun resolution during language comprehension. Method. Continuous EEG signals were recorded when Peking Mandarin speakers read simple sentences describing conversational scenarios (including an utterance and a preceding context) for comprehension. The utterance began with either a respectful pronoun or with a less respectful pronoun. Each utterance was preceded by a context describing a speaker and a hearer in the conversation. The relative social status between the speaker and the hearer was varied, consistent or inconsistent with the status requirement of the utterance pronoun (status-consistent vs. status-reversal). Alternatively, the two persons could be of equal status (status-equal). Result. ERPs locked to the second-person pronouns showed that, compared with the status-consistent condition, the status-reversal condition elicited an anterior N400 for Nin-de and a broad N400 for Ni-de. However, in a later time window, both the status-reversal and the status-equal conditions elicited a sustained positivity effect for Nin-de and a sustained negativity effect for Ni-de. Discussion. These findings suggested the reader builds up expectancy towards the incoming pronoun based on the perceived social status of the communicators; while the inconsistent pronoun causes semantic integration difficulty in an earlier stage of processing, the strategy to resolve the inconsistency and the corresponding brain activity vary according to whether the USge of pronoun is perceived as over-respectful or dis-respectful. The sustained positivity effect may reflect a process of deriving pragmatic (sarcastic) meanings from the situation in which the respectful pronouns were over-used. The sustained negativity effect may reflect the re-evaluation of impolite/morally-inconsistent representations.

B51 The Neural Underpinnings of Theory of Mind Reasoning: Evidence from Aphasia ***Ramachandra, V.*** *(1),* ***Schneider, E.*** *(1); 1. Marywood University, Scranton, PA* – Neuroimaging and neuropsychological data indicate that the frontal lobes play a significant role in theory-of-mind (ToM) reasoning. More recently, the temporoparietal junction (TPJ) has been implicated in ToM reasoning, and understanding of other vital social cues. The current study had two main aims 1) to explore the relationship among executive functions (EF), language and ToM reasoning 2) to determine the area of lesion in people who fail the ToM reasoning tasks. The current paper will only discuss the results related to the second purpose in greater detail. Eight subjects with aphasia participated in the current study. The participants were given a language test (Bedside Evaluation Screening Test, 2nd Edition), an EF test (Colors Trails Test), and ToM reasoning tasks (visual perspective taking). Visual perspective taking tasks required the subjects to infer beliefs in others about the location of a ball based on his/her own visual experience. We did not find a direct relationship between language and ToM reasoning. We were also unable to link the severity of EF deficits with ToM. Both these findings are consistent with past research which has failed to link EF and language with ToM. Interestingly, out of the four individuals who scored below chance on ToM tasks, two had lesions in the left TPJ. The third patient had multiple infarcts affecting bilateral frontal, left temporal, bilateral parietal and bilateral occipital lobes. The fourth patient who scored below chance had suffered a head trauma; she had some memory issues and anomia. She had negative intracranial findings; her failure on ToM tasks could be attributed to her memory problems. Patients who scored above chance on ToM tasks had lesions in various areas excluding the frontal and TPJ. These findings are consistent with previous studies, which have demonstated the importance of frontal lobes and TPJ in ToM reasoning. None of the participants who scored below chance on the ToM reasoning tasks had bilateral TPJ lesions. This bolsters the idea that a unilateral lesion of the left TPJ is sufficient to cause ToM deficits. In conclusion, EF and language deficits could not account for the ToM reasoning deficits seen in patients with aphasia. The site of lesion (damage to the frontal or TPJ) was the only strong factor that could be linked with ToM deficits.

SPEECH PERCEPTION

B52 "A salmon is not a bib" (but perhaps vice versa):

asymmetric mismatch negativity responses to word-final consonants ***Scharinger, M.*** *(1),* ***Bendixen, A.*** *(2),* ***Obleser, J.*** *(1); 1. Max-Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany; 2. Institute of Psychology, University of Leipzig, Germany* – Research in auditory neuroscience has lead to a better understanding of the neural bases of speech perception, but the representational nature of speech sounds within words is still a matter of debate. Electrophysiological research on single speech sounds provided evidence for abstract representational units that may differ in their specificity (phonological categories, e.g. Eulitz & Lahiri, 2004). Here, we test the processing of word-final consonants differing in their place of articulation (coronal [ts] vs. dorsal [ks]) and their acoustic structure (as seen in the time-varying formant frequencies of their onsets, [t] and [k]). The respective consonants distinguish between the German nouns Latz (bib) and Lachs (salmon), recorded from a female native speaker. Initial consonant-vowel sequences were averaged across the two nouns in order to avoid coarticulatory cues before the release of the consonants. Latz and Lachs served as standard and deviant in a passive oddball paradigm, while the EEG from 17 participants was recorded. The change from standard [ts] to deviant [ks] and vice versa was accompanied by a discernible Mismatch Negativity (MMN) response. This response showed an intriguing asymmetry between the deviants Latz and Lachs. Crucially, the MMN for the deviant Latz was more negative than the MMN for the deviant Lachs from 135 to 215 ms post deviance onset. Furthermore, EEG source analyses revealed left-hemispheric temporal sources for both conditions, and an additional right-hemispheric source for the mismatch response to Latz. We interpret these findings as reflecting a difference in phonological specificity: Following from psycholinguistic underspecification theory, we assume coronal segments ([t]) to have less specific or more 'fuzzy' ('featurally underspecified') representations than dorsal segments ([k]). Thus, Latz in standard position generated a less specific predictive value from [t], and the change to [k] in the deviant was more readily 'tolerated'. In contrast, Lachs provided a more specific predictive value from [k] for which the deviant comprising [t] provided a more severe change. Importantly, our results cannot be explained on the basis of segmental or lexical frequency differences. In sum, we argue in favor of a model of speech perception where sensory information is processed in terms of discrete units independent of lexical properties and frequency of occurrence of either whole words or single segments.

Poster Session C

Thursday, November 10 6:15 - 8:15 pm
Senate, Capitol C, and Capitol C Pre-Function

MULTILINGUALISM

C1 Examining the role of proficiency in second language processing: An event-related potential (ERP) investigation of number and gender agreement in L2 Spanish ***Alemán Bañón, J.*** *(1),* ***Fiorentino, R.*** *(1),* ***Gabriele, A.*** *(1); 1. University of Kansas, Lawrence, KS* – Recent ERP studies have examined whether adult L2 learners can show native-like processing (Gillon-Dowens et al., 2010) but few studies test learners at different proficiency levels to investigate how processing develops over time (Rossi et al., 2006). We examine the role of L1 transfer and syntactic distance in the processing of number and gender agreement in English-speaking learners of Spanish at two proficiency levels. English instantiates number agreement, but not gender, which allows us to test competing hypotheses about the role of the L1. Full Transfer/Full Access (FT/FA) (Schwartz & Sprouse, 1996) predicts better performance with number than gender in lower proficiency learners but predicts that gender is ultimately acquirable. In contrast, the Interpretability Hypothesis predicts that native-like processing of gender is impossible regardless of proficiency (Hawkins, 2001). Moreover, recent ERP studies propose that morphological differences in how shared features are realized in the L1-L2 will impact processing (Foucart & Frenck-Mestre, in press). The present study also investigates whether the processing of agreement is modulated by the syntactic distance of the agreeing elements. Clahsen & Felser (2006) propose that L2 learners can only establish syntactic dependencies locally. Previous studies suggest that syntactic distance impacts L2 processing (Gillon-Dowens et al., 2010) but do not tease apart linear and syntactic distance. We compare the processing of number/gender agreement between nouns and adjectives within a noun phrase (condition 1: un edificio muy seguro; a building-MASCULINE(MASC)-SINGULAR(SG) very safe-MASC-SG) and across a verb phrase (condition 2: el cuento es anónimo; the story-MASC-SG is anonymous-MASC-SG). Conditions (1) and (2) manipulate the syntactic distance of the agreeing elements, keeping linear distance constant. FT/FA predicts an advantage for number at lower proficiency, but potentially no gender/number differences for advanced learners. The Interpretability Hypothesis predicts gender/number differences in both learner groups. The Shallow Structure Hypothesis predicts no sensitivity to across-phrase violations for both groups of learners (conditions 1 vs. 2). In condition (3), we examine agreement violations between demonstratives and nouns (este apartamento; this-MASC-SG apartment-MASC-SG), a context in which English requires number agreement. If surface differences in how the L1 and L2 realize a feature affect processing, learners should treat the number agreement violations in conditions (1) and

(3) differently. Results for the Spanish natives (n=24) and the advanced learners (n=24) yielded significant P600s for number/gender violations in the three conditions. The P600 is argued to reflect the repair of morphosyntactic anomalies (Barber & Carreiras, 2005). For the natives, violation effects did not differ between conditions (1-2), suggesting that they were unaffected by the distance manipulation. This was true of the advanced learners for number agreement but not gender agreement (reduced but significant effects in condition 2). Preliminary results for the intermediate learners (n=8) show significant effects for number in conditions (1-2). Effects for gender were significant in condition (1) and marginal in condition (2). Effects approached significance in condition (3) for both number/gender. The results for the advanced learners and the patterns emerging in the intermediate group in conditions (1) and (2) are most consistent with FT/FA.

C2 Neural Substrates Underlying New Word Learning in Adult Monolinguals and Early Spanish-English Bilinguals ***Kailyn Bradley*** *(1),* ***Kelly E. King*** *(2),* ***Arturo E. Hernandez*** *(1); 1. University of Houston, TX; 2. University of Minnesota* – The purpose of this study was to evaluate the neural substrates underlying the early stages of word learning in monolinguals and bilinguals. In particular, we wanted to determine if monolinguals and bilinguals show differences in neural processing of newly learned words that share orthographic similarity to their English translations. English monolingual and early Spanish-English bilingual participants learned 100 German words, 50-cognates and 50-non-cognates. Using an event-related design 100 German words and matched English controls were presented one at a time in an fMRI scanner, and subjects were asked to perform a semantic task after each word was presented. Within group analyses in monolinguals showed fewer, more localized regions were active in the English > German condition compared to the German > English condition. This suggests more automatic, less effortful processing of L1 words compared to new words in monolinguals. Within group analyses in bilinguals showed significant reductions in intensity of activation in the left inferior parietal lobe and Broca's area compared to monolinguals. Bilinguals also showed activation in a variety of cognitive control and memory related regions not present in monolinguals, such as left posterior cingulate, bilateral caudate, insula, and bilateral hippocampus. This suggests that monolinguals and bilinguals may be using different mechanisms to process novel words. Monolinguals showed activity in regions associated with difficult phonological and articulatory processing, whereas bilinguals showed activity in areas involved in memory, cognitive control, and language regions. The between groups 2x3 ANOVA confirmed these results and showed that in the monolingual > bilingual (German) condition, activity in bilateral inferior parietal lobe and right Broca's area was significant in addition to bilateral superior temporal lobes and the right anterior cingulate. These areas are all associated with language processing. The between groups analyses also showed that monolinguals and bilinguals both activate control regions, but in different areas. In monolinguals we observed increased activity in SMA, whereas bilinguals showed increased activity in DLPFC. This supports the theory that monolinguals and bilinguals rely on different neural mechanisms to process novel vocabulary.Our data are also consistent with the view that bilinguals actively formulate strategies for processing new word concepts, whereas monolinguals get held up in the translation process.Taken together these results are consistent with the notion that bilinguals relative to monolinguals may exhibit enhanced cognitive flexibility that allows them to more readily learn novel vocabulary items in a new language.

C3 The Assessment of Code-Switching Experience Survey (ACSES): A new tool for assessing code-switching behavior in Spanish/English bilinguals ***Blackburn, A.*** *(1)* ***Wicha, N.Y. Y*** *(1); 1. The University of Texas at San Antonio, TX* – To study the neurobiology of code switching, it is fundamental to characterize bilinguals who code switch ("switchers") and those who do not ("non-switchers").Studies comparing these groups have found differences between them in task switching [1] and cognitive control [2] abilities.Despite recent literature demonstrating cognitive plasticity due to code switching, there is currently no quick and reliable tool for assessing an individual's code switching experience in daily life. We developed a standardized survey for assessing code switching experience in bilinguals, that can be used for qualitative and quantitative analysis in future studies. A short survey was developed in a two step process, using Survey Monkey with Spanish/English bilinguals, the most prevalent US bilingual population. In Study 1, a short survey was developed using reliability testing.In Study 2, the short version was administered to a new sample for confirmation of internal consistency and standardization. In Study 1, an initial survey consisting of 82 questions, selected based on face validity from a larger question pool, was completed by 408 bilinguals to establish internal consistency. The survey was retaken by 54 participants to establish test-retest reliability.Redundant items from the survey were removed based on factor loading, discriminatory ability, and contribution to Cronbach's alpha.The factor analysis of the resulting 29-question short version extracted six components. Components reflect items that are correlated and presumed to measure the same construct (e.g. switching before age 5 and during elementary school both load onto the early life switching component).The first component, "frequency of code switching", accounted for 40.262% of the variance.Cronbach's alpha was 0.935, demonstrating a high level of internal consistency for this component.Internal consistency indicates that questions are measuring the same construct.Other components to emerge were strong (e.g. cultural identity) and weak (e.g. poor vocabulary) motivation for switching (α=0.865 and 0.843, respectively), switching early in life (α=0.808), daily use of both languages (α=0.777), and time spent in bilingual mode (α=0.747).Combined, these components accounted for 69.4% of the variance.Test/retest correlations were above

0.93 for scores reflecting frequency of code switching and above 0.79 for all other components, indicating high reliability. In Study 2, 730 bilinguals completed the short 29-question survey.Factor analysis in Study 2 revealed the same first five components as Study 1.The component "time spent in bilingual mode" which was present in Study 1 loaded onto "frequency code switching" in Study 2; these components were highly correlated in Study 1 (r=0.445).Internal consistency remained high (α=0.94 for code switching frequency, α>0.79 for all components). Scores were standardized for each factor. The results indicate that this short survey is a reliable tool for measuring code switching in this population.We are currently using the components identified in this survey as regression factors of brain potentials related to code switching, such as the LPC/N400 and N2.A long-term goal is to use this assessment tool in conjunction with ERPs to determine how code switching experience impacts comprehension and production of switches, and executive control more generally. References. 1 Prior, A. and T.H. Gollan, Good language-switchers are good task switchers: evidence from Spanish-English and Mandarin_English bilinguals. Journal of the International Neuropsychological Scoiety, 2011. 17: p. 1-10. 2 Festman, J., A. Rodriguez-Fornells, and T.F. Münte, Individual differences in control of language interference in late bilinguals are mainly related to general executive abilities. Behavioral and Brain Functions, 2010. 6: p. 5.

C4 Pathétique! Or simply sad? Processing emotion in L1 and L2: an ERP study ***Midgley, K.*** *J.(1,2),* ***Delaney-Bush, N.****(1)* ***Holcomb, P. J.*** *(1); 1. Tufts University, Medford, MA; 2. Laboratoire de Psychologie Cognitive, Marseille, France* – There is a sense, based on report and intuition, that bilinguals feel a deeper emotional engagement in their first language (L1) than in a subsequently learned language (L2). There even exists physiological data (SCR, skin conductance response) supporting this position for phrases (Caldwell-Harris et al., 2009). Emotional language is typically described through the two dimensions of aroUSl and valence and so attenuated emotional processing for L2 could be attributable to differential processing of aroUSl and/or valence for L2 words compared to L1 words. In monolingual event-related potential (ERP) studies of the effects of valence on discourse processing both high-valence words (e.g. sunshine) and low-valence words (e.g. death) elicited N400 components of similar amplitude that were in turn more negative-going than the ERPs to neutral words (Holt et al., 2009). The effects of aroUSl on word processing, on the other hand, have been observed on the late positive component (LPC) with high-aroUSl words eliciting a more positive going posterior LPC compared to low-aroUSl words (Delaney-Busch et al., 2011). In our study, two levels (high and low) of aroUSl and valence were crossed in an experiment with bilingual and monolingual participants. Based on previous monolingual findings, we predicted no differences between high- and low-valence words in the N400 epoch and more positive going LPCs for high-aroUSl items for our monolingual group. In testing bilinguals in their L2 we sought to suss out the respective contribution of aroUSl and valence in the hypothesized attenuation of L2 emotionality processing. For our bilinguals, we predicted less or no effect of aroUSl on the LPC, consistent with the idea of attributing the attenuation of L2 emotionality processing to lesser effects of aroUSl in L2 word processing. Differing patterns of valence effects for the bilinguals would implicate valence as an important factor in the attenuation of affective L2 processing. AroUSl results for our monolingual group replicated previous monolingual findings, with high-aroUSl words eliciting a more positive posterior LPC (500-700ms) than low-aroUSl words. The bilingual group showed a very different pattern, with high-aroUSl items eliciting more negative-going waves at anterior sites during the same epoch. For valence, as expected, between 300 and 500 ms the monolingual group showed no significant differences in N400 amplitude between high- and low-valence items. The bilingual group, however, showed clear differences at anterior sites with high-valence items having more negativity in the N400 epoch. These observed anterior negativities for both aroUSl and valence could result, at least in part, from emotional evaluations being more cognitive and less automatic in L2. Nevertheless, that the ERP effects from the bilingual participants vary not only in amplitude but in direction and scalp distribution from that of the monolinguals leads us to propose that emotional processing of L2 differs greatly from that of L1. Very different neural mechanisms appear to be involved in the processing of aroUSl and valence in L2. These results leave a wide path to be followed for exploring the nature of processing for emotionally charged words in an L2 context.

C5 Detection and utilization of prosody in sentence processing: an EEG study of L1 and L2 Japanese ***Naito-Billen, Y.*** *(1),* ***Minai, U.*** *(1),* ***Fiorentino, R****. (1); 1. The University of Kansas, Lawrence, KS* – The precise role of prosody in sentence processing and its brain-level instantiation remain a matter of investigation (Bögels et al., 2010; Itzhak et al., 2010; Steinhauer et al., 1999). It is unclear how prosody is detected and utilized during parsing in a head-final, free-word-order language like Japanese; moreover, the extent to which adult second language learners can utilize prosodic information in real-time processing has not been fully examined. This study utilizes EEG to investigate the nature and neural instantiation of prosodic processing in native (L1) speakers and second-language (L2) learners of Japanese, taking the incremental processing of temporarily-ambiguous sentences as a test case. Eighty-four sentence pairs, comprised of Embedded-Structure sentences (ES) and Main-Structure sentences (MS), were constructed (see 1-2): (1) ES: Takasi-wa (#EP) [tegami-o yondeiru atarasii sensee]-ni sotto esyakusita. Takasi (name)-Top letter-Acc reading new teacher-Dat gently bowed "Takasi gently bowed to the new teacher who was reading a letter." (2) MS: Takasi-wa tegami-o (#MP) [yondeiru atarasii kyookasyo]-ni sotto hasanda. Takasi (name)-Top letter-Acc reading new textbook-Dat gently inserted "Takasi gently inserted the letter in the new textbook that he was

reading." These sentences generate temporary ambiguity such that letter may serve as the object of the embedded verb (reading) or the matrix verb (bowed/inserted), until the disambiguating fifth word, teacher/textbook, appears. Sentences were recorded with prosody congruent with Embedded-Structure (Embedded-Prosody (EP)), and with prosody congruent with Main-Structure (Main-Prosody (MP)). The congruent prosodic breaks are indicated by (#) in (1-2). Japanese native speakers (N=14) and advanced-level learners (N=10) listened to sentences with congruent prosody (Embedded-Structure/Embedded-Prosody and Main-Structure/Main-Prosody), and those with incongruent prosody (Embedded-Structure/Main-Prosody and Main-Structure/Embedded-Prosody). EEG was recorded continuously while participants rated the acceptability of each sentence. The preliminary results revealed an ERP component, the Closure Positive Shift (CPS), elicited at every prosodic break for both native speakers and learners, suggesting the prosodic break is detected immediately by both native speakers and learners. At the disambiguating word, native speakers' data revealed N400-P600 effects for the Main-Structure sentences with both congruent and incongruent prosodies, reflecting a dis-preference for Main-Structure sentences. The effect of prosodic congruency was only evident in the dis-preferred Main-Structure conditions, but not in the Embedded-Structure conditions. Learners showed a broad, sustained negativity from approximately 200ms following the onset of the disambiguating word for Main-Structure sentences with both prosodic types and Embedded-Structure sentences with incongruent prosody, suggesting a difficulty in processing sentences with non-default structure or prosody. The effect of prosodic congruency was also evident in the Main-Structure conditions though it was smaller than that of Embedded-Structure conditions. Acceptability judgment results revealed a structural preference toward Embedded-Structure over Main-Structure for both native speakers and learners. Native speakers' data revealed a preference toward prosody-structure congruent conditions over incongruent conditions as well; however, among learners, a preference toward congruent conditions was evident only for Embedded-Structure. In sum, the ERP results show immediate prosodic break detection and prosodic-congruency effects among both native speakers and learners of Japanese, while prosodic-congruency effects in acceptability judgments are evident to a greater extent among native speakers than learners.

C6 On bilingual lexical access: when does language membership come into play? ***Ng, S.*** *(1),* ***Cisneros, E. M.*** *(1),* ***Wicha, N.*** *(1); 1. The University of Texas, San Antonio, TX* – Recent studies find that visual word recognition has hierarchical functional organization. However, the influence of task demands on the hierarchical functional organization is still unclear. In the current fMRI study, we explored this issue by using tasks that required processing either in deep level (lexical decision) or shallow level (symbol detection) and stimuli that varied in their word-likeness. Seven right-handed native English speakers participated in the experiment. Five categories of stimuli were presented, including: (1) 30 real words (RW); (2) 30 pseudowords (PW) that contained phonological and orthographical information; (3) 30 high bigram strings (HB) with frequent consonant bigrams; (4) 30 low bigram strings (LB) with infrequent consonant bigrams; and (5) 30 false-font strings (NN). Participants performed a lexical decision (LD) task and a symbol detection (SD) task while reading all the stimuli. In the LD task, participate decided whether each presented item was a real word or not by pressing one of two buttons. In the SD task, participants decided whether each presented item was "%" and pressed a button when it was. A main effect of task was found in areas of bilateral inferior frontal gyrus (IFG, BA 44/45/47), left fusiform gyrus (FG, BA 18/19), left inferior parietal lobule (IPL, BA 40), left supramarginal gyrus (SMG, BA 40) and supplementary motor areas (SMA, BA 6). The contrast between tasks indicated that LD task showed stronger effects in left FG (BA 18/19) and left ITG (BA 20/19), while the SD task elicited greater activations in medial sites. A main effect of stimuli was found in areas of left IFG (BA 47), left SMG (BA 40), bilateral AG (BA 39), left FG (BA 18/19) and SMA (BA 6). Finally, a significant interaction effect between task and stimuli type was revealed. In the left hemisphere, areas in MFG (BA 9), IFG (BA 47), SMG (BA 40), FG (BA 18/19) and SMA (BA 6) showed significant effects. In the right hemisphere, areas in MFG (BA 8/9) and SMA (BA 6) also had significant activations (Figure 1). These results demonstrate that task demands have significant interactions with stimuli type throughout the reading network. Lexical information like semantic and phonological information play an important role in RW and PW condition in the LD task, but in the SD task the role of lexical information is weakened. On the other hand, medial sites like mid orbital gyrus have stronger effects in the SD task. Other brain regions, such as left precentral /postcentral gyrus (BA 4/1/2/3) and SMA (BA 6), also showed different activations in LD and SD task. Together, the current results suggest that both task demands and stimuli type can modulate word reading process.

READING & WRITING

C8 Interaction between task demands and stimuli type during word reading ***Yang, J.*** *(1),* ***Zevin, J.*** *(1); 1. Sackler Institute of Developmental Psychobiology, Weill Cornell Medical College, New York, NY* – Recent studies find that visual word recognition has hierarchical functional organization. However, the influence of task demands on the hierarchical functional organization is still unclear. In the current fMRI study, we explored this issue by using tasks that required processing either in deep level (lexical decision) or shallow level (symbol detection) and stimuli that varied in their word-likeness. Seven right-handed native English speakers participated in the experiment. Five categories of stimuli were presented, including: (1) 30 real words (RW); (2) 30 pseudowords (PW) that contained phonological and orthographical information; (3) 30 high bigram strings (HB) with frequent consonant bigrams; (4) 30 low bigram strings (LB) with infrequent consonant bigrams; and (5) 30 false-font strings

(NN). Participants performed a lexical decision (LD) task and a symbol detection (SD) task while reading all the stimuli. In the LD task, participate decided whether each presented item was a real word or not by pressing one of two buttons. In the SD task, participants decided whether each presented item was "%" and pressed a button when it was. A main effect of task was found in areas of bilateral inferior frontal gyrus (IFG, BA 44/45/47), left fusiform gyrus (FG, BA 18/19), left inferior parietal lobule (IPL, BA 40), left supramarginal gyrus (SMG, BA 40) and supplementary motor areas (SMA, BA 6). The contrast between tasks indicated that LD task showed stronger effects in left FG (BA 18/19) and left ITG (BA 20/19), while the SD task elicited greater activations in medial sites. A main effect of stimuli was found in areas of left IFG (BA 47), left SMG (BA 40), bilateral AG (BA 39), left FG (BA 18/19) and SMA (BA 6). Finally, a significant interaction effect between task and stimuli type was revealed. In the left hemisphere, areas in MFG (BA 9), IFG (BA 47), SMG (BA 40), FG (BA 18/19) and SMA (BA 6) showed significant effects. In the right hemisphere, areas in MFG (BA 8/9) and SMA (BA 6) also had significant activations (Figure 1). These results demonstrate that task demands have significant interactions with stimuli type throughout the reading network. Lexical information like semantic and phonological information play an important role in RW and PW condition in the LD task, but in the SD task the role of lexical information is weakened. On the other hand, medial sites like mid orbital gyrus have stronger effects in the SD task. Other brain regions, such as left precentral /postcentral gyrus (BA 4/1/2/3) and SMA (BA 6), also showed different activations in LD and SD task. Together, the current results suggest that both task demands and stimuli type can modulate word reading process.

C9 Stimulus by task interactions in Chinese character processing ***Jason D. Zevin*** *(1,2),* ***Jianfeng Yang*** *(3),* ***Xiaojuan Wang*** *(4)* ***Hua Shu*** *(4); 1. Sackler Institute of Developmental Psychiatry, Weill Cornell Medical College, New York; 2. Haskins Laboratories, New Haven, CT ; 3. Institute of Psychology, Chinese Academy of Sciences, Beijing, China; 4. State Key Laboratory of Cognitive Science and Learning, Beijing Normal University, Beijing, China* . – In the visual word recognition literature, it is well understood that various stimulus effects interact with behavioral task. For example, effects of word frequency are exaggerated and effects of spelling-to-sound regularity are reduced in the lexical decision task, relative to reading aloud. Neuroimaging studies of reading also examine effects of task and stimulus properties on brain activity, but potential interactions between task demands and stimulus effects have not been extensively explored. We conducted lexical decision and symbol detection tasks using stimuli that varied parametrically in their word-likeness, and tested for task by stimulus class interactions. We did this by first identifying spatially independent regions using independent components analysis, then testing the temporal modes of these components for correlation with an omnibus task > rest regressor. Mean percent signal change values from regions identified in the ICA were subjected to a 2 (lexical decision vs. symbol detection) x 6 (levels of word-likeness, from artificial combinations of strokes to real words) ANOVA. Main effects of task were observed only in sensorimotor and medial visual regions that are not thought to have any particular specialization for reading, perhaps reflecting differences in overall task difficulty. Main effects of stimulus were observed mainly in lateral visual regions, possibly suggesting differential responses to stimuli with increasingly complex spatial relations. Interactions were found throughout the reading system, such that stimulus selectivity was not observed during the symbol detection task, but was observed during the lexical decision task. Further, the pattern of stimulus selectivity was directly related to task difficulty, so that the strongest brain activity was observed to the most word-like stimuli that required no responses, whereas brain activity to words, which elicit rapid and accurate yes responses were relatively weak. This is in contrast to models that suggest task-independent stimulus selectivity in the reading system, but in line with models that argue for task-dependent specialization.

C10 Association of the DYX1C1 dyslexia susceptibility gene in the general Chinese population ***Zhang, Y.*** *(1)* ***Shu, H.*** *(1),* ***Shi, B.*** *(1),* ***Li, J.*** *(1),* ***Burmeister, M.*** *(2),* ***Tardif, T.*** *(2); 1. Beijing Normal University, Beijing, China; 2. The University of Michigan* – **Objective:** DYX1C1 (dyslexia susceptibility 1 candidate 1) was the first candidate gene for dyslexia susceptibility to be identified. Since the first report by Taipale et al. (2003), although several independent studies have been published in supporting it in association with dyslexia, the role of DYX1C1 in general reading development is still unsettled. Besides, most previous studies of DYX1C1 were performed with alphabetic languages and thus those earlier identified association needs further to be tested with non-alphabetic languages (i.e., Chinese). Based on a longitudinal study data, we investigated the contribution of this gene to reading abilities, especially visual-orthography skills, between 6 and 11-year-old in a sample of 284 unrelated children (158 boys, 126 girls). Methods. Two SNPs (rs3743205 and rs57809907) originally reported by Taipale et al. (2003) and another SNP (rs11629841) reported by Wigg et al. (2004) were genotyped for all 284 children. The associations were examined using the quantitative association analyses for four quantitative traits: a) visual skills between 5 and 8-year-old; b) orthographic judgment between 6 and 8-year-old; c) Chinese character reading between children's 5 to 10-year-old; d) Chinese character dictation between 9 and 11-year-old. The phenotypic measures are highly correlated and we aimed to limit the number of tests by analyzing targeted SNPs previously reported. Thus our strategy provided a significant level of 0.0167 for each SNP (three SNPs) and each haplotype (three common haplotypes) after the Bonferroni correction. Results. In the single-marker analysis, association signals were found between rs11629841 and Chinese character dictation between ages 9- and 11-year-old (P = 0.0124, 0.0091, and 0.0130 separately for three years) and remained significant when corrected for multiple testing.

Significant association was also detected between rs11629841 and orthography judgment at ages 7- and 8-year-old (P = 0.0003 at age 7 and 0.0198 at age 8) and only orthography at age 8 remained significant after correction for multiple testing. In the haplotype analyses, association signals were detected for several haplotypes involving the marker rs11629841. The two-marker haplotype T/G (rs11629841/rs57809907) was associated with orthography at ages 7 and 8-year-old and dictation at ages 9 to 11-year-old. Another two-marker haplotype C/T (rs3743205/rs11629841) were only associated with orthography at age 7-year-old and with dictation at age 10-year-old, when corrected for multiple testing. The three-marker haplotype C/T/G (rs3743205/rs11629841/rs57809907) were found to associate with orthography at age 7 and dictation all through ages 9 to 11-year-old. Conclusion and Discussion. As significant associations were proved for Chinese character dictation and orthography judgment in our sample, we could conclude that DYX1C1 is associated with reading, especially orthographic processing, in the general Chinese population. Our data also implied that DYX1C1 gene influences poor reading performances and reading development all through the critical developmental stages. To the best of our knowledge, this is the first genetic study showing DYX1C1 in association with normal reading development. Existing association between DYX1C1 and reading development still needs to be tested in any other population.

C11 The repeated name penalty in Hebrew using MEG ***Almor, A.****(1),* ***Harpaz, Y.****(2),* ***Goldstein A.****(2); 1. The University of South Carolina, Columbia, SC; 2. Ghonda Brain Center, Bar Ilan University, Ramat Gan, Israel* – Anaphoric reference is an important part of coherent discourse, and discourse anaphors can take many forms. Linguists has noted that there is a cross linguistic tendency to use general expressions to make anaphoric references to salient discourse referents. This observation has been supported by behavioral research showing that this tendency is reflected in expectations during comprehension. However, to date there have been only few studies using imaging techniques to uncover the brain basis of this tendency, and these studies have relied on either EEG/ERP or fMRI techniques that provide good temporal resolution OR good spatial resolution but not both. Indeed, due to differences in the timing of the events the two methodologies are sensitive to, it is not entirely clear whether findings from these methodologies reflect the same neural processes. Here we used MEG to investigate the neural underpinning of referential processing with good temporal AND spatial resolution. We used Hebrew, which unlike the languages used in previous studies (mostly English and German), allows null references. Our first aim was to identify a MEG correlate of the N400 that has been found in EEG/ERP studies in which comprehenders encountered an unnecessarily specific anaphor to a salient referent. Our second aim was to identify the brain regions that are associated with this effect. Finally, we also wanted to compare full pronominal reference with null references, which by some accounts should be preferable to full pronouns (because they are even more general). We tested 19 subjects in the MEG as they were reading Hebrew items in one of three conditions (repeated name / pronoun / null pronoun): MOSHE HALAX LAMAKOLET AXAREI SHEMOSHE/SHEHU/SHE-RAAH ET HAMEKARER HAREK. Moshe went to the grocery store after Moshe/He/_ saw the empty refrigerator. In the 300-500 ms post stimulus time window we found a higher amplitude response in the repeated name condition than in the pronoun condition, similar to the N400 reported in previous EEG/ERP studies. The null pronoun condition led to the highest amplitude response showing that, in contrast to the general claim that more general expressions are universally preferred, the null pronoun in Hebrew is less preferred. SAM beamforming analyses identified several brain regions associated with the differences in activation between the conditions, including left inferior parietal regions, which were also found by previous fMRI work to be sensitive to anaphor forms. Overall, our results show that the N400 effects reported in previous ERP research extend to MEG, and suggest that these effects are associated with some activation patterns found in fMRI studies. Our results further extend previous research on referential processing to Hebrew, and show that null references in Hebrew are not automatically preferred to full pronouns.

C12 Patterns of language and reading deficit in children exposed to domestic violence ***Blackburn, J.****(1); 1. Towson University, Towson, MD* – The primary goal of this study was to identify patterns of language and reading deficits in children exposed to domestic violence.A secondary goal was to identify factors associated with domestic violence that were correlated with children's performance on the language and reading measures.Children 6-12 years old were identified as being exposed to domestic violence based on their mothers' responses on the revised Conflict Tactics Scales (CTS2).The children were administered the following tests: (a) the Clinical Evaluation of Language Fundamentals-4th edition (CELF-4) to assess receptive, expressive, and core language skills; (b) the Woodcock Reading Mastery Tests-Revised (WRMT-R), to assess word decoding and reading comprehension skills; and (c) the Matrices subtest of the Kaufman Brief Intelligence Test (K-BIT) to measure nonverbal IQ.The children's mothers completed the following questionnaires: (a) the CTS2, to measure the frequency and severity of violence between the mother and her partner; (b) the Parent-Child Conflict Tactics Scales (CTSPC), to measure the frequency and severity of child maltreatment in the family; (c) the Child Behavior Checklist (CBCL), to measure behavior problems in the child; and (d) the Parent-Child Relationship Inventory (PCRI), to measure parenting skills and attitudes, as reported by the mother.The children's reading and language scores were compared to national standardized norms (M=100, SD=15) using one-sample t-tests.CELF-4 Core Language (M=93.79, SD=15.78) and Receptive Language (M=90.79, SD=13.80) composite scores were significantly lower than national standardized norms ($t(27) = 2.08$, $p<.05$ and $t(27) = 3.53$, $p<.01$, respectively), while the

Expressive Language (M=97.46, SD=16.46) composite score was not significantly different from the national norms.Reading scores were not significantly lower than the national standardized norms for the WRMT-R Word Identification (M=98.11, SD=12.10) and Passage Comprehension subtests (M=96.89, SD=10.93). Correlations were calculated between the reading and language measures and measures of violence, parenting, socioeconomic status (SES), family history of language or reading disorders, and child behavior problems.For the language measures, the family history of language or reading disorders, nonviolent discipline measure, and parenting measures were significantly correlated with expressive, receptive, and core language skills. For the reading measures, the parenting measures, nonviolent discipline measure, and language measures were significantly correlated with word decoding and reading comprehension skills. In contrast, the nonverbal IQ scores were significantly correlated with measures of domestic violence, but not the parenting measures.In summary, the children exposed to domestic violence performed more poorly on standardized measures of receptive language compared to national norms, while their reading skills were within normal limits.Surprisingly, violence factors did not seem to be directly correlated with reading and language performance; instead, measures of parenting, family history of reading or language disorders, and nonviolent discipline were most strongly correlated with reading and language performance. These patterns of performance may reflect a cumulative effect on children's performance, including possible genetic factors (e.g., a predisposition to language problems based on family history) and environmental factors (e.g., the mother's parenting skills) in children exposed to domestic violence.

C13 ERP evidence of a cost for metrical reanalysis in silent reading ***Breen, M.*** *(1),* ***Sanders, L. D****. (2),* ***Clifton, C. Jr.*** *(2); 1. Mount Holyoke College, South Hadley, MA; 2. UMass Amherst, Amherst, MA* – The Implicit Prosody Hypothesis (Bader, 1998; Fodor, 1998) maintains that suprasegmental information (e.g., prosodic phrasing, prominence, or metrical structure) can influence on-line sentence processing during silent reading. Breen & Clifton (2011), for example, demonstrated that implicit metrical structure plays a role in controlling eye movements during silent reading. In their study, participants read sentences like those in (1a) and (1c), which required either syntactic reanalysis (1c) (i.e., revision of famous study from Adj/Noun to Noun/Verb) or simultaneous syntactic and metrical reanalysis (1a) (i.e., revision of famous recall from Adj/Noun to Noun/Verb as well as a stress shift from REcall to reCALL). Breen & Clifton observed evidence of a greater cost for simultaneous metrical and syntactic reanalysis as evidenced by longer reading times on the stress-alternating homograph (recall) when it was subsequently disambiguated as a verb than the non-alternating homograph (study). The present ERP experiment was designed to further investigate this phenomenon, and, specifically, to use electrophysiological evidence to determine if metrical and syntactic reanalysis are distinct processes. Sixteen subjects silently read sentences like those in (1), in which a target homograph was disambiguated as a verb by prior sentence context (1b, 1d) or by subsequent context (1a, 1c). Sentences were presented word-by-word, with a 600 ms SOA. The target homographs either had different stress patterns as a noun and a verb (recall: REcall/reCALL) or the same stress pattern (study). All critical homographs were matched on length and syntactic category frequency. The experiment employed a within-subjects design: Participants saw all conditions of all 32 items, which were distributed across four lists according to a latin-square design. Although homographs on all 32 critical trials in a list were disambiguated as verbs, there were also 100 filler trials on each list in which noun/verb homographs were disambiguated as nouns. Including these sentences encouraged a garden-path effect on the critical trials. ERPs to the first disambiguating word (their) revealed an interaction such that the disambiguation of syntactically ambiguous stress-alternating homographs (recall in 1a) elicited a larger anterior, slightly right-lateralized negativity 300-500 ms after presentation compared to all other conditions. This result suggests that, upon encountering evidence that the target word is a verb as opposed to a noun, readers must re-engage lexical access, in order to select the correct lexical entry with the correct stress pattern for the target word. These findings demonstrate that metrical reanalysis in combination with syntactic analysis incurs a greater cost than syntactic reanalysis alone. In fact, syntactic reanalysis alone did not result in any reliable differences in ERP waveforms. These results support the conclusion of Breen & Clifton (2011) that metrical stress is activated during silent reading and influences parsing decisions, thereby providing additional support for the Implicit Prosody Hypothesis (Bader, 1998; Fodor, 1998). (1) a. Ambiguous; stress-alternating The famous recall their coverage in the press. b. Unambiguous stress-alternating The mobsters recall their coverage in the press. c. Ambiguous; non-alternating The famous study their coverage in the press. d. Unambiguous non-alternating The mobsters study their coverage in the press. Bader, M. (1998). Prosodic influences on reading syntactically ambiguous sentences. In J. Fodor & J. Ferreira (Eds.), Reanalysis in sentence processing (pp. 1–46). Dordrecht: Kluwer. Breen, M. and Clifton, C., Jr. (2011). Stress matters: Effects of anticipated lexical stress on silent reading. Journal of Memory and Language, 64 (2), 153-170. Fodor, J. D. (1998). Learning to parse? Journal of Psycholinguistic Research, 27, 285–319.

C14 ERP evidence for distinguishing between orthographic/phonological and balanced adult English readers ***Karuzis, V.*** *(1)* ***Dien, J.*** *(1),* ***Berens, M****. (1),* ***O'Rourke, P.*** *(1),* ***Haarmann, H.*** *(1); 1.The University of Maryland, College Park, MD* – An ongoing issue in the study of both developmental and adult acquisition of language is the nature of individual differences in reading style.One such example is the proposal (Baron & Strawson, 1976) that adult readers can be divided into those relying more on phonology ("Phoenicians") and those relying more on orthography ("Chinese").A more recent proposal is that dyslexics can be divided into those suffering deficits in

phonological analysis and orthographic analysis (Castles & Coltheart, 1993).Both these proposals are plausible in the abstract whether one ascribes to a dual-route or triangle model approach but have been the subject of continuing debate.A corollary of this view that has thus far not been explored is that there might exist a population which relies on both reading mechanisms in a balanced manner ("Phonese") and which would therefore need to somehow integrate the sometimes diverging outputs from the two types of analysis.In the present experiment, we test the proposal (Dien et al., 2008; Dien, 2009) that the Recognition Potential might index such a mechanism. The participants read sentences, presented wordwise, that in principle should favor orthographic processing (letter transpositions), phonological processing (pseudo-homophones), or both (normal).The task was to indicate which of two probe words appeared in the sentence. The accuracy rates were not significantly different between the orthographic and phonological conditions (83% versus 81%). Amongst the ERP participants (n=29), the Recognition Potential was indeed significantly greater for the "Phonese participants" (quadratic trend between orthography-phonology accuracy and amplitude of Recognition Potential, p=.03). These results help further illuminate how the orthographic and phonological systems work together in the reading process.They also suggest that in studies of reading style, it would be best to divide readers into three groups ("Chinese", "Phonese", and "Phoenicians") rather than just two groups and that an additional cognitive skill is involved in the case of the "Phonese" readers that could serve as a target for remediation of reading deficits.

C15 Age-related Differences in the Posterior-Anterior Gradient of Word-Specificity in the Visual Word Form System ***Olulade, O.*** *(1),* ***Flowers, D-L.*** *(1),* ***Napoliello, E.*** *(1), and* ***Eden, G.*** *(1; 1. Georgetown University Medical Center, Washington, D.C.* – Orthographic processing of visually presented words has been demonstrated to occur in the Visual Word Form System (VWFS). Using region of interest (ROI) analyses, several studies have revealed a posterior-to-anterior gradient of increasing specificity to words within this region in adults, adolescents and children (Vinckier et al., 2007; Brem et al., 2006, 2009). One would expect that the specific pattern of specialization to words along this VWFS depends on the amount of reading experience, since reading acquisition occurs over a protracted period of time. While there is event-related potential data in support of developmental changes in the pattern of activity in the VWFS (Brem et al., 2009), studies using fMRI have not been able to differentiate between pediatric and adult participants in this region, either using whole brain analysis (Turkeltaub et al., 2003) or the ROI approach that specifically maps the posterior-to-anterior-gradient (Brem et al., 2006, 2009). In this study, we repeated an experiment employing an implicit word processing task (Turkeltaub et al., 2003), this time at higher field strength, and applied an ROI analysis approach along the ventral occipito-temporal cortex to test the prediction that the degree of specificity along the extent of the VWFS is age dependent. Eleven children (7-15 yrs) and 15 adults (19-25 yrs) were asked to detect a tall character within visually presented real words (RW) or false font strings (FF). Following whole-brain analysis, 8 non-overlapping spherical ROIs (4mm3 each) were generated along the fusiform gyrus within ventral occipito-temporal cortex to sample the VWFS. For each subject, mean percent signal change was computed for each task relative to baseline in each ROI, and entered into an ANOVA. Differential activation between tasks yielded the previously observed posterior-to-anterior gradient of word specificity in both groups. However, this specialization occurred at a more anterior location in the adults. ROI analysis yielded significant interactions of ROI x Task ($F(7,19) = 2.78$; $P = 0.007$) and ROI x Group ($F(7,19) = 3.28$; $P = 0.002$). Post-hoc t-tests revealed significantly greater activation for RW over FF at y = -50 and -42 in children, and more anterior locations: y = -34 and -26 in adults. RW activation was significantly greater for children than adults at y = -50 ($p < 0.001$) and greater for adults at y = -26 ($p < 0.005$). Between-task performance did not differ within each group, so observed differential activation could not be attributed to in-scanner task performance. Results present evidence for greater word specificity in the anterior left ventral occipitotemporal cortex in adults compared to children.

C16 Resting-state functional connectivity related to single-character reading in healthy Chinese-speakers ***Wang, X.*** *(1),* ***Han, Z.*** *(1),****He, Y.*** *(1),* ***Bi, Y.*** *(1); 1. Beijing Normal University, Beijing, China* – **Background:** Resting-state functional connectivity (RSFC) offers a novel approach to reveal the temporal synchronization of brain networks.Recent studies have identified several RSFCs whose strengths were associated with reading behaviors of healthy adults in alphabetic languages (Hampson et al., 2006; Koyama et al., 2011).Given that the logographic system, Chinese, differs from alphabetic scripts in several aspects, such as the lack of grapheme-phoneme correspondence and the complex spatial configuration of visual forms, we examined the correlation between RSFC maps of nine Chinese reading-related seeds and Chinese single-character reading performance to explore the role of intrinsic brain activity for Chinese reading. Methods. Resting-state functional imaging data and behavioral performance in the Chinese single-character reading task were collected from thirty-two right-handed healthy college students (13 male, age range = 20–26 years).Nine Chinese reading-related seeds were selected based on a meta-analysis study on single word reading in Chinese (Bolger et al., 2005). RSFC maps were generated by correlating mean time series of each seed with the time series of every other voxel within a gray matter mask for each participant.Then correlation analysis between RSFC maps of each seed and reading performance was conducted in a voxel-wise manner across participants.To more explicitly address the issue of the language specificity, we further examined whether the six previously reported RSFCs observed with English speakers (Koyama et al., 2011) could also predict Chinese reading performance of our participants. Results. We found that the strengths of the following RSFCs positively

correlated with Chinese reading performance: between the seed left inferior occipital gyrus and left superior parietal gyrus (L.IOG-L.SPL, R2 = 0.40, p < 0.005), between the seed right posterior fusiform gyrus and right superior parietal gyrus (R.pFFG-R.SPL, R2 = 0.33, p < 0.01), and between the seed left inferior temporal gyrus and left supramarginal gyrus (L.ITG-L. SMG, R2 = 0.32, p < 0.05).Moreover, none of the six RSFCs showing correlations with English reading competence in Koyama et al' s study were associated with Chinese reading performance in Chinese-speakers (ps > 0.12). Discussion. Our findings differ from the resting-state reading network for English speakers in important aspects and could be explained by the linguistic and cognitive differences between these two scripts.For instance, the finding that the closer coupling between visual areas and superior parietal regions were associated with better reading performance might indicate the importance of automatized spatial configuration analysis during Chinese reading.Our study extends cross-linguistic effects between English and Chinese to the resting-state mechanisms, and promotes the necessity of further studies incorporating a combination of brain measures.

C17 Impaired inflectional morphology in children with Developmental Dyslexia: converging evidence from behavioral and electrophysiological measures ***Cantiani, C.*** *(1,2),* ***Guasti, M. T.*** *(2),* ***Perego, P.*** *(1),* ***Lorusso, M. L.*** *(1); 1. Scientific Institute E. Medea, Bosisio parini, LC, Ital; 2. University of Milano-Bicocca, Italy* – General agreement has been reached on the presence of impaired inflectional morphology in Specific Language Impairment (SLI) (e.g., Leonard, 1998). Based on the widely recognized overlap between SLI and Developmental Dyslexia (DD) (e.g., Bishop & Snowling, 2004), the study of these features in DD gains theoretical and clinical relevance. Recent studies focusing on children with DDonly revealed impaired inflectional morphology in this population as well, suggesting that the linguistic deficit in DD goes beyond the sphere of phonology. In particular, previous studies revealed deficits in production (Altmann et al., 2008; Joanisse et al., 2000) and comprehension (Leikin & Hagit, 2006; Rispens et al., 2006; Robertson & Joanisse, 2010) of inflectional morphology. However, some issues need further investigation, in particular concerning the direct comparison between DD children with (DD+SLI) and without SLI (DD-only), and between the domains of production and comprehension. In the present study we used converging evidence to better characterize impaired inflectional morphology in a sample of Italian DD children. 32 children with DD (16 with DD-only and 16 with DD+SLI) and 16 control children (aged 8-12) participated in the study. A behavioral linguistic battery requiring the production of nominal and verbal inflections using words and pseudo-words was administered to all children. In addition, sentences containing subject-verb agreement violations were auditorily presented and children were asked to judge the grammaticality of the sentences while ERPs time-locked to the critical morphemes were recorded. The behavioral results show impaired production of inflectional morphology in DD children. In particular, the deficit emerges in the inflectional manipulation of both words and pseudo-words in DD+SLI children, while it is evident only in the inflectional manipulation of pseudo-words in DD-only children. In comprehension, the sensitivity to subject-verb agreement violations (expressed as A' score) is impaired only in the DD+SLI children group (p < .01). Interestingly, the three groups show different ERP responses to the violations: the control group shows the typical pattern associated to agreement violations (LAN+P600), the DD+SLI group shows only a non-significant Positivity, and the DD-Only group shows a broadly distributed Negativity (p < .005), interpretable as a N400 component. These results provide us with a better understanding of the impairment in inflectional morphology in DD children with and without SLI. DD+SLI children show a pervasive disorder involving both production and comprehension. DD-only children show a more restricted deficit. At the behavioral level, it only involves production, and only the manipulation of pseudo-words. However, the difference between the two dyslexic groups is not likely to be only quantitative, since a qualitatively different pattern emerges at the electrophysiological level in the DD-only group. In particular, the presence of a N400 suggests the use of a lexical strategy. Based on theoretical models of morphology (e.g., Ullman, 2001), we hypothesize that the strategy reflected in the N400 is related to the retrieval of the inflected forms as stored in the lexicon. This hypothesis, coherent with the behavioral result of specific difficulties with the inflections of pseudo-words, highlights the peculiarity of the morphological impairment in DD.

C18 Lexical Processing is Delayed by 100 ms in a Second Language ***Coderre, E****.(1),* ***van Heuven, W.J.B.****(1),* ***Conklin, K****. (1); 1. The University of Nottingham, Nottingham, UK* – The temporal delay assumption of the BIA+ model (Dijkstra & van Heuven, 2002) states that lexical access is delayed in bilinguals' second language (L2) compared to their first (L1) because of lower proficiency.The reduced frequency hypothesis (Pyers et al., 2009) proposes that bilinguals' use of multiple languages leads to reduced frequency of use and therefore weaker language ties in the L1 compared to monolinguals. However, as it is generally a language production hypothesis, it is unclear whether the reduced frequency hypothesis extends to word recognition studies, predicting slower lexical access in bilinguals' L1 compared to monolinguals. Previous EEG studies investigating lexical processing speed have mainly either failed to test monolinguals against both languages of bilinguals (Proverbio et al., 2009), and/or have focused on later semantic components like the N400 (Ardal et al., 1990; van Heuven & Dijkstra, 2010) We investigate these two hypotheses of lexical processing speed in the context of automatic reading by directly comparing monolinguals and bilinguals in L1 and L2 using concurrent EEG.We focus on an early orthographic recognition component, the N170, which is shown to be sensitive to language proficiency (Maurer et al., 2005). The Stroop task is used as a measure of automatic word processing, with long-latency stimulus onset asynchrony (SOA) variation (-400 ms, 0 ms, +400 ms) to gain additional automatic and temporal information on

lexical processing in native and second languages. Experiment 1 tested monolingual English speakers on an English Stroop task with 128-channel EEG recording.Experiment 2 tested Chinese-English bilinguals on Chinese (L1) and English (L2) Stroop tasks in separate sessions.All bilinguals were native Chinese speakers with a late age of English acquisition (mean 11 years) and a self-rated English proficiency of 7/10. All three groups showed an N170 following word presentation in all SOAs, demonstrating the automaticity of word reading even in a second language. At the N170 peak, monolinguals and bilinguals' L1 showed differences in the symbol string control condition ('%') relative to word conditions.In the L2, words and symbol strings were distinguished later, on the downslope of the N170 peak. To directly compare the groups, difference waves (incongruent minus symbol string) were computed for each group and SOA. The difference waves showed peaks at 170 ms for monolinguals and bilinguals' L1, reflecting lexical distinction at the N170 peak. These peaks did not significantly differ in latency, indicating no difference in lexical processing speed between bilinguals' native language compared to monolinguals.The bilingual L2 lexical distinction peak, however, occurred significantly later (100 ms) compared to both the L1 and monolinguals (Figure 1) in all SOAs and despite repetition effects, suggesting a robust delay in lexical processing. Thus monolinguals and bilinguals' L1 showed no latency differences in lexical processing, suggesting that the reduced frequency hypothesis does not hold for bilingual word recognition. The L2, however, experienced significantly delayed early lexical processing, supporting the temporal delay assumption and confirming that a second language is automatically activated but significantly delayed due to reduced proficiency and frequency of use.

C19 The effect of mood on second language word processing ***van der Meij, M****. (1),* ***López-Pérez, J.*** *(1),* ***van de Velde, A.*** *(1),* ***Barber, H.A.*** *(1); 1. University of La Laguna, La Laguna, Spain* – Previous studies have shown that induced transient moods can affect language processing. In the present study, Event Related Brain Potentials (ERPs) were used to test if emotional states affect differently to first (L1) and second language (L2) processing in late bilinguals. Some theoretical proposals assume attenuated emotionality of L2 as compared to L1 processing, due to the stronger links between the emotional and the native language vocabulary established during development. Alternatively, mood could constraint especially those cognitive operations with higher demands, as is the case for L2 compared to L1 processing. Twenty-four Spanish-English bilinguals who learned the second language (English) after the age of eight years read word pairs that could either be written in Spanish or in English. In one experimental condition the second word of the pair was the translation of the first word (e.g. boca-mouth), in the other condition both words were of a different language but unrelated (e.g. boca-house). Word pairs were presented in blocks and happy or sad moods were induced before each block by displaying sets of happy or sad pictures. ERPs time locked to the second word presentation showed a translation effect; larger N400 amplitudes for the unrelated pairs as compared to the translation pairs. This effect was independent of the induced mood state. However, ERPs time-locked to the presentation of the first words revealed a mood effect only for L2 words, with larger N400 amplitudes for the words read under sad mood than for words read under happy mood. This effect could indicate that the cost of meaning activation with L2 words increases under sad mood. The results extend previous reports about the relation between mood and language during sentence reading to the level of single word processing. Moreover, the results suggest that mood can affect word processing in L2 because in unbalanced bilinguals it requires more cognitive recourses.

C20 Semantic parafoveal processing in reading Chinese: An ERP study *Suiping Wang (1),* ***Wenjia Zhang****(1),* ***Nan Li*** *(1),* ***Hsuan-Chih Chen*** *(2); 1. South China Normal University, Guangzhou, China; 2.Chinese University of Hong Kong, China* – Previous studies have confirmed that readers can obtain sub-lexical information (e.g., orthographic or phonological) from the parafovea during reading (Ashby & Rayner, 2004; Ashby, Treiman, Kessler, & Rayner, 2006; Chace, Well, & Rayner, 2005; Miellet & Sparrow, 2004; Pynte, Kennedy, & Ducrot, 2004; Inhoff, Starr, & Shindler, 2000). However, no consensus has been reached on whether semantic information can also be extracted from parafoveal preview and influence the processing of the currently fixated word (Altarriba, Kambe, Pollatsek, & Rayner, 2001; Yan, Richter, Shu, & Kliegl, 2009; Yang, Wang, Tong, & Rayner, 2010; Barber, Ben-Zvi, Bentin, & Kutas, 2010; Barber, Donamayor, Kutas, & Münte, 2010). In this study, an ERP paradigm using the rapid serial visual presentation (RSVP) with flankers (Barber, Ben-Zvi, et al., 2010; Barber, Donamayor, et al., 2010) was used to study semantic parafoveal processing in reading Chinese sentences. Seventeen participants' event-related brain potentials (ERPs) were recorded as they read sentences presented character by character at fixation, flanked 2° bilaterally by the preceding character (n-1) on the left and the next character (n+1) on the right. Each sentence contained a verb that was either congruent or incongruent with the target single-character noun that appeared 4 or 5 characters after the verb. Importantly, the critical trials (i.e., those containing the target noun as the right flanker) were the same across the congruent and incongruent conditions (see examples below). A larger negativity was found between 300 and 500ms when the right flanker was a contextually incongruent target noun than when it was a contextually congruent noun, indicating that semantic information was not only extracted from a parafoveal word, it was quickly and incrementally integrated with the evolving sentence representation in reading Chinese. References H.A.Barber, S.Ben-Zvi,S.Bentin, & M.Kutas.(2010) Parafoveal perception during sentence reading?:An ERP paradigm using rapid serial visual presentation(RSVP) with flankers.Psychophysiology,1-9. H.A.Barber, N.Donamayor, M.Kutas, & T.Münte. (2010) Parafoveal N400 effect during sentence reading. Neuroscience

Letters, 152-156.

C21 Parafoveal N400 effect during sentence reading: a fixation-related brain potentials (FRPs) study in combination with the boundary technique ***Muñoz, S****.(1),* ***Hawelka, S****.(2),* ***Barber, H.A****.(1),* ***Hutzler, F****.(2); 1. University of La Laguna, Spain; 2 . University of Salzburg, Austria* – Previous research has shown that during reading, parafoveal information might be at least partially processed, but the exact extension of this processing is still a matter of discussion. While eye-tracking research suggests only a shallow processing of parafoveal information (e.g. word length or partial orthographic processing), recent ERP studies have provided evidence of parafoveal semantic processing under some circumstances. In the present study, we obtain fixation-related potentials (FRPs) by means of concurrent electroencephalographic and eye-movement measures to explore parafoveal processing during natural reading. Participants read semantically congruent sentences whereas parafoveal information was manipulated employing the boundary technique. When a pre-target word was fixated, the word displayed in the parafovea could be either the same word as the target word (identity condition), a semantically related word congruent with the sentence context (semantic condition) or a semantically unrelated word incongruent with the sentence context (unrelated condition). FRPs to the first fixation on the target word showed a difference between the identity condition and the other two conditions; the semantic and the unrelated conditions become more positive around 110 ms after fixation. This difference could reflect the disruption of the continuity in the semantic sentence processing when information in the parafovea is inconsistent with that in the fovea. Interestingly, between 175 ms and 300 ms after target fixation, the unrelated condition showed more negative amplitudes than the semantic condition. This negativity has the same topographical distribution as the typical N400, although with an early latency. To our knowledge this is the first study combining the FRPs and boundary technique and the results support the view that during reading it is possible to extract semantic information from the parafovea and integrate it with the evolving representation of the sentence meaning.

C22 Neural bases of dyslexia in primary progressive aphasia ***Henry, M.L****. (1),* ***Galantucci, S.*** *(1,2),* ***Tartaglia, M.C****. (3),* ***Gesierich, B.*** *(1),* ***Wilson, S.M****. (4),* ***Babiak, M****. (1),* ***Miller, B.L****. (1),* ***Henry, R.G.*** *(1),* ***Gorno-Tempini, M.L.*** *(1); 1. University of California San Francisco, 2. Scientific Institute and University Hospital San Raffaele, Milan, Italy; 3. University of Toronto; 4. University of Arizona* – **Objective:** The purpose of this study was to examine the relation between gray and white matter damage and reading ability in individuals with primary progressive aphasia (PPA). Previous research has linked impairment of pseudoword reading to atrophy of left inferior parietal and posterior temporal cortex in individuals with PPA. Conversely, impairment of irregular word reading has been associated with atrophy of the left anterolateral temporal lobe. The role of white matter damage in these deficits has not been directly investigated. Methods: 27 individuals with PPA were included in the study (9 logopenic, 8 nonfluent, and 10 semantic variant). Oral reading of regular words, irregular words, and pseudowords was assessed and lexicality effect (real words minus pseudowords) and regularity effect (regular words minus irregular words) were calculated. Probabilistic tractography was used to generate maps of the inferior longitudinal fasciculus (ILF), uncinate fasciculus, and superior longitudinal fasciculus (SLF). Fractional anisotropy (FA) and mean diffusivity (MD) were calculated for each tract. DTI metrics were evaluated as predictors of regularity and lexicality effects, and voxel-based morphometry (VBM) was used to identify correlations between reading scores and gray matter volumes. Results: Multiple regression analyses revealed that reduced FA and increased MD values in the SLF were associated with a greater lexicality effect (i.e. disproportionately poor performance on pseudowords). Reduced FA and increased MD values in the ILF were associated with a greater regularity effect (i.e. disproportionately poorer performance on irregular words). DTI metrics for the uncinate did not predict either of these reading measures. VBM results revealed that gray matter atrophy in the left inferior and middle frontal gyri and inferior parietal lobe was associated with a greater lexicality effect, and gray matter atrophy in the left anterior temporal lobe was associated with a greater regularity effect. Discussion and conclusions: Damage to left frontal and parietal cortex and/or the SLF is related to an increased lexicality effect in individuals with PPA. These findings support the existence of a dorsal, phonologically mediated reading sub-system that is particularly critical for letter-sound transcoding involved in reading pseudowords. Conversely, damage to the left anterior temporal lobe and/or the ILF results in an increased regularity effect, supporting the existence of a ventral, semantically mediated sub-system that is critical for reading words with atypical sound-letter correspondences. The significance of these findings, and particularly the relation between DTI metrics and reading scores, lies in their capacity to inform cognitive and neuroanatomical models of reading, which have previously focused primarily on cortical regions implicated therein.

C23 Dysfunctional visual word form area in a case of progressive alexia ***Wilson, S.M.*** *(1),* ***Beeson, P.M.*** *(1),* ***Rising, K.*** *(1),* ***Andersen, S.M.*** *(1),* ***Stib, M.T.*** *(1),* ***Gendreau, A.*** *(1),* ***Rapcsak, S.Z****. (1); 1. University of Arizona, Tucson, AZ* – The visual word form area (VWFA), located in left ventral occipito-temporal cortex, plays an essential role in reading. Progressive alexia refers to an acquired reading deficit caused by neurodegenerative disease, and structural imaging studies have suggested that impaired visual word processing in these patients is associated with degeneration of dominant hemisphere posterior brain regions. However, to our knowledge, the functional status of the VWFA in progressive alexia has not previously been investigated. Patient B is a 73-year old man with logopenic progressive aphasia and progressive alexia. His reading deficit is

profound: on the Arizona Battery for Reading and Spelling, he read 20% of words and 0% of pseudowords correctly. His most frequent error types were unrelated words (30%) and visually similar words (22%). He had difficulties even at the single letter level, with only 71% correct performance on a two-alternative forced choice case matching task, and his attempts at reading by a letter-by-letter strategy were generally unsuccessful. Structural MRI revealed widespread cortical atrophy, most prominent in left posterior temporal cortex, and extending to the VWFA in left ventral occipito-temporal cortex. PET revealed hypometabolism of these same regions. To examine the functional status of the VWFA, we used fMRI with a covert reading task. Patient B and a group of control participants were presented with rapid sequences of words or false font strings, as well as resting blocks. In controls, viewing words or viewing false font strings strongly activated bilateral occipito-temporal regions (including the VWFA) relative to rest, and the contrast of words versus false font strings activated the VWFA in the left hemisphere, consistent with prior studies. Patient B showed a strikingly different pattern of activity. His occipito-temporal activation for viewing words or false font strings relative to rest was exclusively localized to the right hemisphere, and he showed no activation in the VWFA for the contrast of words versus false font strings. In sum, patient B had no measurable functional activity in response to reading in the VWFA. Our findings suggest that in progressive alexia, atrophy and hypometabolism of left ventral occipito-temporal cortex render the VWFA dysfunctional, resulting in a profound reading impairment. The magnitude of the reading deficit in the present case is comparable, if not more severe, than most cases where the VWFA is completely destroyed by a stroke or surgical resection.

C24 Making the brain dyslexic: Evaluation of a novel simulation paradigm ***Heim, S.*** *(1,2),* ***Tholen, N.*** *(2,1),* ***von Overheidt, A.****C. (2,1),* ***Grande, M.*** *(1),* ***Weidner, R.*** *(2),* ***Amunts, K.*** *(1,2); 1. Medical School, RWTH Aachen University, Aachen, Germany; 2. Institute of Neurosciences and Medicine (INM1,INM3), Research Centre Juelich, Germany* – Reading deficits in developmental dyslexia often result from phonological or visuo-magnocellular deficits. Here, we report a novel technique to simulate dyslexic symptoms in normal readers by selectively introducing such deficits in isolation or combination. Experiment 1 investigated the behavioural effects of such simulation, whereas Experiment 2 established whether the simulations tapped neural systems comparable to those affected in "real" dyslexics. In Experiment 1, 30 healthy volunteers performed visual lexical word-pseudoword decisions. Grapheme-to-phoneme conversion (GPC) was impaired by manipulating the identifiability of letters via familiar or unfamiliar letter shapes. Visuo-magnocellular processing was impaired by presenting letters in a moving, non-stationary manner. Lexical decision times were systematically higher for both types of simulation. Moreover, both simulations did not interact. Pseudowords elicited higher reaction times than words in all simulations, thus implying that the lexical advantage for words was maintained despite increasing processing difficulty. Moreover, pseudoword processing was extra difficult in the GPC simulation, as indicated by a significant interaction of word-type and letter shape. In Experiment 2, 30 different subjects performed the paradigm during fMRI scanning. Behavioural data replicated the findings from Experiment 1. FMRI data revealed that the magnocellular simulation indeed tapped area V5/MT+ in the magnocellular pathway also affected in "real" dyslexics. The GPC simulation revealed different effects localised predominantly in bilateral inferior frontal gyrus (IFG) and inferior parietal lobule (IPL), regions usually differing in activation between dyslexic and normal readers. Thus, in summary, the novel simulation paradigm replicates earlier findings in the literature on "real dyslexics" both behaviourally and with respect to functional neuroanatomy. It thus provides insights into the neurocognitive mechanisms underlying dyslexia and, most importantly, a means for piloting studies testing novel hypotheses about dyslexia with easy-to-recruit normal readers.

SOCIAL & EMOTIONAL PROCESSING

C25 Neural correlates of lyrical improvisation and musical communication: an fMRI study of freestyle rap ***Liu, S.*** *(1),* ***Chow, H.*** *(1),* ***Xu, Y.*** *(1),* ***Erkkinen, M.*** *(1),* ***Rizik-Baer, D.*** *(2),* ***Eagle, M.*** *(2),* ***Braun, A.*** *(1); 1. National Institutes of Health, National Institute on Deafness and Other Communication Disorders; 2. Justice by Uniting in Creative Energy* – Spontaneous musical performance (jazz improvisation) has been associated with a dissociated pattern of frontal cortical activity that may support creative behavior in the absence of focused attention.The present study was undertaken to see how this pattern - activation of medial prefrontal (MPFC), deactivation of dorsolateral prefrontal (DLPFC) areas – might be modified during spontaneous generation of language in a musical context. Art forms that involve improvisation of musical lyrics are rare (e.g. African griot, Karelian lament).In our own culture, one such form exists: freestyle rap, a form of hip-hop involving generation of freely improvised, rhythmically-guided rhyming phrases. This genre also allows examination of a unique type of musical communication: call and response, or trading-8s - alternating production of improvised material for eight bars in length, in which subjects attend to and elaborate on each other's performance. Twelve right-handed male freestyle artists with at least five-years professional experience participated in this BOLD fMRI study.Artists performed three tasks using the same musical background track: Freestyle (spontaneous, improvised rap), Memorized (performance of an overlearned set of lyrics) and Trade8 (spontaneous production, in alternating eight bar segments as described above).Data were acquired using a block paradigm with a block length of 8 bars (22.58 s).Subjects alternated blocks with a designated host artist situated outside the scanner room.Differences between conditions were identified using GLM contrasts and seed voxel connectivity analyses, guided by these contrasts, were conducted. The Freestyle vs.

Memorized contrast showed robust left-lateralized activation along the frontal midline, extending from ventral MPFC the pre-SMA, accompanied by increases in the perisylvian language areas (left inferior frontal, middle and superior temporal gyri). Consistent with our predictions, we observed robust deactivation of the right DLPFC, although deactivation of the left DLPFC did not attain statistical significance. Significant deactivations were also observed regions comprising the dorsal attention network. Connectivity analyses, using MPFC as a seed, showed strong positive correlations with left IFG during improvisation.When the IFG was used as seed, it was strongly connected to the left amygdala, which itself showed widespread connections throughout the brain during improvisation. The Trade8 vs. Freestyle contrast showed activations that were in general stronger in the right hemisphere and maximal in the right temporoparietal junction (TPJ)/angular gyrus.Functional connectivity analyses, using this region as a seed, showed widespread connections with cortical and subcortical areas that were present only during the Trade8 condition. In summary, lyrical improvisation was associated with dissociation of MPFC and DLPFC activity but, unlike the pattern observed for jazz improvisation, responses were strongly left lateralized and coupled to activation of perisylvian language areas.This may represent a domain-specific modification of a general pattern that supports spontaneity in the absence of focused attention. Activation – and increased connectivity – of the right TPJ/angular gyrus during the Trade8 condition suggests that this region may underlie the establishment joint action and common ground during musical as well as other forms of interpersonal communication.

C26 Activation of a mentalizing region predicts behavioral accuracy in the classification of 'posed' and genuine amusement laughter ***McGettigan, C.*** *(1),* ***Agnew, Z.K.*** *(1),* ***Walsh, E.*** *(1,2),* ***Jessop, R.*** *(1),* ***Scott, S.K.*** *(1); 1. Institute of Cognitive Neuroscience, University College London, UK; 2. Institute of Psychiatry, King's College London, UK* – We used fMRI to investigate the neural correlates of the authenticity of amusement laughter. The stimuli were produced by three adult female speakers of British English and recorded in an anechoic chamber. The 'posed' laughs (similar to the polite or 'phatic' laughter used in conversation) were generated first, followed by tokens of real amusement laughter that were elicited while the speakers watched their favorite funny YouTube videos. Twenty-one tokens from each laughter category were subjected to extensive behavioral testing. The tokens were successfully categorized by a group of 17 participants, with accuracy significantly above chance for both laughter types ($p < .0001$). A further 20 listeners rated the data on 7-point scales for AroUSl, Valence, Intensity and Contagion (emotional and physical). The real laughs were perceived as significantly more intense ($t(40) = 4.84$, $p < .001$), more contagious (emotional: $t(40) = 6.43$, $p < .001$; physical: $t(4) = 3.32$, $p < .005$)and more positively valenced ($t(40) = 6.19$, $p < .001$) than the 'posed' samples (although both categories were rated as positive overall: Real - 5.38, Posed - 4.74). The 42 laughter samples were presented to 21 listeners (7 male; aged 18-40) in a sparse sampling paradigm in fMRI, along with posed sounds of disgust and unintelligible (spectrally rotated) emotional sounds. The participants were instructed that they would hear 'emotional sounds' and to listen closely. After the scan, the participants were informed that only some of the laughs they had heard in the scanner reflected genuine amusement, and were immediately tested on overt classification of all 42 laughs as real or posed. All participants performed above chance on this post-test (Mean d prime 1.72, SD 0.47, range 1.11-2.57). A random-effects T-contrast of Real > Posed ($p < .001$, uncorrected; cluster extent threshold = 12 voxels)* showed greater activation in bilateral superior temporal cortex in response to the genuine laughter condition. At the same threshold, the reverse contrast of Posed > Real gave increased activation in left medial BA 10, anterior cingulate, thalamus and a cluster encroaching on right parahippocampal gyrus. Individual differences analyses on these contrasts showed that activation in BA10 and thalamus (for Posed > Real) and right STG (Real > Posed) was positively correlated with individual post-scan classification accuracy scores (see Figure). A further analysis, in which all the laughter events were modelled in the GLM as a single regressor parametrically modulated by item-specific authenticity ratings, showed the same sets of activations as observed in the category subtractions. Thus, we demonstrate implicit modulation of neural activity in auditory and mentalizing areas by the authenticity of sounds of amusement. The involvement of BA10 may signal a difference in 'communicative intent' across the laughs (Frith & Frith, 2006), where the 'posed' samples possess more of the qualities of the phatic laughter that we encounter every day as the 'social glue' of conversation (Provine, 2000). *This cluster extent threshold was established using a Monte Carlo simulation in Matlab (Slotnick et al., 2003; correcting for a whole-brain alpha of 0.05).

ACQUISITION

C27 Contributions of development and oral motor skill to functional neural activation for picture naming in school-aged children and young adults ***Krishnan, S.*** *(1),* ***Leech, R.*** *(2),* ***Mercure, E.*** *(3),* ***Lloyd-Fox, S.*** *(1),* ***Dick, F.*** *(1); 1. Birkbeck, University of London, UK; 2. Imperial College London, UK; 3.Institute of Cognitive Neuroscience, University College London, UK* – In recent years, much has been learned about the structural and functional neural networks that support language production, but comparatively less is known about how they develop (but cf Brown, et al, 2005, Schlaggar and McCandliss, 2007). A continuing challenge for pediatric neuroimaging is unraveling the contribution of the multiple auditory and motor skills that drive changes in language organization. Oral motor control is one of the skills that supports language (Alcock, 2010), and children are slower and more variable in their articulatory patterns until 14 - 16 years of age (Smith, 2006). In the present study, we examined functional changes using fMRI in 40 school aged children (7 - 12 years) and 20 adults (20 - 25 years), engaged in a language task

of overt picture naming. We then used behavioral performance on an out-of-scanner oral motor control task to understand how individual differences in oro-motor skill predicted differences in activation patterns underlying language production. We find that even for this simple task, there is a prolonged developmental maturational course, and patterns of activation show complex developmental effects. As has been previously reported for picture naming (Wilson, et al, 2009; Moore & Price, 1997), the overall pattern of activation shows increases in activation in bilateral visual and motor regions, and decreases in activation around the supramarginal gyri. For children who were naming pictures, the right superior temporal sulcus, the right inferior frontal gyrus and the superior parietal lobule bilaterally, was recruited to a lesser extent than for adults. Interestingly, even for adults at the tail end of development, lower oral motor scores were associated with greater activation in the right hemisphere (somato-motor mouth areas). Our results indicate that the functional organization of language processing in school-age children is still undergoing significant developmenteven when children's performance was extremely similar to that of adults. These group differences are likely to be related to interactions between general maturation patterns, task-related differences and strategic differences when learning language.

C28 Untrained word combinations and grammatical forms in a previously non-verbal adult with autism ***Loughlin, E.*** *(1),* ***Thorne, J.*** *(1),* ***O'Grady, J.*** *(1),* ***Gordon, B.,*** *(1); 1. The Johns Hopkins University, Baltimore, MD* – The use of novel word combinations and grammatical affixes have been considered among the key features differentiating true language from simple communication. However, there is considerable controversy as to just what features are fundamental to language, and what intermediate steps might exist between basic communication and full language use.A 23-year-old previously nonverbal individual with regressive autism, who began producing meaningful sounds at the age of 14, has recently begun spontaneously producing novel, untrained word combinations and grammatical suffixes that suggest what intermediate stages may be necessary for the development of language, and in the evolution of the language faculty. Subject: AI spoke his first words at approximately 1:3;by age 1:6, he imitated words and produced a few word approximations spontaneously. However, at approximately 2:0, there was a marked decrease in social relatedness, and his vocalizations were reduced to unintelligible sounds. He was ultimately diagnosed with autism, and was considered low-functioning and nonverbal for many years. Methods:For the past 11 years, AI has been in an immersive, home-based, training program, with a wide range of activities in- and outside the home. He has had extensive training on speech and language skills, including attempts at reading. Of particular relevance to this report, focused efforts at increasing spontaneous speech have been implemented over the past two years. For training and data collection purposes, all educational sessions have been video- and/or audio-recorded; contemporaneous notebooks kept by instructors; and family reports elicited for times when the student was not in the presence of instructors. Results:AI began producing meaningful sounds at the age of 14, words at 16, and by age 21.8 had utterances up to 7 words in length (Loughlin et al., IMFAR, 2010).In the past two years, spontaneous productions (requests, comments, and questions) have increased in frequency from ~100/month at age 21, to ~500-1000/month at age 23:5.Productions have been up to 9 words long. Some of these productions have consisted of word combinations, combinations with grammatical function words, and inflected forms, that were never explicitly taught.As examples (CAPITALIZED items were not teaching targets):"Give ME phone" ; "I'm reading A book" ; "I want TO watch TV" ; "I want you TO stand up";"LoudER music." All of these productions have appeared to be contextually appropriate, and reflective of his intentions. Discussion:At least some, if not all, of these productions may have been acquired by incidental learning, even though none were explicitly taught.Regardless, they suggest that elements of true language may emerge when two conditions are met: (1) an individual develops a sufficiently large enough workspace in which to formulate expressions, and (2) they have a large enough vocabulary to populate that workspace (cf. proposals made by E. Bates & colleagues).

C29 Age-of-acquisition effects on temporal integration windows: Evidence from non-native sign language processing ***Langdon, C.*** *(1),* ***Hwang, S.-O.*** *(2),* ***Pucci, C.*** *(1),* ***Idsardi, W.*** *(2),* ***Mathur*** *(1); 1. Gallaudet University, Washington, D.C.; 2. University of Maryland, College Park, Maryland* – **Purpose:** We investigate the effect of late acquisition on temporal integration windows by testing the cognitive restoration of temporally distorted sentences on non-native users of American Sign Language (ASL). These results are compared with previous findings from native signers who have been exposed to ASL since birth, demonstrating the impact of developmental factors on these aspects of language processing. Background:Parallel to findings from speech perception (Saberi & Perrott, 1999; Greenberg & Arai, 2001; Figueroa et al., 2009), locally-reversed sentences of ASL can also be cognitive restored, but intelligibility falls drastically at greater reversal sizes of ~300 ms, versus ~60 ms in speech) (Hwang et al., 2010; Hwang et al., 2011).This set of findings demonstrate the impact of modality (auditory versus visual processing) on the time windows for integrating linguistic information.Previous work has only tested native users of a language, and here, we present results from deaf signers who were not exposed to ASL until late childhood, which is prevalent because ~95% of deaf individuals are born to non-signing hearing parents (Mitchell & Karchmer, 2004). Experiment: Non-native deaf signers are defined here as those whose first language is English, became deaf at birth or by age 2, then acquired ASL after the age of 10 and have used ASL as their primary language for at least 4 years.Participants viewed 40 sentences of ASL, which were balanced for phonological parameters and have a relatively low degree of semantic predictability.Frame sequences were locally reversed in 8 conditions at sizes ranging from the

control condition of 0 ms to 934 ms. Participants were instructed to repeat back all signs that they were able to detect after each presentation of the video clip.Participants were permitted to view each sentence up to four times.Percent accuracy was scored offline to measure the intelligibility of the sentences, which was measured by dividing the number of morphemes the participant correctly identified by the total number of morphemes present in the stimuli. Results: Overall, non-native participants perform at lower levels of accuracy compared to native signers (~10% lower across all the conditions).Moreover, the scores of non-native signers drop quickly at the smallest reversal condition (133ms), whereas scores were at ceiling among native signers at this condition. Conclusion: These results provide continued support for modality specific effects on the size of integration windows for language processing, given that intelligibility still falls at a greater size than in speech.Additionally, we find age-of-acquisition effects on ASL processing, where late learners are more sensitive to temporal distortions in the input. These findings have implications for the neurocognitive underpinnings of integration in perception and the role of input in early development for these processes.

C30 Experience affects neural basis of language development: evidence from blind children. ***Bedny, M.*** *(1),* ***Richardson, H.*** *(1), and* ***Saxe, R.*** *(1); 1. Massachusetts Institute of Technology, Cambridge, MA* – In the vast majority of adults language processing depends on a left-lateralized network of brain regions in the prefrontal and temporoparietal cortex. By contrast, congenitally blind people additionally activate "visual" areas of the occipital lobe during language processing. We examined how this distinct language system develops in early blind children. Nine blind and twenty sighted children participated in an fMRI study (ages 4-17 years). Blind children had lost their sight due to eye or optic nerve conditions and did not suffer from any neurological or cognitive disabilities. While undergoing fMRI, children listen to short stories, speech in foreign languages, and short music clips. On each trial, children heard a target followed by a probe and made a "does this come next" judgment. For stories, they decided whether a probe sentence was the correct continuation of that story. For foreign speech, they decided whether the probe segment was in the same language as the target. For music, they decided whether the probe was of the same melody as the target. We measured the response of occipital areas during the target portion of the trial. In blind children, but not in sighted children, lateral occipital cortex responds more to language than to foreign speech or music. This language-sensitive response was present in blind children as young as 4 years old, and did not depend on Braille learning. Within classic language areas, lateral temporal cortex was selective for language in both sighted and blind children. By contrast, left lateral prefrontal areas were selective for language only in sighted children. We conclude that blindness enables occipital areas to develop language functions and effects language specialization in prefrontal areas. The data suggest that the typical adult language system emerges as a result of an experience-sensitive developmental process.

C31 Developmental changes in sentence processing: from adolescence to adulthood ***Humphreys, G.*** *(1),* ***Levita L.*** *(1),* ***Pfeifer, G.*** *(1),* ***Eimontaite, I.*** *(1),* ***Oladapo, F.*** *(1),* ***Gennari, S.*** *(1); University of York, UK* – It is well known that the brain develops through adolescence. Myelination processes in pre-frontal cortex are not yet complete until late adolescence (Daniel et al, 2000, Adleman et al, 2002). This is reflected in (a) lower pre-frontal cortex activity in adolescent compared to adults in conflict resolution tasks such as Stroop, and (b) activity increases in posterior temporal and parietal brain regions, indicating that adolescent rely more on posterior than pre-frontal regions to resolve conflict. Here we examine sentence processing in 35 participants (17 adults and 18 adolescents) aged 12-30 years to establish the impact of pre-frontal cortex development on the language processing network. We used sentences already known to involve semantic competition in determining who-is-doing-what-to-whom in the sentence (semantic-role processing) (Traxler et al, 2002; Gennari & MacDonald, 2008). 1) The movie that the director watched received a prize. (low-competition) 2) The director that the movie impressed received a prize. (high-competition) In (1), the nouns' configuration easily activates the likely relationship between the movie and the director (watch). In (2), in contrast, this relationship is more difficult to determine because many strong alternatives are possible, which conflict with the one provided (impress) (Gennari and MacDonald, 2008). This thus allowed us to examine semantic competition resolution across ages. Using event-related fMRI, two tasks were completed: a sentence comprehension task, where sentences were visually presented followed by comprehension questions, and a Stroop task, which identified brain regions sensitive to conflict resolution (localizer). Verbal IQ was also collected. Comparisons of the language networks in whole-brain analyses indicated that adults showed stronger activity than adolescence in right pars opercularis and right posterior temporal gyrus. In contrast, adolescents showed more activity in left anterior temporal structures, which are associated with semantic integration. Unlike previous Stroop-results, anterior, rather than posterior, temporal regions aid conflict resolution in adolescent language comprehension. Within the Stroop-responding pars-opercularis region, adults show stronger language activity overall, as in previous Stroop results. However, adolescents show larger differences between high- vs. low-competition language conditions, indicating that despite overall low activity, adolescents experienced more competition in the high-competition condition. Finally, age negatively correlated with language activity in several regions, after controlling for language ability: medial frontal and superior frontal regions (BA8, 9, 10), left subcortical structures (putamen) and left insular and opercular cortex. The older the participant, the less recruitment of these regions. This suggests recruitment of regions outside the typical adult fronto-temporal network for younger participants. The results suggest that the adults' language network is more efficient in

resolving competition, recruiting circumscribed fronto-temporal regions (left posterior temporal, pars opercularis) as well as their right-hemisphere homologues. In contrast, adolescents engage the left anterior temporal lobe more strongly, and recruit additional medio-frontal and subcortical regions outside the adult language network. Overall, the role of pre-frontal cortex in adults' successful comprehension is performed by the interplay of a larger distributed network in adolescents, with less efficient inter-hemisphere pre-frontal communication. This suggests that as the brain develops, more regional specialization and efficiency occurs in language processing.

MANUAL & SIGN LANGUAGE

C32 Functional-anatomy of auditory-motor integration involving hand, eye, and tongue motor effectors ***Isenberg, A.L.*** *(1),* ***Rong, F.*** *(1),* ***Saberi, K.*** *(1),* ***Hickok, G.*** *(1); University of California, Irvine, CA* – The neural basis of auditory-motor integration has been studied predominantly in the speech domain.This work has identified an auditory network involving several cortical regions including dorsal and ventral premotor, superior temporal, and area Spt in the posterior planum temporal region (Hickok, Buchsbaum, Humphries, & Muftuler, 2003).One previous fMRI study examined the motor effector specificity of this network, Spt in particular, using tonal stimulation and covert humming or imagined piano playing as output (Pa & Hickok, 2008).This study found that Spt was more active when the output task involved the vocal tract compared to the manual effectors, suggesting a sensory-motor network that is vocal tract selective. Here we re-examine this issue using spatial auditory stimuli and overt spatial tracking using hand, eye, or tongue effectors. Sensory stimuli consisted of an externalized moving sound source that changed direction unpredictably.During fMRI scanning, subjects were instructed using a visual cue in blocked trials, to either (i) point their finger, (ii) move their eyes, or (iii) "point" their tongue in the direction of the sound source and track its movement. Activation in motor related cortex was found to distinguish between the various conditions in a way that is consistent with known motor somatotopy.A conjunction analysis between the three conditions showed common areas of activation, including the posterior planum temporale (PT). However, within this region we found evidence of a patchy organization associated with the different motor effectors, similar to findings of spatially organized modality specific regions in multisensory association cortex in nonhuman primate (Dahl et al, 2009).Pattern classification analyses in this region yielded significant classification for each of the three motor effector conditions.Figure 1 depicts the posterior PT ROI used in pattern classification for a representative subject as derived from the conjunction analysis. We conclude that auditory-motor integration for a variety of motor effectors involves the posterior planum temporale generally, with some degree of internal organization that is dependent on the motor effector involved. Dahl, C.D., Logotheitis, N.K., & Kayser, C. (2009) Spatial Organization of Multisensory Responses in Temporal Association Cortex. Journal of Neuroscience, 29(38):11924-11932. Hickok, G., Buchsbaum, B., Humphries, C., & Muftuler, T. (2003). Auditory-motor interaction revealed by fMRI: Speech, music, and working memory in area Spt. Journal of Cognitive Neuroscience, 15, 673-682. Pa, J., & Hickok, G. (2008). A parietal-temporal sensory-motor integration area for the human vocal tract: Evidence from an fMRI study of skilled musicians. Neuropsychologia, 46, 362-368.

C33 Signs that violate phonological rules differentially activate parietal areas in deaf native signers. ***Cardin, V.*** *(1),* ***Orfanidou, E.*** *(1),* ***Kästner, L.*** *(1,2),* ***Capek, C.M.*** *(3),* ***Rönnberg, J.*** *(4),* ***Woll, B.****,(1),* ***Rudner, M.*** *(4); 1. University College London, UK; 2. Ruhr-University Bochum, Germany;3. University Of Manchester, UK; 4. Linnaeus Centre HEAD, Swedish Institute for Disability Research, Linköping University, Sweden* – Semantic and phonological processing, and the neural mechanisms that support them, are traditionally studied in the context of spoken languages. However, sign languages (SL) are processed in the visuo-spatial domain, and their specific semantic and phonological components have to be extracted from a different kind of sensory information. To characterise semantic and phonological processing in the visuo-spatial domain, we conducted an fMRI experiment using SL stimuli that varied in semantic and phonological content. Native signers of Swedish Sign Language (SSL) and British Sign Language (BSL) were scanned while performing monitoring tasks for specific components of (i) a familiar SL (phonology and semantics), (b) an unfamiliar (foreign) SL (phonology only), and (c) non-signs (non-existing signs violating phonological rules of both BSL and SSL: neither phonology nor semantics). Preliminary results show that non-signs activate more strongly phonological-processing areas in the inferior parietal cortex, indicating that more processing is required when signs violate phonological rules, and the right superior parietal lobe. Our results suggest that areas involved in phonological processing in SL partially overlap with those processing phonology in spoken language, butalso constitute modality specific regions, such as the right superior parietal cortex, which we hypothesise may play a role in specific visuo-spatial integration of SL sensory information. They also suggest that phonological processing occurs even when phonotactically illegal items are presented, and that the phonological characteristics of a language arise so to maximize the perception and production of the language components.

C34 Spatial and temporal dynamics of lexico-semantic processing in American Sign Language ***Ferjan Ramirez, N.*** *(1),* ***Leonard, M.*** *(1),* ***Torres, C.*** *(1),* ***Hatrak, M.*** *(1),* ***Mayberry, R.*** *(1),* ***Halgren, E.*** *(1); 1. University of California San Diego* – The ability to understand words is central to human communication and thought. The neural activity evoked by written and auditory words begins its course in modality-specific brain areas bilaterally and then spreads anteriorly, converging on a supramodal left fronto-temporal network ~400 ms post-stimulus onset, which is when lexico-semantic processing is thought to occur (Marinkovic et al, 2003; Kutas & Federmeier, 2000).We ask whether the

same is true when one's native language is acquired in a visuo-motor modality, as is the case in congenitally deaf individuals who acquire American Sign Language (ASL) from birth. Like written words, ASL signs are perceived through the eyes, but analogous to auditory words, signs are dynamic and unfold over time on a millisecond level. Also unlike written language, ASL is a natural language acquired from birth by some deaf individuals in North America. The question we ask is whether the modality of early language experience impacts development of the neural networks for language processing. In particular, we ask if the spatiotemporal dynamics of lexico-semantic encoding in response to sign language stimuli in deaf participants are similar to those observed in hearing participants in response to auditory and written words. We use an innovative multimodal imaging technique combining magnetoencephalography (MEG) and structural magnetic resonance imaging (MRI) to achieve high spatiotemporal accuracy that allows us to examine the timecourse of activity in response to ASL signs across the whole brain. This method, known as dynamic statistical parametric mapping (dSPM; Dale et al., 2000) allows us to resolve specific stages of sign processing (early perceptual processing vs later lexico-semantic encoding), presenting an important advantage over previous studies using hemodynamic methods, which have poor temporal resolution. While native deaf signers of ASL sat in the MEG, we recorded their neural responses to signs that were either matched or mismatched to a preceding picture of an object. Our results show that ASL signs evoke a characteristic event-related response peaking at ~400 ms post-stimulus onset that localizes to a left-lateralized fronto-temporal network, including anteroventral temporal, superior temporal, superior planar, and inferior prefrontal regions. Importantly, lexico-semantic activity in response to ASL signs is remarkably similar to that of auditory and written words in terms of neural timing and localization (Marinkovic et al, 2003; Patterson et al, 2007). These results suggest that lexico-semantic encoding is driven by supramodal neural mechanisms regardless of the modality of the lexical stimulus. Further, our results suggest that the canonical left-lateralized neural network is used for lexico-semantic processing regardless of the modality through which early language is acquired. Our results agree with previous hemodynamic and lesion studies that demonstrate a similar substrate for sign and speech (Poizner et al, 1987; Emmorey et al, 2003; MacSweeney et al, 2002; Mayberry et al, 2011), and further elucidate the temporal dynamics of the lexico-semantic processing of signs.

PATHOLOGY

C35 Verb and Noun Comprehension in Frontotemporal Degeneration ***Camp, E.*** *(1),* ***Boller, A.*** *(1),* ***Burkholder, L.*** *(1),* ***Morgan, B.*** *(1),* ***Moore, P.*** *(1),* ***Weinberg, D.*** *(1),* ***Grossman, M.*** *(1); 1. The University of Pennsylvania, Philadelphia, PA* – **Objective:** To assess how nouns and verbs are interpreted based on patterns of impairment in patients with frontal disease due to behavioral variant FTD (bvFTD), Alzheimer disease patients (AD), and elderly controls (WNL). Background:Previous research has shown that nouns are processed in a multi-loci fashion, such that visual and other perceptual features are represented in temporal areas of the brain, while the representation of the manipulation of objects occurs elsewhere in the brain.There are theories suggesting a similar pattern for the processing of verbs or actions; that is, the image of the action occurring is stored in lateral-temporal cortices, whereas motor-specific information, which prepares one to initiate or mimic a movement is localized in frontal and parietal areas of the brain. Design/Methods:Demographically-matched bvFTD patients (n=10), AD patients (n=8), and elderly controls (n=10) completed a triad task involving the matching of both verbs and nouns.There were 120 triads total (60 verb triads and 60 noun triads).All items in the triads were matched for imaginability, familiarity, age of acquisition, and frequency. Results:Independent sample t-tests indicate a significant difference between bvFTD patients and elderly controls on verb triad accuracy (p=0.013), and no significant difference on noun triad accuracy (p=0.153).In addition, paired sample tests comparing verb and noun accuracy for bvFTD, AD, and WNL patients showed only bvFTD patients had any significant difference between nouns and verbs (p=0.007).The paired sample results for AD were p=0.293, and WNL p=0.255. Discussion:The results are consistent with the theory that frontal areas of the brain are more heavily relied on for verbs than for nouns.Patients with bvFTD have increased frontal dysfunction compared to the AD population, which is why we didn't see the same distinction between verbs and nouns that we did for the bvFTD patients.

C36 Patterns of Aphasia and Language Recovery in a Prospective Cohort of At-Risk Neurosurgical Patients ***Deleon, J.*** *(1),* ***Babiak, M.*** *(1),* ***Perry, D.*** *(1),* ***Berger, M.*** *(1),* ***Chang, E.*** *(1); 1. University of California, San Francisco* – **Background:** Patients undergoing surgical resection for tumor or epilepsy in the dominant hemisphere are at high-risk for induced language impairment. Discrete surgical lesions can manifest with distinct postoperative language deficits, which are different than those observed in stroke and neurodegenerative diseases. Because surgical patients can be studied immediately before and after the onset of aphasia, they offer a unique opportunity to: 1) characterize the patterns of language deficits from surgical lesion locations, and 2) determine the course of recovery from acquired aphasia. Methods: Two standardized measures of language function, the Western Aphasia Battery (WAB) and the 15-item Boston Naming Test (BNT), were administered to a prospective cohort of 43 neurosurgical patients at four time-points (preop, 2 days, 1 month, and 3 months postop). The patients were divided into three groups (13 frontal, 21 temporal, 6 parietal) based on lesion/surgery location. We included 3 patients with non-dominant hemisphere lesions as controls. Language performance on the WAB and BNT was correlated with lesion site. Results: Preoperatively, 83% of patients had normal scores

(mean AQ>93.8). When assessed by group, 88% of the frontal group (AQ=97.8, SD=3.05), 60% of the parietal group (AQ=93.6, SD=7.04), and 90% of the temporal group (AQ=96.1, SD=2.99) scored within the normal range. Within 2 days after surgery, only 19% of patients demonstrated normal AQ scores. Thirty-six percent of the frontal group (AQ=83.07, SD=24.44), 100% of the parietal group (AQ=68.52, SD=26.22), and 85% of the temporal group (AQ=72.39, SD=29.88) had abnormal scores. By far, the most common aphasia subtype was anomic (N= 19), followed by fewer instances of global (N=2), conduction (N=3), and Broca's (N=2).Significant improvements and evolution of aphasia subtype were observed at 1- and 3- month follow-ups overall, but some temporal patients had persistently abnormal AQ (1 mo: AQ=90.2; 3 mo: AQ=92.3). On the BNT, the frontal and parietal groups scored within normal limits (>14) preoperatively, but the temporal patients scored below normal and performed worse than the frontal and parietal groups (score=11.5, SD=2.51, p=0.005). This effect persisted through the 2-day, 1- and 3-month follow-up periods (p<0.05). Frontal and parietal patients were relatively unaffected at any time point. BNT errors were coded and stratified by group. Temporal patients had a higher rate of semantic paraphasias and circumlocutions at 2 days postop (p<0.01).At the same time point, parietal patients had a higher number of phonological paraphasias. Conclusion: Our results demonstrate the feasibility and utility of a prospective cohort study of surgical patients at-risk for acquired aphasia. Our findings reveal new information regarding the dynamic evolution of aphasia symptoms and the relationship between surgery location and specific aphasia subtypes. Continued research in this novel population should offer new insights to the basis and recovery of acquired language disorders.

C37 Impaired Verbal Memory in Patients with Traumatic Brain Injury ***Yang, F.*** *(1),* ***Luks, L.T.*** *(2),* ***LaHue, S.*** *(2),* ***Chu, L.*** *(1),* ***Mukherjee, P.*** *(2); 1. National Tsing Hua University; 2. University of California San Francisco* – The influence of semantic property and grammatical class on semantic competition. Research has reported that patients with mild traumatic brain injury (TBI) suffer from impaired verbal memory using measures of neuropsychological testing. Verbal memory deficits might arise from failure in memory retrieval or semantic selection. It remains unclear how TBI patients' language and memory networks are affected at the neuronal level after trauma and how TBI patients differ from healthy controls in processing literal and abstract words . The present study uses functional MRI to investigate semantic retrieval and selection in TBI patients during lexical ambiguity resolution of homonyms and metaphors. We hypothesize that either or both of these two processes are impaired in patients and patients will demonstrate more difficulty in processing metaphors. Eleven mild TBI adults (8 males, 3 females, mean age: 32.6, SD=9.3) and five age-matched healthy controls (5 males, mean age: 31, SD=11.4) participated in the study. Subjects were asked to decide whether words in a pair were related, and to indicate their decision by pressing the right button (related) or the left button (unrelated). Each trial contained the first pair as a probe, the second pair as a target, and a focal point. Subjects responded to both probe and target pairs. We had three conditions: consistent, inconsistent, and control. Words in all trials were nouns. The second word in the probe and target noun pairs were ambiguous in semantic meaning (either homonyms or metaphors). In the consistent condition, the first and the second word pairs referred to the same meaning of the ambiguous word (e.g., money-bank, vault-bank).In the inconsistent condition, the target pair referred to a different meaning of the homonym or metaphor than the probe pair (e.g., meat-chicken, coward-chicken).The control condition contained probe and target pairs of words that did not share a common meaning (diaper-baby, gas-truck). Consistent and inconsistent trials contained the same class of ambiguous words (e.g., metaphors or homonyms) in the second position of both probe and target pairs. All image processing was performed using SPM5. Patients exhibited more activation in inconsistent conditions than controls, whereas controls showed more activation in the consistent condition than patients.The inconsistent metaphor>consistent metaphor contrast revealed that patients activated more left precentral gyrus, supramarginal gyrus and inferior parietal lobule than controls. The inconsistent homonym>consistent homonym contrast showed that patients had more activation in the right insula. In comparison with patients, controls showed more activation in the precuneus and precentral gyri in response to the consistent metaphor condition. These findings suggest that patients may engage more attention and memory functions in parietal and frontal cortices to resolve semantic ambiguity. In contrast, controls tend to engage more of the precuneus imagery network than patients in processing metaphor-related words. In sum, TBI patients' verbal memory deficits may be related to poor semantic selection but not associated with semantic retrieval, as increased activation and significantly longer reaction time than controls was only observedin inconsistent conditions (that requires semantic selection) but not in consistent conditions (that requires semantic retrieval).

C38 Deficits in the organization and anatomy of narrative comprehension and expression in Lewy body spectrum disorders ***Ash, S.*** *(1),* ***Xie, S.*** *(1),* ***Gross, R. G.*** *(1),* ***Dreyfuss, M.*** *(1),* ***Boller, A.*** *(1),* ***Camp, E.*** *(1),* ***Morgan, B.*** *(1),* ***Grossman, M.*** *(1); 1.University of Pennsylvania, Philadelphia, PA* – Patients with Lewy body spectrum disorders (LBSD) such as Parkinson's disease (PD), Parkinson's disease with dementia (PDD), and dementia with Lewy bodies (DLB) exhibit deficits in both narrative comprehension and narrative expression. If this is due to a material-neutral deficit in organizational executive resources rather than to impairments of language per se, we would expect to find that comprehension and expression would be similarly affected.Also, we would expect that deficits in both expression and comprehension would be related to the same frontal disease.We examined 29 LBSD patients (20 non-

demented PD and 9 mildly demented PDD/DLB) and 25 healthy seniors on their comprehension and expression of temporally ordered discourse. The comprehension task involved judging the ordering of events from familiar scripts such as going fishing; accuracy and latency in judging pairs of events was used to monitor organization during comprehension. The expression task involved narrating a story from a wordless picture book; connectedness of the sequence of reported events and maintenance of the overall story theme were measured to assess organization during expression. Grammaticality and semantic competence in expression were measured, and neuropsychological tests of executive and language functioning were conducted. We found that LBSD patients were impaired on measures of organization during both comprehension and expression relative to healthy seniors. Measures of organization during narrative expression correlated significantly with measures of organization during script comprehension. Measures of discourse organization during both comprehension and expression correlated with executive measures but did not correlate with neuropsychological measures of lexical access or grammar.Using voxel-based morphometry, we found overlapping regressions relating frontal atrophy to script comprehension, narrative expression, and measures of executive control.Thus, impairments in communication in LBSD patients affect both comprehension and expression. Difficulties appear to stem from a common deficit at the level of overall organization for both comprehension and expression, not at the levels of syntax or lexicon. These impairments are related to impaired executive functioning and are associated with cortical atrophy in frontal regions in LBSD.

C39 Object naming during overt picture naming in healthy and anomic stroke patients ***Holland, R.*** *(1),* ***Leff, A.P.*** *(1),* ***Price, C.P.*** *(1),* ***Crinion, J.*** *(1); 1. Institute of Cognitive Neuroscience, University College London* – **Background:** Anomia is the single feature aphasic patients complain most about in the chronic phase post stroke. Good recovery after aphasic stroke has been linked with recruitment of left perilesional regions and, in particular for speech function, Broca's area. In this study, we investigated whether patients with good picture naming ability, despite lesions involving Wernicke's area but sparing Broca's area, showed additional recruitment of this region and its right hemisphere homologue when compared to healthy older controls. Methods: From an ongoing study, we report here behavioral and neural data from nine chronic aphasic patients with good single word picture naming (monosyllabic, high frequency, CVC nouns, e.g. "pig" and "well") and healthy older controls (n = 22) during a functional magnetic resonance imaging (fMRI) experiment of overt picture naming. All patients had damage to the normal naming network, i.e., left middle cerebral artery (MCA) strokes: 7 with primarily temporo-parietal damage and 2 with premotor cortical damage. Importantly, for all patients, Broca's area was structurally intact. Data were processed using a unified normalization routine1 and smoothed at 8mm FWHM within SPM8. First level data were modelled as discrete events and contrast images computed for control cue versus rest. Patient and control images were then entered into a factorial design matrix at the second level for statistical analyses. Results: As expected, patients and controls were at ceiling on the task. Neural responses from both patient and control groups during successful object naming revealed an extended, fronto-temporal naming network involving superior and middle temporal gyri, precentral and insula cortices. Direct statistical comparison (p=0.001 uncorrected, whole brain analyses) between the two groups found that the control > patient group, showed increased activity within left superior temporo-parietal cortices corresponding to the patients' maximum cortical area of lesion damage. The control group also had significantly more activation in right superior cerebellum, consistent with functional diaschisis2. The reverse contrast, patients > controls, revealed increased activity in (i) left middle temporal cortex and (ii) the right head of the caudate (Figure 1). No significant differences between the patient and controls groups were identified in either left or right inferior frontal cortex. In summary, this group of chronic aphasic patients with good naming performance despite partial damage to the normal naming network showed additional activation in both left perilesional middle temporal cortex and the contralateral right head of the caudate. The left middle temporal gyrus has been implicated widely in a variety of different tasks, including picture naming, that require semantic information3-6 and is connected in a broad neural network to regions further associated with processes of speech production and language control. The head of the caudate has also been identified as a subcortical structure associated with the production of speech7 and control processes, such as the suppression of inappropriate responses8,9. 1 Crinion, J. et al. Neuroimage 37, 866-875 (2007). 2 Price, C. J., Warburton, E. A., Moore, C. J., Frackowiak, R. S. & Friston, K. J. J Cogn Neurosci 13, 419-429 (2001). 3 Schuhmann, T., Schiller, N. O., Goebel, R. & Sack, A. T. Cereb Cortex (2011). 4 Price, C. J. Ann N Y Acad Sci 1191, 62-88 (2010). 5 Hickok, G. & Poeppel, D. Nat Rev Neurosci 8, 393-402 (2007). 6 Binder, J. R., Desai, R. H., Graves, W. W. & Conant, L. L. Cereb Cortex 19, 2767-2796 (2009). 7 Chang, S. E., Kenney, M. K., Loucks, T. M., Poletto, C. J. & Ludlow, C. L. Neuroimage 47, 314-325 (2009). 8 Aarts, E., Roelofs, A. & van Turennout, M. Neuropsychologia 47, 2089-2099 (2009).9 Ali, N., Green, D. W., Kherif, F., Devlin, J. T. & Price, C. J. J Cogn Neurosci 22, 2369-2386 (2010).

C40 Effects of lexical processing impairments on sentence comprehension in Broca's aphasia ***Choy, J. J.*** *(1, 2); 1. University of Kansas, Life Span Institute, Lawrence, KS* – **Introduction:** The effect of syntactic structure on comprehension in Broca's aphasia (BA) has been well studied in numerous studies. These studies have shown that persons with BA show particular difficulty comprehending sentences with complex syntactic structure, especially non-canonical sentences involving syntactic movement, such as object relatives. This has led to the view that BA is a largely syntactic deficit and that Broca's area is the seat for syntax. In comparison, while lexical processing has

been shown to be impaired in BA (Hagoort, 1993), the effects of lexical processing deficits on sentence comprehension in BA have largely been ignored. In this paper, we investigated the hypothesis that lexical integration, the process by which words are integrated into higher-level contexts, is impaired in BA and the deficit in lexical integration significantly impacts sentence comprehension in BA. Methods. Ten individuals with BA (ages: 37-74; WAB AQs: 56.4-86.2) and ten healthy age-matched controls (ages: 35-75) participated in an eyetracking-while-listening task. Eye movements to pictures on the panel were recorded while participants listened to canonical subject-relatives (SR) and non-canonical object-relatives (OR) with either high (HC) or low cloze probability (LC). Cloze probability was manipulated to test lexical integration because different levels of cloze probability have been shown to require different levels of lexical integration (Federmeier & Kutas, 1999). In addition to eye movement patterns, comprehension was assessed for ORs and SRs, using comprehension probes, which were presented after each sentence. Results. The BA group showed lower accuracy on both cloze conditions compared to the control group in the comprehension probes (HC: Z=3.526, p=.001; LC: Z=3.514, p=.001). The control group showed no difference in accuracy between the two cloze conditions (Z=1.192, p=.233) whereas the BA group did (Z=2.666, p=.008). Analysis of the eye movement data showed that both groups showed patterns of successful syntactic processing at the site of syntactic movement. The BA group showed evidence of antecedent activation at the trace position in ORs, even for incorrectly comprehended items. When the two cloze conditions were compared, the two groups showed similar eye movement patterns for the HC condition at the trace position. In comparison, differences in eye movements were observed at the trace position between the groups for the LC condition, with the BA group showed increased looks to the competitor items. Furthermore, increased lexical competition was associated with failed comprehension, with the BA group showing more looks to the competitor in the incorrectly comprehended sentences compared to the correctly comprehended sentences. Conclusions. Overall, these results suggest that lexical integration is impaired in Broca's aphasia. Furthermore, the results suggest that impaired lexical integration may be a significant contributor toward sentence comprehension difficulty in Broca's aphasia. Federmeier, K. D., & Kutas, M. (1999). A rose by any other name: Long-term memory structure and sentence processing. Journal of Memory and Language, 41, 469-495. Hagoort, P. (1993). Impairments of lexical-semantic processing in aphasia: evidence from the processing of lexical ambiguities. Brain and Language, 45(2), 189-232.

C41 The common neuroanatomical basis for ideomotor apraxia and aphasia: a lesion-symptom mapping investigation ***Turken, A.U.*** *(1),* ***Dronkers, N.F.*** *(1,2); 1. US Department of Veterans Affairs, Research Service, Martinez, CA; 2. University of California Davis, Davis, CA* – We investigated the relation between language impairments in aphasic patients and deficits in producing purposeful movements (praxis). The majority of apraxic patients have left hemisphere lesions that also cause aphasia (Basso et al., Brain, 1981; Kertesz & Hooper, Neuropsychologia, 1982). Using behavioral measures from the Western Aphasia Battery (WAB) and brain imaging data from a large number of chronic stroke patients (138 cases), we examined whether a shared neural basis could be identified for praxis and language functions. This question is of interest not only for a better understanding of the neuropathology underlying disorders of language and cognition, but also for gaining insights into the evolution of language, as it has been proposed that the sensori-motor networks for praxis have supported the development of language ability in the brain (Arbib, Aphasiology, 2006).Voxel-based lesion symptom mapping (VLSM) analysis (Bates et al., 2003) identified the brain regions critical for praxis and language, based on the WAB measures of apraxic and aphasic deficits. A left hemisphere fronto-posterior network for praxis was revealed by the voxel-based lesion-symptom mapping analysis,consistent with the notion that the control of complex goal-directed movements is mediated by a distinct left hemisphere network organized along the anterior-posterior axis (Haaland et al., Brain, 2000). When the VLSM maps for praxis and WAB measures of speech and language impairments were compared, the major areas of overlap were found in deep white matter structures. Cross-sections from the VLSM maps of praxis (Figure 1, left) and overall aphasia severity (Figure 1m right) are shown in relation to the probabilistic map of the superior longitudinal fasciculus (ICBM DTI81 White Matter Atlas, Mori et al., NeuroImage, 2008), a crucial white matter pathway for fronto-posterior network interactions. The pathways that subserve fronto-posterior integration, the superior longitudinal fasciculus and the superior occipito-frontal fasciculus, might constitute the shared neural basis for language and praxis functions, both of which depend upon coordinated activity in distributed left hemisphere networks. Disconnection of these long fronto-posterior pathways candisrupt both the linkbetween the idea of an action and its execution in apraxia (Liepmann, 1901), and the link between the formulation oflinguistic representations and their expression in speech in aphasia, accounting for the high coincidence of thetwo disorders.

C42 The timecourse of anticipatory sentence comprehension in children with SLI ***Borovsky, A.*** *(1,2),* ***Elman, J. E.*** *(1),* ***Evans, J. L.*** *(1,3); 1. University of California, San Diego, La Jolla, CA; 2. Stanford University, Palo Alto, CA; 3. San Diego State University, San Diego, CA* – Despite showing numerous deficits in spoken sentential comprehension (Montgomery, 2000) and processing speed (Windsor & Hwang, 1999), relatively little is known about how children with specific language impairment (SLI) comprehend lexical information as sentences unfold.Arguably, this task requires swift and efficient processing in order to successfully comprehend a continuously evolving sentential message. One remarkable characteristic of sentence comprehension in typically developing adults and

children is the astonishing speed with which information is integrated across multiple lexical items to anticipate upcoming referents. In this study, we explore the possibility that sentence comprehension and processing deficits in SLI arise from a difficulty in efficiently combining lexical information across multiple words. Using a similar design to Kamide, Altmann and Haywood (2003), Experiment 2, we examined the timecourse of lexical activation to objects that varied in association to the Agent and Verb of a simple transitive sentence. 12 teenagers with a documented history of SLI and 14 typically developing (TD), age matched controls were tested.Participants' eye-movements were recorded as they looked at a four-alternative forced-choice display while they heard a sentence in which the object referred to one of the pictures (e.g. "The pirate hides the treasure"). The task was to select the picture that best matched the sentence. In addition to the target picture (Target; treasure), nontarget pictures were either related to the agent (Agent-Related; ship), related to the verb (Verb-Related; bone), or Unrelated (cat). Pictures were rotated across stimuli so that, across all versions of the study, each picture appeared in all conditions, yielding a completely balanced within-subjects design. Our analysis focused on two goals: 1) to measure anticipatory looks directed to the target object and 2) compare the activation of looks to non-target items across the sentence. We did not observe any group differences in anticipatory looks to the Target, nor were there group differences in looks to the Target while it was spoken, or with the speed at which participants initially generated anticipatory looks that differentiated between the Target and other items.Group differences did emerge post-verb onset in fixations to the Verb-Related item. TD participants increased looks to the Verb-Related item (compared to the Distracter) for a duration of 390 ms starting at 607ms after verb onset, (much like adults and children do on this task) whereas the SLI group did not show this pattern for any period of time post verb-onset. Together, these findings indicate that teenagers with SLI integrate lexical information across words to anticipate upcoming meanings with the same relative fluency and speed as their TD peers. However, the failure to find increased fixations to Verb-Related items after verb onset in the SLI group suggests that this group may consider fewer alternate sentential interpretations across the sentence and insteadgenerate sentence continuations that correspond closely to event-level expectations.Therefore, these results fail to support general slowing accounts of SLI, and potentially support the idea that these participants might rely on compensatory mechanisms that recruit real-world knowledge to rapidly interpret spoken sentences

C43 Use of Multi-modal Imaging in uncovering the pathological basis of Primary Progressive Aphasia syndromes ***H . Chertkow*** *(1),* ***James Nikelski*** *(1),* ***Gabriel Leger*** *(2),* ***Ziad Nasredinne*** *(3),* ***Victor Whitehead*** *(1),* ***Randi Pilon*** *(1),* ***Stephan Probst*** *(4); 1. Lady Davis Institute, Jewish General Hospital, McGill; 2. (CHUM)Centre Hospitalier de l'Université de Montréal; 3. Neuro Rive Sud, McGill; 4. Jewish General Hospital, McGill University* – **Background:** Asa better understanding of Primary Progressive Aphasia (PPA) emerges, the clinical and imaging delineation of PPAneurobiology is under intense examination. Some PPA subjects appear to have Alzheier's Disease (AD) as the underlying pathology (so-called atypical AD). Others have tauopathies, tardopathies, and a variety of neurodegenerative illnesses. We wondered if the distinction between PPA due to AD could be made with neuroimaging, and whether multi-modal imaging with magnetic resonance imaging (MRI), Flouro-deoxyglucose PET(FDG) andC-11 amyloid PET imaging with Pittsburgh B Compound (PIB) would converge in the analysis of such individuals in a coherent fashion. We hypothesized that theseimaging modalities would be convergent, and usually all point in thedirection ofatypical AD vs. FTD/PPA. Methods: Eighty four subjects were studied, including 24normal elderly controls and 20 typical AD subjects. For the 40 remaining "atypical" subjects, clinical likelihood of AD vs non-AD diagnosis was rated as low, medium, or high. 1.5 teslaMRI imaging with thin 1 mm cuts was carriedout. Distribution of cortical atrophy and Grey matter VBM were noted. FDG PETscans were assessed as typical AD [ie., bitemporo-parietal decreased glucose uptake] or not.PIB PET amyloid imaging was considered positive if there wasSUVR > 1.5 for association cortex regions, corresponding to medium or large PIB uptake on visual inspection. Results. In AD subjects, all 3 imaging modalities were suggestive of AD positive in 80% of cases. Three AD subjects were"PIB negative", and they were young or showed slower progression. Two of 24 Normal elderly subjects were "PIB Positive". The sixmost convincing cases of FTD (behavioural variant or Nonfluent Progressive Aphasia) all were PIB Negative, with frontotemporal MRI atrophy and VBM changes andfrontal FDG PET in5/6. Of the 34 other "atypical" cases, PIB was positive in over 2/3 suggesting Alzheimer's as underlying etiology. However, convergence between MRI, PIB, and FDG PET was found in less than 1/3. Conclusion. Among those clinically labeled as FTD, those with convincing clinical presentations do not demonstrate amyloid positivity, and multi-modal imaging confirms FTD.In atypical dementias and uncertainFTD/PPA cases, use of PIB increased diagnostic certainty . The different imaging modalities [MRI, FDG PET, PIB PET] did not always converge. An emerging issue will be how to use these multiple modalities together in an efficient manner. Acknowledgements. Dr. Chertkow was Supported by the CIHR (Canadian Institutes of Health Research),and the FRSQQuebec Aging Network (RQRV).

C44 Patterns of Dysgraphia in Primary Progressive Aphasia ***Faria, A. V.*** *(1),* ***Tsapikini, K.*** *(1),* ***Race, D.*** *(1),* ***Crinion J.*** *(3),* ***Mori, S.*** *(1),* ***Hillis, A.*** *(1); 1. Johns Hokins University, Baltimore; 3. Institute of Cognitive Neuroscience, University College London, UK* – **Objective:** The aim of this study is to investigate the anatomic basis of dysgraphia in patients with primary progressive aphasia (PPA). Specifically, we will report anatomic differences between participants that commit phonologically plausible errors

(PPEs, where each letter produced is a valid instance of the phoneme in the corresponding stimulus at that position) and phonologically implausible nonword errors (PINs, nonwords in which at least one letter did not correspond to the phonology of the stimulus). These patterns have been reported in chronic unilateral stroke, but it is particularly interesting here because PPA affects distinct areas of brain that are not typically affected by vascular lesions, and the patterns of performance observed are not a result of rehabilitation. Methods: The Johns Hopkins Dysgraphia Battery was administered, and PPA participants were classified into two groups according their predominant error type: PPEs(15) and PINs(10) . The high resolution MPRAGE T1-WMRI of each participant was mapped to a template brain1 using LDDMM (large deformation diffeomorphic metric mapping)2, which allows the direct comparison and quantization of morphometry3. A parcellation map defined in the template was transferred to each individual automatically parceling and labeling each brain into 120 structures. The volume of each area was normalized by the intracranial volume and volumetric differences among regions were minimized by calculating the z-scores of each parcel, using a group of healthy controls paired by age. Differences between groups, in each structure, were accessed by MANOVA. Age, gender and image protocol were added as co-variables. Significance threshold was set at $p<0.01$. Results: As shown in figure 1, participants who made PPEs had on average greater atrophy in left sagittal striatum (including inferior longitudinal fasciculus), insula, uncinate, entorhinal area, and inferior occipital and fusiform gyrus than patients who made PINs ($p<0.01$). Discussion and Conclusion: Consideration of the computational demands of spelling to dictation would suggest that patients who make PPEs in spelling to dictation may do so because: 1) the distributed components of the orthographic word form are not accessible together; 2) the word form is not being activated appropriately from the impaired semantic representation (or from the spoken input), or 3) the orthographic word form (the "orthographic lexical representation") is degraded in some way. Although it would be empirically difficult to distinguish these causes of PPEs, our findings might indicate that the disruption of white matter tracts, leading to impaired connections between critical nodes of a network, could lead to any of these three causes of such errors, particularly the first two. References: 1Mori S, Oishi K, Jiang H, et al. Stereotaxic white matter atlas based on diffusion tensor imaging in an ICBM template. Neuroimage. 2008; 40(2): 570-582. 2 Wang L, Beg F, Ratnanather T, et al. Large deformation diffeomorphism and momentum based hippocampal shape discrimination in dementia of the alzheimer type IEEE Trans Med Imaging. 2007; 26(4): 462-470. 3Oishi K, Zilles K, Amunts K, et al. Human brain white matter atlas: Identification and assignment of common anatomical structures in superficial white matter Neuroimage. 2008; 43(3): 447-457.

C45 Effects of subthalamic nucleus deep brain stimulation on language in Parkinson's disease ***Litcofsky, K. A.*** *(1),* ***Hershcovitch, L.*** *(2),* ***Pelster, M****. (2),* ***Gelfand M.*** *(1),* ***Charles, P. D.*** *(2),* ***Ullman, M. T.*** *(1); 1. Georgetown University, Washington DC; 2. Vanderbilt University, Nashville TN* – While deep brain stimulation (DBS) of the subthalamic nucleus (STN) has become an increasingly common therapy to treat Parkinson's disease (PD) motor symptoms, its effects on cognition, particularly on language, remain unclear. Such effects may elucidate not only the nature of DBS, but also the neural organization of language. This study investigates the impact of DBS on two well-studied tasks probing aspects of language (grammar and lexicon) and higher-level motor function, each with built-in control conditions. METHOD: Ten early PD patients undergoing DBS treatment were compared to 10 early PD patients on medication, and 24 healthy controls. All subjects were tested twice; PD patients were tested first on and then off DBS or medication, with a sufficient washout period between the sessions to ensure the validity of the off state. To assess language, subjects were asked to produce the past-tenses of regular verbs (to assess grammatical processing) and irregular verbs (to assess lexical processing); evidence suggests that regular past-tenses (and aspects of grammar more generally) depend particularly on procedural memory and frontal/basal-ganglia circuits, and thus may be especially affected by DBS. To assess higher-level motor function, subjects named objects that are or are not commonly manipulated (e.g., hammer, elephant); evidence suggests that naming manipulated objects, but not non-manipulated objects, depends on motor circuits, and thus should be especially affected by DBS. RESULTS: DBS, but not medication, affected performance on both regular past-tenses and manipulated objects, but in opposite directions. On-DBS yielded better performance at naming manipulated (but not non-manipulated) objects than off-DBS. In contrast, on-DBS yielded worse performance at producing regular (but not irregular) past-tenses than off-DBS, suggesting that STN-DBS negatively impacts language, but is specific in depressing grammatical but not lexical performance. DISCUSSION: The mechanisms underlying the differential impact of stimulation on motor (improvement) and grammar (impairment) remain to be elucidated. Nevertheless, the finding that both motor and grammatical measures, but not lexical measures, were affected by stimulation supports links between grammar and motor function, and is consistent with the hypothesis that the procedural memory brain system underlies both. Though the benefits of improved motor outcomes from subthalamic nucleus deep brain stimulation likely outweigh any disadvantages of the observed language impairments, the results suggest that further studies are warranted.

SPEECH PRODUCTION

C46 Independent distractor frequency and age-of-acquisition effects in picture-word interference: fMRI evidence for post lexical and lexical accounts according to distractor type ***de Zubicaray, G.I.*** *(1),* ***Miozzo, M.*** *(2),* ***Johnson, K****. (1),* ***Schiller, N.O****. (4),* ***McMahon, K.L****. (1); 1.The University of Queensland, Brisbane, Australia; 2. Cambridge University, Cambridge, UK; 3. Leiden University, Leiden*

Institute for Brain and Cognition (LIBC), Netherlands – Forty years of psycholinguistic research have demonstrated that saying a word, the most fundamental task in speaking, requires selecting from among a set of activated word candidates. To the extent that multiple lexical candidates are activated, theories of spoken word production need to identify the nature of these candidates as well as the degree to which they interfere with target word production. We tested hypotheses from rival input and output accounts in two fMRI experiments using the picture-word interference (PWI) paradigm, in which participants named pictures with superimposed distractors that were high or low in frequency or varied in terms of age-of-acquisition (AoA). Pictures superimposed with low frequency words were named more slowly than those superimposed with high frequency words, and late acquired words interfered with picture naming to a greater extent than early-acquired words, replicating previous studies (Catling, Dent, Johnston, & Balding, 2010; Miozzo & Caramazza, 2003). The distractor frequency effect (Experiment 1) was associated with increased activity in premotor and posterior superior temporal cortices, consistent with the operation of an articulatory response buffer and verbal self-monitoring system. Conversely, the distractor AoA effect (Experiment 2) was associated with increased activity in the left mid- and posterior-middle temporal cortex, consistent with the operation of lexical level processes such as lemma and phonological word form retrieval. The results support a post-lexical locus for the distractor frequency effect (Miozzo & Caramazza, 2003), and a lexical-semantic locus for the distractor AoA effect (Belke, Brysbaert, Meyer, & Ghyselinck, 2005). The spatially dissociated patterns of activity across the two experiments indicate that distractor effects in PWI may occur at input or output levels of processing in speech production. Thus, although hypotheses from two rival accounts of distractor interference in PWI were supported in each experiment, neither account is capable of providing a complete explanation. References: Belke, E., Brysbaert, M., Meyer, A.S., & Ghyselinck, M. (2005). Age of acquisition effects in picture naming: Evidence for a lexical-semantic competition hypothesis. Cognition, 96, B45-B54. Catling, J. C., Dent, K., Johnston, R. A., & Balding, R. (2010). Age of acquisition, word frequency, and picture-word interference. Quarterly Journal of Experimental Psychology, 63, 1304-1317. Miozzo, M., & Caramazza, A. (2003). When more is less: A counterintuitive effect of distractor frequency in the picture-word interference paradigm. Journal of Experimental Psychology: General, 132, 228–252.

C47 Speech Production: Towards an Integration of Motor Control, Psycholinguistic, Neurolinguistic, and Neurophysiological Models

Hickok, G. *(1); University of California, Irvine, CA* – Motor control and psycho/neurolinguistic models of speech production have traditionally targeted different levels of the speech production system with the former more concerned with low-level control of articulators and the latter more concerned with understanding more abstract linguistic stages of the process.Consequently, the representational vocabularies and architectures look quite different between the various traditions and there is little interaction between them. The suggestion here is that the chasm between traditions is more an accident of history than a real theoretical divide. The concepts from the motor control literature such as efference copies, internal forward models, and sensory goals can be applied productively to higher (phonological) levels of the speech production system.Similarly, research on computational stages of speech production derived from psycho- and neurolinguistic models can be integrated into motor control architectures. Toward this end, and building on much previous work (e.g., Golfinopoulos, Tourville, & Guenther, 2010; Gracco, 1994; Hickok, Houde, & Rong, 2011; Perkell, in press), an integrated hierarchical feedback control (IHFC) model of speech production is proposed (Figure 1).Consistent with motor control models of speech production, the IHFC assumes that the goals (targets) of speech production are sensory.Higher-level goals are predominantly auditory and code roughly syllable-level information, whereas lower-level (fine motor) goals are predominantly somatosensory and correspond more closely to phonemic-level information. The two hierarchical levels include both sensory and motor representations, much like the concept of the phonological input/output lexicons derived from neurolinguistic research. Consistent with psycholinguistic models but unlike most motor control models, input to the network comes from a lemma level network, which, it is assumed here, projects in parallel to both sensory and motor systems.Processing within each level involves inverse (sensory-to-motor) and forward (motor-to-sensory) transforms mediated by area Spt for the higher-level network and the cerebellum for the lower-level network. Forward prediction is instantiated as an inhibitory signal and, rather than evaluating the outcomes of motor programs, is part of the motor planning process.A simplified version of the model is simulated computationally, demonstrating the feasibility of the architecture and computational assumptions. The proposed model provides an explanation of (i) clinical disorders such as conduction aphasia and aspects of stuttering, (ii) motor induced suppression, (iii) possible motor influence on speech perception, and (iv) may shed light on why syllables seem to be the units of speech perception and the relation of these units to phoneme-level representations. Golfinopoulos, E., Tourville, J. A., & Guenther, F. H. (2010). The integration of large-scale neural network modeling and functional brain imaging in speech motor control. Neuroimage, 52(3), 862-874. Gracco, V. L. (1994). Some organizational characteristics of speech movement control. J Speech Hear Res, 37(1), 4-27. Hickok, G., Houde, J., & Rong, F. (2011). Sensorimotor integration in speech processing: computational basis and neural organization. Neuron, 69(3), 407-422. Perkell, J. S. (in press). Movement goals and feedback and feedback control mechanisms in speech production. Journal of Neurolinguistics.

C48 Cortico-cortical connectivity differs for action versus object naming ***Liljeström, M.*** *(1),* ***Kujala, J.*** *(1),* ***Vartiainen, J.*** *(1),* ***Salmelin, R.*** *(1); Aalto University, Brain Research Unit, Espoo, Finland* – Verb and noun production can be differentially disrupted in patients suffering from aphasia. Yet, previous brain imaging studies with healthy individuals have indicated that action and object naming engage a common cortical network when the brain is intact (Liljeström et al. 2008, 2009) and that the content of the image (depicting/not depicting action) is a far more relevant differentiating factor. In this study we investigated whether differences between the grammatical categories in healthy individuals could emerge in the strength of cortico-cortical interactions, rather than in activation strength. Specifically, we investigated whether cortical connections between areas involved in picture naming differ when either verbs or nouns are named from identical images, and how the content of the image affects the strength of these connections. We recorded magnetoencephalography (MEG) data from 11 healthy participants performing both a silent and an overt picture naming task. In a first step, we identified frequency bands of interest from sensor-level coherence analysis of the MEG data. Significance was determined using permutation testing. To identify the cortical regions with significant differences in coherence between experimental conditions we used a spatial filter (event-related Dynamic Imaging of Coherent Sources; DICS; Kujala et al., 2007; Laaksonen et al., 2008) The present results show that cortico-cortical connectivity differs for silently naming actions versus objects from the same images although neural activation, as measured by evoked responses, was similar in both action and object naming (Liljeström et al., 2009). Differences in coherence were identified between several cortical regions. For example, increased coherence for naming actions was observed between the visual cortex and the left middle temporal cortex within the alpha (~10-Hz) and beta (~20-Hz) frequency bands. Modulations of coherence between cortical regions may thus reveal functionally relevant dissociations between experimental conditions without any accompanying changes in activation strengths.

C49 The Error-Related Negativity (ERN) as general marker of monitoring in speech production: Evidence from the overt naming of cognates ***Acheson, D. J.*** *(1,2),* ***Ganushchak, L. Y.*** *(1),* ***Christoffels, I. K.*** *(3),* ***Hagoort, P.*** *(1,2); 1. Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands; 2. Donders Institute for Brain, Nijmegen, The Netherlands; 3. Leiden University, Leiden Institute of Psychology & Leiden Institute of Brain and Cognition, Leiden, The Netherlands* – One of the physiological markers of monitoring in both speech and non-speech situations is the so-called error related negativity (ERN), an even-related potential that is typically observed after error trials. Recent work by Riès et al. (2010, Journal of Cognitive Neuroscience), however, has demonstrated that the ERN can also be observed in the context of correct picture naming, suggesting that it might be a physiological marker for the monitoring of response conflict. The present work tests whether the ERN is marker of conflict in speech production by exploring a situation that naturally induces increased response conflict, namely, when multiple outputs are simultaneously activated in bilingual speech production. Event-related potentials were recorded while participants overtly named pictures in their first (L1; German) and second (L2; Dutch) languages. Activation of multiple outputs was manipulated through the form similarity between translation equivalents (i.e., cognate status). Pictures were named in either blocked (L1 or L2) or mixed format (L1 and L2 switching).Rather than imposing severe frequency cutoffs (e.g, 12 Hz low pass filtering), motor-artifact associated with speaking were removed using the same techniques as in Riès et al. (2010): blind source separation on the basis of canonical correlation (BSS-CCA; see De Clerq et al., 2006; IEEE Transaction on Biomedical Engineering).

Replicating previous results, cognates were faster to name than non-cognates, and naming in blocked contexts was faster than mixed contexts.Interestingly, response-locked analyses not only showed a reliable ERN on correct trials, but that the amplitude of the ERN was larger for cognates compared to non-cognates. No effect on the ERN amplitude was observed for the context in which pictures were named (blocked vs. mixed). Thus, despite being faster to name, cognates seem to induce more conflict during response monitoring. This in turn indicates that the ERN is not simply sensitive to conflicting motor responses, but also to more abstract conflict resulting from co-activation of multiple phonological representations. The present study thus has three important implications for studying the physiological basis of language production. First, in terms of bilingual language production, the present study provides additional evidence (beyond faster RTs) that multiple phonological codes are activated in bilingual naming situations. Methodologically, the current study demonstrates that techniques such as BSS-CCA can remove motor-artifact sufficiently enough such that ERP studies of overt language production are possible without utilizing severe frequency cutoffs. Finally, the present study supports the idea that the ERN serves as a physiological marker of response conflict in language production, thus opening the door for future ERP research into monitoring processes in production.

C50 Denoising the speaking brain: characterizing and removing image artifacts in BOLD fMRI of continuous overt speech production ***Xu, Y.*** *(1),* ***AbdulSabur, N.*** *(1,2),* ***Liu, S.*** *(1),* ***Chowh, H.*** *(1),* ***Braun, A.*** *(1); 1. National Institutes of Health, Bethesda, MD ; 2. University of Maryland, College Park, MD* – Imaging functional brain activity during continuous speech production is crucial for the neurobiological study of language. However, application of BOLD functional magnetic resonance imaging (fMRI) to overt speech production has been severely limited by artifacts generated by movements of the articulators. Here we report development of an effective scheme to isolate, characterize and remove these artifacts based on their spatial sources that can be directly revealed in whole-head fMRI images. The sources of speech-related artifacts were validated

by examining the temporal relations between articulation gesture scores and mixing vectors of independent component analysis (ICA). Other sources of artifact such as head motion and cardiac vascular noise were also identified spatially and validated by demonstrating temporal relationships to relevant external measures. The systematic classification of artifactual and neuronal ICA components was based on their degree of spatial clustering, location of major positively weighted clusters and neighborhood connectedness between positively and negatively weighted clusters. Reliable and consistent classification results were derived from both human and machine classifiers. Functional images reconstructed after artifact removal showed similar activation patterns when compared to positron emission tomography (PET) data collected in the same subjects using the same tasks. This method opens a new avenue for reliably investigating an array of topics related to discourse production. Importantly, the effectiveness of this approach is not sensitive to block length or task duration, enabling the study of continuous speech production under ecologically valid conditions in which these variables cannot be controlled, such as natural conversation. Moreover, unlike sparse acquisition methods frequently used to image overt speech, our method makes it possible to conduct fine-grained connectivity analyses and event related analysis of discrete cognitive-behavioral processes that occur in the course of continuous speech.

C51 Working, Declarative and Procedural Memory in Specific Language Impairment ***Jarrad A. G. Lum*** *(1,2),* ***Gina Conti-Ramsden*** *(3),* ***Debra Page*** *(3),* ***Michael T. Ullman*** *(4); 1. Deakin University, Melbourne, Australia; 2. The University of Southern Denmark, Odense, Denmark; 3. The University of Manchester, UK; 4. Georgetown University, Washington D.C.* – According to the Procedural Deficit Hypothesis (PDH), abnormalities of frontal/basal-ganglia circuitry and other brain structures that underlie procedural memory largely explain the language deficits in children with Specific Language Impairment (SLI). These abnormalities are posited to result in core deficits of procedural memory, which in turn explain the grammar problems in the disorder. The abnormalities are also likely to lead to difficulties with other, non-procedural, functions, such as working memory, that rely at least partly on the affected brain structures. In contrast, declarative memory is expected to remain largely intact, and should play an important compensatory role for grammar (Ullman and Pierpont, 2005). METHOD: These claims were tested by examining multiple measures of working, declarative, and procedural memory in 51 children with SLI and 51 matched typically-developing (TD) children (mean age 10).Working memory was assessed with the Working Memory Test Battery for Children, declarative memory with the Children's Memory Scale, and procedural memory with a visuo-spatial Serial Reaction Time (SRT) task. RESULTS: As compared to the TD children, the children with SLI were impaired at procedural memory, even when holding working memory constant. In contrast, they were spared at declarative memory for visual information, and at declarative memory in the verbal domain after controlling for working memory and language. Visuo-spatial short-term memory was intact, whereas verbal working memory was impaired, even when language deficits were held constant. In correlation analyses, neither visuo-spatial nor verbal working memory were associated with either lexical or grammatical abilities in either the SLI or TD children. Declarative memory correlated with lexical abilities in both groups of children. Finally, grammatical abilities were associated with procedural memory in the TD children, but with declarative memory in the children with SLI. DISCUSSION: The evidence from this and other studies suggests the following. SLI is associated with procedural memory deficits. Declarative memory is intact for visual information, and for verbal information once working memory and language deficits are controlled for. Working memory is normal for visuo-spatial information, but appears to be problematic in the verbal domain. Lexical abilities in both SLI and TD children are related to declarative memory. In TD children, grammatical abilities are related to procedural memory. In SLI, variability in grammatical abilities seems to be explained both by procedural memory deficits (Tomblin et al., 2007) and by compensation by the largely intact declarative memory system (the present study). Overall, the evidence appears to largely support the predictions of the Procedural Deficit Hypothesis, though additional research is needed to further investigate a number of issues.In sum, this study highlights the importance of simultaneously considering multiple memory systems and their interactions in developing our understanding of the nature of the language difficulties in SLI.

C52 Discourse-Level Impairment in "Well-Recovered" Post-Stroke Aphasia ***Wagage, S.*** *(1),* ***Ryder, J.*** *(2),* ***Chow, H.M.*** *(1),* ***Liu, S.*** *(1),* ***Solomon, B.*** *(2),* ***Braun, A.*** *(1); 1. The National Institute on Deafness and Other Communication Disorders, The National Institutes of Health; 2. Rehabilitation Medicine, The National Institutes of Health* – Discourse production and comprehension are synonymous with successful real-world communication, one of the most critical aspects of daily life, yet are largely underexamined in assessment of post-stroke aphasia. Indeed, the classic tests by which aphasia is assessed—the Western Aphasia Battery (WAB), Psycholinguistic Assessments of Language Processing in Aphasia (PALPA), etc—rely on assessing linguistic ability on lexical and sentential levels, though recovered aphasics are anecdotally troubled by difficulties at the discourse level. Such difficulty at the naturalistically relevant level of communication in spite of recovery at lexical and sentential levels appears to be troublingly widespread, as it described 55% of our general aphasic cohort who were "well-recovered" by standard criteria (as defined by an Aphasia Quotient (AQ) of 85 or greater on the WAB). A battery of standard tests of aphasia, including subtests of the WAB and PALPA, Caplan sentences, Pyramids and Palm Trees, Object/Action Naming Battery, Birmingham Object Recognition Battery, and Nonverbal Test of Auditory Processing was administered to comprehensively assess lexical and sentential abilities. We studied 22 "well-recovered" subjects (AQ M=92.71, SD=3.88) ranging in

age from 34-79 years (M=56.09, SD=12.78), an average of 7.14 years following stroke in the territory of the left middle cerebral artery, and compared their performance to that of 21 age-matched controls on an array of discourse tasks including story generation (from story stems, wordless picture books, and single paintings), story and fable retell and comprehension, interpretation of proverbs and fables, procedural discourse, and extralinguistic and paralinguistic production and comprehension (prosody and gesture, via the Assessment Battery of Communication (ABaCo). Data were analyzed using analysis of variance. Voxel-based lesion symptom mapping (VLSM), which assesses the relationship between tissue damage and behavioral scores on a voxel-by-voxel basis, was conducted using lesion masks from 17 subjects' anatomical MRIs. Aphasic subjects were significantly impaired relative to controls across-the-board on measures of both discourse production and comprehension ability, despite their strong performance on tests that are considered standard measures of linguistic ability. Macro level deficits (in story structure, content, and episodic structure) were indicative of impairment in grasping the essence of the task or the demands of the task as a whole, while micro level deficits (in richness of stories) were also present, though factual accuracy was unimpaired. The VLSM data shows differing lesion-behavioral performance relationships between procedural discourse and story generation: the area most associated with procedural discourse performance was the insula and contiguous frontal operculum, while performance on story generation involved lesions extending from the inferior frontal gyrus to the dorsolateral prefrontal cortex and superior middle frontal gyrus. VLSM results indicate that discourse-level impairments are associated with damage to frontal areas outside typical perisylvian regions that may play a role in the attentional and mnemonic processes required for organization and execution of discourse-level tasks. Recognition and better characterization of these patients may lead to new directions in future therapeutic strategies.

Poster Session D

Friday, November 11 10:00 - 11:30 am
Senate, Capitol C, and Capitol C Pre-Function

ANATOMY

D1 Characterizing Functional-anatomic Variability of Sensory-Motor Integration Area Spt ***Isenberg, A. L., Okada, K.*** *and* ***Hickok, G.****; University of California, Irvine, CA* – fMRI work has identified a region in the left posterior Sylvian fissure at the parietal-temporal boundary, area Spt, which exhibits auditory-motor response properties (Buchsbaum et al, 2001; Wise et al., 2001; Hickok et al, 2003; Warren et al., 2005) and when damaged impairs verbatim repetition of heard speech, leaving speech perception relatively spared. These findings have implicated area Spt in sensory-motor integration for vocal tract actions (Hickok et al, 2009, Pa & Hickok, 2008). Spt is most evident in individual subject data in that activation i) is more robust in individual subjects than group averages and (ii) sometimes localizes to the inferior parietal lobe in normalized group averages. This can largely be attributed to high variability in both the anatomy of the posterior Sylvian fissure (SF; Desai et al, 2005) and the functional distribution of area Spt.Activation of thisfunctionally defined region has been observed in both medial and lateral posterior Sylvian fissure and additionally can appear along the horizontal extent of the SF as well as the descending and ascending ramus, leading to high variance in the vicinity of area Spt. Here we characterize the functional-anatomic variability of area Spt in a large sample of subjects.

D2 Why white matter matters in understanding chronic stroke aphasia: Novel evidence from Anatomical Connectivity Mapping ***Rebecca A. Butler*** *(1),* ***Anna M. Woollams*** *(1),* ***Karl V. Embleton*** *(2),* ***Geoffrey J. M. Parker*** *(3),* ***Matthew A. Lambon Ralph*** *(1); 1. Neuroscience and Research Unit, University of Manchester; 2. School of Psychological Sciences, University of Manchester; 3 Biomedical Imaging Institute, University of Manchester* – **Objective:** Language processing depends upon large-scale distributed neural networks, which are predominantly left lateralised. Recent research suggests that it is not only the integrity of cortical components of this network that is essential to intact language function, but also that of white matter (WM) pathways connecting these components.Neuroimaging and patient studies indicate the importance of dorsal and ventral WM pathways connecting anterior and posterior language regions for efficient language function. The dorsal route has been associated with phonology and motor production of speech, and sentence-level syntactic processing; whilst the ventral route has been attributed a role in semantic representation. In practice, both routes are likely to work in parallel to achieve most language tasks. The aim of the current study was to look at how changes in WM connectivity, particularly in the dorsal and ventral pathways, relate to language performance in chronic stroke aphasia. The goal was to demonstrate that information regarding WM connectivity may help better explain patients' performance and, consequently, unexplained variance in lesion-symptom mappings. Methods. Data will be presented from a small illustrative case series of chronic stroke aphasic participants. For all participants we obtained a structural T1 MRI scan and a diffusion-weighted MRI scan. Participants also completed a battery of language tests. The T1 scans were used to derive lesion outlines using an automated method.Diffusion-weighted data were used to create whole-brain probabilistic tractography maps called Anatomical Connectivity Maps (ACMs). Results. Results will be presented from patients with connectivity changes focussed on either the dorsal or the ventral route (Figure 1). Within the dorsal route patients are examples of patients with overlapping cotical lesions but markedly differing performance on language tasks. On examination of their ACMs it is clear that those patients with

more impaired performance on language tasks are those with greater WM connectivity changes in the dorsal language pathway. In all of the dorsal patients language deficits were primarily phonological in nature, with severity of deficit relating to extent of dorsal WM connectivity changes. In contrast, a patient whose ACM reveals reduced WM connectivity in the ventral route demonstrates a markedly different behavioural profile, with intact phonological processing but impaired performance on semantic tasks. Conclusions. Information regarding WM connectivity can complement cortical lesion site information when attempting to understand performance of chronic stroke aphasic patients on language tasks. Changes in different parts of the dual pathway language system impact differently on performance of stroke aphasics, with reduced connectivity in the dorsal route being associated primarily with phonological impairment and reduced connectivity in the ventral route being linked to semantic deficits. The extent of changes in connectivity can also help explain differences in severity of patient deficits. The significance of these findings is two-fold; firstly, understanding WM connectivity of patients could potentially influence design of speech therapy; and secondly, they demonstrate that ACMs represent a hypothesis-free way of examining whole-brain connectivity in chronic stroke aphasia.

COGNITIVE AND EXECUTIVE PROCESSING

D3 Role of Working Memory in Explicit and Implicit Artificial Grammar Learning ***Yang, J.*** *(1),* ***Clark, P.*** *(1),* ***Swick, K.*** *(1),* ***Watkins, H.*** *(1),* ***Li, P*** *(1); Pennsylvania State University, University Park, PA* – Explicit learning depends on explicit memory for facts and events, served by hippocampal and diencephalic brain systems (Cohen, Poldrack, & Eichenbaum, 1997). Implicit learning refers to the ability to learn independently of conscious efforts, often incidentally during the processing of other tasks. Artificial grammar learning (AGL, Reber, 1967) has been one of the most popular tasks to study implicit learning of language. After viewing a series of letter strings formed according to a finite-state grammar, people are usually able to classify new letter strings as to whether these strings are formed in accordance with the grammatical rules. One interesting finding from this literature is that although participants often show little confidence in their conscious judgment, they consistently perform above chance level in AGL task. Previous research has shown that explicit and implicit learning may rely on different memory systems, but the underlying neural mechanisms remain unclear (e.g. Seger et al., 2000). In this study, we explore the neural systems that underlie explicit versus implicit learning by using the AGL task in an fMRI study. We are particularly interested in whether individual differences in working memory contribute differently to the two learning procedures. In a block-design fMRI experiment, 40 right-handed undergraduates from Penn State University were randomly assigned to an implicit (18 participants) versus explicit (22 participants) AGL condition after they took a battery of behavioral tests of vocabulary, processing speed, nonverbal intelligence and working memory abilities. Then the participants were trained on the AGL task either in an explicit or implicit procedure: in both cases they saw sequences of syllables that form a rule according to a finite-state grammar, but in the explicit condition they were told to find out the rule while in the implicit condition they told to simply read the sequences with attention. After the training for 20 minutes, both groups saw new sequences inside the fMRI scanner and were asked to judge whether the sequences followed the rules as in the previous training session. Results showed that the accuracy for the grammar task in both groups was significantly better than chance. Greater neural response was found in the left posterior brain regions including precuneus gyrus for the explicit learning group, whereas stronger brain activation was found in the left anterior areas including anterior cingulated gyrus, insula, and the left caudate for the implicit learning group during the same grammar judgment task. Moreover, regression analyses indicated that participants' working memory abilities significantly and positively correlated with brain activity in the left inferior parietal lobe (related to phonological store) for the explicit group, and in the right middle frontal gyrus and left caudate (related to cognitive control) for the implicit group. In sum, our study indicates significant differences between explicit and implicit grammar learning with regard to neural representations, which is consistent with Lieberman et al. (2004) that showed caudate activation to be associated with rule adherence.More importantly, our study identifies the role of working memory in contributing to explicit learning versus implicit learning in different ways.

D4 The effect of active prediction on the N400: MEG evidence for a left anterior temporal generator *Lau, E. (1,2),* ***Burns, S.*** *(1,2),* ***Gramfort, A.*** *(1),* ***Delaney-Busch, N.*** *(1,2),* ***Fields, E.*** *(1,2),* ***Fanucci, K.*** *(1,2),* ***Holcomb, P.*** *(2),* ***Hamalainen, M.*** *(1,2),* ***Kuperberg, G.****(1,2); 1. Massachusetts General Hospital, Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA; 2. Tufts University, Medford, MA* – This study uses a combination of EEG, MEG, and fMRI to explore predictive mechanisms in language processing. Previous work has demonstrated that ERP responses to words, such as the N400, are modulated by contextual prediction. Such effects could reflect active prediction, passive spreading activation from memory representations activated by the context, or a combination of both. In the current paradigm we isolate the effect of active prediction on the N400 by using identical contexts but manipulating the proportion of related pairs in a long-SOA semantic priming design. Differences in the priming effect under low and high proportion conditions can therefore be attributed to differences in active prediction as the predictive validity of the prime is modulated. Results of a recent ERP study demonstrate more N400 reduction to related targets in the high-proportion block, showing that active prediction alone can facilitate lexico-semantic processing. In the current study we used the same paradigm in a within-subjects fMRI and

simultaneous EEG/MEG design to determine the neural locus of the differential effect of active prediction. Here we report the results of a first set of analyses on the EEG/MEG recordings. ERP results (n=21) replicated the earlier finding, showing a significantly larger difference in the N400 response (300-500 ms) to related and unrelated targets in the high-proportion block relative to the low-proportion block, even though the low-proportion and high-proportion prime-target pairs were counterbalanced across subjects. MNE distributed source solutions were used to estimate the source of differences in MEG activity. In the high-proportion condition, a whole-brain analysis of the average activity between 300-500 ms estimated a significant difference in the response to unrelated and related targets ($p < 1e\text{-}5$ uncorrected) in left anterior temporal regions only (Figure 1). This activity was only seen in the high proportion block. These results suggest that the N400 effect specific to active prediction in this paradigm is due to differential activity in left anterior temporal cortex. This finding is consistent with previous intracranial work demonstrating N400-like effects in these regions. We take these results as consistent with a multi-generator model of N400 effects in which the contribution of active prediction to the N400 effect is driven by activity within the left anterior temporal cortex. Analyses of fMRI data from the same participants will be used to confirm this anterior temporal generator and determine its location more precisely.

D5 Towards the Functional Neuroanatomy of a Common Meaning System for Language and Visual Images Revealed by fMRI and DTI ***Jouen*, *A-L.*** *(1),* ***Ellmore*, *T.M.*** *(2),* ***Madden*, *C.*** *(1),* ***Pallier*, *C.*** *(3),* ***Dominey P.F.****(1),* ***Ventre-Dominey J.*** *(1); 1.INSERM Stem Cell and Brain Research Institute, Robot Cognition Lab, Lyon, France; 2.The University of Texas Medical School at Houston, Houston, TX; 3.Unité de Neuroimagerie Cognitive INSERM-CEA, Neurospin center, Gif-sur-Yvette, France* – Embodied theories of meaning argue that the human conceptual system is implemented in distributed brain networks whose mechanisms are shared by perceptual and action processing.Such meaning representations should be accessible by different perceptual routes, including language and vision. In this context, the current research tests two hypotheses:1. When human subjects process sentences describing physical events and images of equivalent events, the meaning encoded in these different modalities will be represented in a common network, independent of the input modality.2.This meaning network will include parietal sensorimotor and multimodal integration areas, and more amodal frontal areas involved in sequential organization of events in time. To test this hypothesis we exposed 19 healthy young subjects to written sentences and visual images of actions in an event-related fMRI protocol.In the same subjects we recorded 61 direction diffusion images in order to reconstruct their white matter tracts. Using SPM5, conjunction analysis of areas that were active simultaneously for sentence and image processing revealed a distributed fronto-temporo-parietal network.Frontal areas included inferior frontal gyrus BA47, BA46, BA10.Temporo-parietal activation was observed in the medial temporal gyrus BA22, BA37 extending into BA39 and 21 and in the inferior parietal lobe BA40. For the DTI analysis, we used AFNI to compute diffusion tensors, and DTI-Query to generate and visualise deterministic tracts. We placed seed volumes within the region of principal activation in the parietal activation site (MNI coordinates -48, -66, 9), and traced the white matter pathways connected with and traversing this area.In each subject, the MNI seed was projected into native space where the tractography was performed.The resulting tracts were projected back into a common space.A group map of white matter tracts revealed a trifurcating network, with a ventro-lateral component reaching into the temporal pole (by way of the inferior longitudinal fasciculus), a medial component reaching into the ventral frontal pole (by way of the inferior fronto-occipital fasciculus), and a dorsal component reaching into the premotor cortex (by way of the superior longitudinal fasciculus). These data are consistent with the hypothesis that independent of sentence vs. image input, aspects of meaning is represented in a common network including a parietal sensorimotor simulation system interacting with higher level planning and temporal organization functions of the frontal pole and object semantics in the temporal pole.This research is supported by the French ANR Comprendre and EU FP7 project Organic.

D6 White Matter and Letter Fluency: a Correlational Story With Frontotemporal Lobar Degeneration ***Strain*, *J.*** *(1),* ***Hart*, *J.*** *(1),* ***Diaz-Arrastia*, *R.*** *(2), and* ***Womack*, *K.*** *(2); 1. The University of Texas at Dallas, TX; 2. The University of Southwestern Medical Center at Dallas, TX* – Frontotemporal lobar degeneration (FTLD) refers to a group of neurodegenerative disorders that are characterized by personality changes as well as deficits in executive function, and language.Among the clinical findings that are associated with FTLD, word generation is frequently impaired, particularly for phonemic fluency, with category fluency deficits varying among subgroups.We investigated the locations where white matter degradation would reflect impaired performance on these cognitive tasks.The Controlled Oral Word Association Test (COWAT) tests a subject's ability to generate words from a letter prompt.We predict that scores on this test will correlate with an MRI measure of white matter integrity in a regionally specific manner.Diffusion tensor imaging (DTI) is an MRI technique that measures the directional diffusivity of water and is sensitive to changes in white matter integrity. Analyses may utilize diffusivity measures, directly or use derived values such as fractional anisotropy (FA).Subjects: 28 cognitively normal controls (NC), 19 patients with frontotemporal dementia behavioral variant (FTD) and 9 primary progressive aphasics (PPA).5 of the PPA subjects had progressive non-fluent aphasia while the remaining 4 had semantic dementia.The FTLD patients were recruited from the Alzheimer's Disease Center at UT Southwestern where they had received neuropsychological testing.Methods:Images were collected from a 3T scanner and processed using the brain-imaging program FSL.Global voxel-wise analyses of mean diffusivity (MD), axial diffusivity (DA),

radial diffusivity (RD) and FA were conducted in FSL with the tract based spatial statistics (TBSS) and Randomize modules (α=0.05, corrected for multiple comparisons).Two separate analyses were performed, and correlations between diffusivity measures and COWAT scores only included our FTLD group. Between group comparisons utilized age and gender as covariates, while correlations between verbal fluency performance and diffusivity measures used the Mini-Mental State Examination (MMSE) as an additional covariate to control for global impairment.Results: Robust differences in all diffusivity measures were found between NC's and patients ($p<0.05$). Voxels that exhibited a positive correlation for FA and a negative correlation for MD ($p < 0.05$) were primarily localized in frontal regions, especially on the left and involving the corpus callosum.The same frontal regions show negative correlations for RD at a trend level ($p = 0.06$ respectively) but no significant voxels were found for DA. Category fluency failed to show any significant voxels for any diffusivity measures. Conclusions:Striking differences in white matter integrity were demonstrated between NC and patients with FTLD.COWAT performance was specifically correlated with white matter integrity in both frontal lobes, especially in the corpus callosum and on the left.

D7 Common cognitive control mechanisms in sentence production and comprehension ***Humphreys, G.*** *(1), and* ***Gennari, S****. (1); 1. University of York, UK* – Previous research suggests that language production and comprehension share a common knowledge base, e.g., the lexicon and grammatical rules (1). However, these tasks differ in the specific processes engaged, e.g., word retrieval vs. word recognition, as reflected by many clearly distinct production and comprehension models proposed in the literature. Yet, whether producing and comprehending recruit common mechanisms is an important question because such commonality would change the putative processes and architecture(s) entailed. Here, we ask whether sentence production and comprehension engage similar processes when determining who-is-doing-what-to-whom (semantic-role processing). In particular, we hypothesize that competition between alternative roles (agent vs. patient) in both comprehension and production involve common neural resources inhibiting and selecting alternative representations, as in other cognitive tasks entailing response conflict. To address this issue, we compared the production and comprehension of the same sentences. These sentences are known to differ in the degree of semantic-roles' competition elicited in comprehension: -1 The movie that the director watched received a prize. (low-competition) -2 The director that the movie impressed received a prize. (high-competition) In (1), the animacy configuration easily activates the likely interaction between the movie and the director. In (2), in contrast, this interaction is more difficult to determine, as many alternatives are possible after the word "movie" (2). Using event-related fMRI, three tasks were completed: sentence comprehension, sentence completion, and a Stroop task, which identified brain regions sensitive to conflict resolution (localizer). In the comprehension task, full sentences were visually presented and followed by comprehension questions. In the sentence completion task, participants were given a sentence prompt to covertly complete but these trials were intermixed with reading trials of the prompts. The prompts were like "the director that the movie …" in (2), therefore verbs and other words were produced following the prompts. By contrasting the prompt reading trials with the completion trials, we isolated the production-only activity. Results showed overlap between production and comprehension in Broca's area (BA44), which included activity elicited by the Stroop task. Within the Broca's region activated by the Stroop task, the degree of semantic competition modulated activity for both comprehension and production. This suggests that semantic competition modulates brain responses common to production, comprehension and cognitive control tasks. For the production task alone, an effect of semantic role competition was found in an additional network of regions that are known to be involved in motor planning. This suggests that during production alternative possible utterances compete for articulation at the level of motor planning. Overall, the results suggest that language comprehension and production share cognitive control mechanisms and resources that are used elsewhere in cognition. Models of production and comprehension therefore should account for these common processes. References. 1) Bock, K., Dell, G. S., Chang, F., & Onishi, K. H. (2007). Persistent structural priming from language comprehension to language production. Cognition, 104(3), 437-458. 2) Gennari, S. P., & MacDonald, M. C. (2008). Semantic indeterminacy in object relative clauses. Journal of Memory & Language, 58, 161-187.

D8 Subdivision of frontal cortex mechanisms for language production ***Thothathiri, M.*** *(1,2,3),* ***Gagliardi, M.*** *(1), and* ***Schwartz. M. F.*** *(1); 1. Moss Rehabilitation Research Institute, Philadelphia, PA; 2. University of Pennsylvania, Philadelphia, PA; 3. Swarthmore College, Swarthmore, PA* – Neuroimaging has been used to investigate sub-specialization within the frontal cortex for different linguistic and executive functions. Here, we explore this issue from a neuropsychological perspective. What are the implications of damage to different frontal regions for language production? Participants. We undertook case studies of 5 patients. Three had damage to posterior frontal cortex (BA 44/6), one to more anterior regions (BA 45/47), and one to non-frontal areas only. We report two relevant tasks from a larger study comprising many tasks. Priming. Participants named two pictures shown on the screen using "the X and the Y". Experimental trials were triads, where one noun was repeated.In the first two trials of the triad (primes), the repeated noun appeared in the same position (the apple and the cup, the apple and the shoe). In third trial (target), the position of the repeated noun was "consistent" (the apple and the star) or "inconsistent" (the star and the apple) with the primes. Interference was computed as the difference in onset latencies between inconsistent and consistent trials as a percent of latency on filler trials. The non-frontal patient did not show higher interference compared to controls (Control

N=8, Mean=4.2%, SD=5.1%. Patient mean = 3.5%. Crawford test p>0.9). The three BA 44/6 patients showed heightened interference (23-37%. Crawford test p<.01 for each). The BA 45/47 patient also showed significantly higher interference than controls (17.5%. Crawford test p<.05). Impairment in the priming task can arise from a deficit in inhibiting prepotent representations or responses, or in resolving competition between to-be-sequenced items (sequencing interference). To disentangle the two contributions, we tested participants in a sequencing task that did not involve priming. Sequencing. Participants reproduced four-item sequences shown on the screen using the keyboard. Stimuli were letters (A, B, C) or colored squares (blue, yellow, red). Items appeared one at a time (sequential) or all at once (simultaneous). Healthy controls are known to slow down in the simultaneous condition for item 1 (cost for planning) but go faster for subsequent items (benefit from planning ahead). In contrast, frontal patients may incur initial interference costs without reaping much subsequent benefit. We computed the difference between cost (item 1 simultaneous minus sequential) and benefit (item 2 simultaneous minus sequential), normalized by the baseline RT to item 1 in the sequential condition. We found different patterns in patients with different lesion profiles. Figure 1a shows sequencing interference averaged across the color and letter tasks for patients and controls (N=6). The patient with damage mainly to BA 6 showed the greatest interference. This might reflect a general motor planning deficit. Interestingly, the two patients with damage to BA 44 and 6 were the only participants who showed higher sequencing interference for letters compared to colors (Figure 1b). We are currently exploring whether this specificity is linguistic vs. non-linguistic, or non-semantic vs. semantic. Together, our data suggest possible subdivision of frontal mechanisms for language production. Posterior frontal regions (BA 44/6) may be important for sequencing, with further sub-specialization for sequencing in different domains.

SYNTAX

D9 Shared Network for Noun and Verb Reading in the Ventral and Dorsal Streams: Converging Evidence From fMRI Activation and Reaction Time

Borowsky, R. *(1),* ***Esopenko, C.*** *(1),* ***Gould, L.*** *(1),* ***Kuhlmann, N.*** *(1),* ***Sarty, G.****(1),* ***Cummine, J.*** *(2); 1. University of Saskatchewan, Saskatoon, SK, Canada; 2. University of Alberta, Edmonton, AB, Canada* – **Objective:** Some researchers have argued in favor of verbs primarily activating the left frontal operculum (FO) in the dorsal stream, and left middle temporal (MT) region in the ventral stream, and that nouns primarily activate the left inferior temporal (IT) region in the ventral stream.Others have suggested that the activation representing noun and verb processing involves a shared neural network.We explored the naming of identical, homonymous, separately cued nouns (the bat) and verbs (to bat) presented in word format, and required participants to also provide a word associate following their naming of the target word to ensure that they were treating the target as a noun or a verb. Using homonymous words for both the noun and verb referents provides for an optimally controlled comparison given that the target stimulus and response is identical, and only the cue differs. Methods: Experiment 1 - Functional Magnetic Resonance Imaging (fMRI) - Traditional subtractive methodology does not fully address the extent of how modular or shared the underlying cortical activation is for nouns and verbs, as the subtractive method results in an activation map that attributes the region to the higher intensity condition even if both conditions that are being considered yield significant activation. As such, we used an alternative method that maps the activation that is significant and shared, separately from activation that is significant and unique to one of the conditions.Experiment 2 - Reaction Time (RT) – Given previous research that suggests that the dorsal stream is primarily activated when reading is based on grapheme-to-phoneme conversion (GPC), and that the ventral stream is primarily activated when reading is based on orthographic lexical activation (OLA), we examined the effects of bigram frequency and word frequency as measures of GPC and OLA, respectively, and in combination with our noun/verb part of speech (POS) manipulation. Using the additive factors method, overadditive interactions between two variables on RT can be taken as evidence for both variables affecting a shared system of processing. Results: Experiment 1 (fMRI) - The majority of activation was shared by both the noun and verb conditions, and across both the ventral and dorsal streams, including the regions suggested by previous researchers as unique to verbs (FO, MT) or nouns (IT).In contrast, there was little unique activation attributable to noun processing, and practically no unique activation attributable to verb processing.Experiment 2 (RT) – An overadditive interaction on naming RT between POS and bigram frequency provided converging evidence that the shared dorsal activation for nouns and verbs involves GPCs, whereas an overadditive interaction between POS and word frequency provided converging evidence that the shared ventral activation for nouns and verbs involves OLA. Conclusions and Significance of the Results: Using a tightly controlled design where the same written word targets serve in both of the critical noun and verb conditions, we provide converging fMRI and RT evidence for a predominantly shared processing network for nouns and verbs, both spatially along the ventral and dorsal streams, and temporally through OLA and GPC.

D10 Neural mechanisms supporting implicit versus explicit acquisition of grammar in adults

Batterink, L., *(1)* ***Neville, H.****(1); 1.The University of Oregon, Eugene, OR* – Converging lines of evidence suggest that children and adults rely upon different neural mechanisms for the acquisition of grammar. While children acquiring their native grammar depend primarily on implicit memory systems, adults appear to rely more heavily upon explicit memory systems when learning a new grammar. Although maturational factors undoubtedly play a major role in these observed differences,

type of linguistic exposure may also be an important factor, as language learning in adulthood typically occurs through explicit instruction rather than the implicit immersion characteristic of childhood language acquisition.However, few empirical studies to date have examined the effect of type of exposure on neural outcomes.The present study addressed this question by comparing the neural mechanisms involved in second language learning under conditions of implicit exposure versus explicit instruction.Adults were presented with simple stories in a foreign language, paired with accompanying pictures to illustrate meaning.In an implicit group, no mention of the grammatical rules governing the foreign language was made, while in an explicit group participants were explicitly taught the underlying grammatical rules before exposure began.Following exposure, participants completed a grammaticality judgment task to assess learning.In the implicit group, a late positivity to violations, similar to the P600, predicted behavioral success in grammar learning. Explicitly taught participants also showed a late positive violation effect, as well as additional ERP components not typically observed in native speakers. These results suggest that type of linguistic exposure has an important effect on the neural mechanisms that are recruited to acquire and process a second language.In addition, it appears that L2 processing in adulthood predominantly depends upon accessing explicit knowledge, at least at early learning stages, even under implicit training conditions.

D11 Is there a lexical boost for syntactic repetition effects as measured by fMRI adaptation? ***Segaert, K.*** *(1,2),* ***Kempen, G.*** *(1,3),* ***Petersson, K.M.*** *(1) and* ***Hagoort, P.*** *(1,2); 1. Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands; 2. Radboud University, Donders Institute for Brain, Cognition and Behavior, Nijmegen, the Netherlands; 3. Cognitive Psychology Unit, Leiden University, Leiden, the Netherlands* – **Introduction:** Numerous behavioral studies have demonstrated that verb repetition is a lexical enhancer of syntactic priming effects (e.g. [1]). This suggests, in line with lexicalist grammar formalisms (e.g. [2]), that human syntactic processing is strongly lexically guided. We investigated whether a lexical boost of syntactic priming also shows up in neuronal activity in brain regions subserving grammatical processing. Specifically, during sentence production as well as comprehension, we measured the extent of fMRI adaptation to repetition of syntactic structures with vs. without repetition of the main verb. fMRI adaptation is defined as reduction of the BOLD-response in regions sensitive to a certain stimulus property, in reaction to repeated presentation of that stimulus property. Method: In sentence production trials, Dutch-speaking subjects described pictures which were color-coded to elicit transitive clauses in either active or passive voice. In comprehension trials, subjects listened to transitive descriptions of black-and-white pictures in active or passive voice. Within-subjects factors were: (1) voice of the target sentence (active or passive); (2) syntactic repetition (voice of the produced/heard clause in prime and target sentence was same or different); (3) processing modality (all four combinations of producing or hearing the prime and the target were tested). As between-subjects factor we manipulated whether the main verbs of prime and target sentences were identical or different. Results: ROI analyses (with coordinates based on the syntactic repetition effect in [3]) in left inferior frontal (LIFG) and left middle temporal gyrus (LMTG) revealed a 3-way interaction between syntactic repetition, voice and verb repetition ($p<.02$; (Figure1). Follow-up contrasts showed that under conditions of verb repetition, there was an effect of syntactic repetition ($p<.001$) which did not interact with voice ($p>.3$). Under conditions without verb repetition, we found no overall effect of syntactic repetition ($p>.3$); however, the effect of syntactic repetition appeared to depend on voice ($p<.02$), with adaptation effects only for passives, not for actives. Processing modality did not affect the extent of syntactic adaptation. None of these effects interacted with whether the ROI was LIFG or LMTG. Discussion: Crucially, we observed a lexical boost of fMRI adaptation to syntactic repetition only in sentences with active voice, not in passives. We tentatively suggest that syntactic repetition effects for actives vs. passives occur at different levels of processing. When processing a passive clause, a major source of difficulty is to overcome competition/inhibition from two angles: inhibition from the more frequent and strongly preferred active-voice alternative, and competition between two possible word orders (differing linearizations of the Dutch by-phrase). Lexical repetition is irrelevant here. None of these problems affect actives, so a boost due to verb repetition can readily manifest itself. [1] Hartsuiker, Bernolet, Schoonbaert, Speybroeck & Vanderelst (2008), Journal of Memory and Language, 58, 214-238. [2] Vosse & Kempen (2000), Cognition, 75, 105-143. [3] Menenti, Gierhan, Segaert & Hagoort (in press), Psychological Science.

D12 Extending Template Construction Grammar: A Model of Language Comprehension ***Barres, V.****(1),* ***Lee, J.*** *(1),* ***Arbib, M.*** *(1,3); 1. University of Southern California, CA; 2. USB Brain Project* – The present study is inscribed within our effort to develop a model which relates linguistic processes to mechanisms of action and perception. Our first step was to propose a computational model for production of descriptions of visual scenes (Arbib & Lee, 2008). We developed a new kind of semantic representation, SemRep, which is an abstract form of visual information with an emphasis on the spatial linkage of entities, attributes and actions. SemRep provides a graph-like hierarchical structure with enough formal semantics for verbal description of a scene. As a result, it reduces the relatively complex task of semantic processing to a graph matching task. Moreover, we adopted Construction Grammar as an appropriate framework for a schema-based linguistics. We implemented a system called Template Construction Grammar (TCG) whose role is to parse a SemRep into linguistic expressions. Constructions, represented as schema instances in our approach, compete and cooperate to cover the SemRep to produce a description of the visual scene at hand. Here we present the recent extension of TCG from production to comprehension. Going beyond most of the other

comprehension models whose goal is to generate a syntactic tree, we design a system which produces a semantic representation in the form of SemRep as the interpretation of the comprehended verbal expression. The system performs the comprehension process according to the TCG rule in which constructions compete and cooperate in a similar manner to its production counterpart. Other parsing models, for instance the U-Space model (Vosse & Kempen, 2000), used a similar paradigm, but our model is unique in the sense that the parsing process is directed not so much a extracting syntactic structure so much as finding the semantic structure of SemRep. Particularly, our model actively engages different types of semantic cues available upon receiving a verbal expression. The pieces of representation produced as the intermediate results of interpretation eventually converge towards a coherent set of SemRep by considering constraints both from heavy semantics and light semantics. The former includes the discourse context or general world knowledge while the latter is provided from the lexical and syntactic knowledge embedded in linguistic constructions. This corresponds to Piñango's (2006) insistence on the importance of the structuring role of semantics alongside syntax in addressing data on aphasics. Such semantic cues pre-shape the landscape of the applicable constructions for parsing and the resultant SemRep is again added to the discourse context, extending the existing semantic cues. We discuss the relation of our model to the eADM model (Bornkessel & Schlesewsky, 2006), which also incorporates semantic and syntactic cues altogether in the form of prominence. Different types of constructions emphasize different types of information that they encode, and this naturally leads to different styles of processing according to the available constructions at the moment. This procedural flexibility and dynamicity is one of the main characteristics of the competition and cooperation paradigm as compared to the separate parsing stages of the eADM.

D13 Cognitive and language proficiencies predict variability in neural activity mediating semantic and syntactic processing in children ***Hampton Wray*, *Amanda*** *(1),* ***Weber-Fox*, *Christine*** *(1); Purdue University, West Lafayette, IN* – To date, understanding of relationships between cognitive domains and language development has been primarily based on observations of and correlations between individual abilities, such as categorization abilities and emerging grammar skills (e.g. Bates, Dale, & Thal, 1995; Marchman & Thal 2005; Piaget & Inhelder, 1969; Tomasello, 2003).Very little evidence exists regarding the interactions between various aspects of cognition and the underlying neural activity for specific language functions in children.The current study addresses the following question: How do proficiencies in specific cognitive and language functions impact neural indices mediating language processing in children?Methods: Thirty typically developing seven- and eight-year-olds were divided into high-normal and low-normal proficiency groups based on performance on nonverbal IQ, auditory word recall, and grammatical morphology tasks.ERPs were elicited by semantic anomalies and phrase-structure violations in naturally spoken sentences.Results: Our findings demonstrated that the proficiencies for each of the specific cognitive and language tasks uniquely contributed to individual variability in neural indices of semantic (N400) and syntactic (P600) processing.The peak latencies of the N400 indicated that children with greater nonverbal IQ differentiated semantic anomalies more rapidly than lower performing peers.In contrast, stronger verbal working memory abilities were associated with greater ease of lexical access, or easier generation of meaning representations, indexed by smaller N400 amplitudes.For syntactic processing, children with better auditory word recall abilities demonstrated greater allocation of neural resources for reprocessing of phrase-structure violations compared to lower performing peers, revealed by larger P600 amplitudes.A different type of facilitated processing was associated with grammatical morphology abilities, as children with better grammatical performance demonstrated faster processes of repair or reanalysis of syntactic violations, indexed by earlier P600 peak latencies.Conclusions: These results suggest that distinct aptitudes within broader domains of cognition, even within the normal range, influence the neural signatures of semantic and syntactic processing in children.Furthermore, the current findings have important implications for the design and interpretation of developmental studies of ERPs indexing language processing, and they highlight the need to take into account cognitive abilities both within and outside the classic language domain.

D14 Neural mechanisms underlying noun-verb distinction— fMRI Evidence from semantic processing of Chinese words ***Yu*, *X.*** *(1),* ***Law*, *S.-P.*** *(1),* ***Han*, *Z.*** *(2),* ***Bi*, *Y.*** *(2); 1. The University of Hong Kong, Hong Kong; 2. Beijing Normal University, Beijing, China* – **Background.** Numerous studies have been carried out to investigate whether and how grammatical class distinction may be represented in the human brain in the past three decades. However, as concluded by two recent extensive reviews (Crepaldi et al., 2011; Vigliocco et al., 2010), compelling evidence supporting separate neural correlates of noun and verb processing is still lacking, due to confounding from the frequent involvement of inflectional operations in experimental tasks and the fundamental differences between nouns and verbs that were not controlled for. In the current study, these limitations were circumvented by studying the comprehension and production of both concrete and abstract nouns and verbs at the semantic level in a language with minimal inflection morphology, i.e., Chinese. Methods. A semantic relatedness judgment task and a semantic associate production task were administered to the same group of 20 Mandarin-speaking participants, who were right handed, and aged from 19 to 29. For each experiment, imaging data were modeled by the four event types (concrete noun, concrete verb, abstract noun, abstract verb) at the subject level. Contrast maps of overall nouns versus verbs and vice versa were built, and fed into a 2 (noun, verb) *2 (judgment, production) within-subject

design at the group level. Within the mask of positive activation for each word class (voxelwise $p > 0.05$), a conjunction analysis of grammatical contrasts between the two tasks was conducted with a corrected clusterwise significance of 0.05 (voxelwise $p < 0.005$, $k = 49$) to look for word class-specific regions that were independent of tasks. An ROI analysis of interaction effects between concreteness and word class was performed in each of the activated regions for the two tasks respectively, to examine possible differential grammatical class effects across concreteness levels. Results. The conjunction analysis revealed verb-specific activation in left posterior superior and middle temporal cortex (LpSTG&MTG, [-48, -51, 9], $k = 124$) and left inferior frontal area (LIFG, [-51, 6, 9], $k = 49$), and noun-specific activation in left fusiform gyrus ([-30, -30, -24], $k = 96$).No interaction effects were found in the ROI analyses for either experiment in the verb-specific regions (see figure 1). However, a significant interaction in the judgment task and a marginally significant interaction in the production task were observed in left fusiform gyrus, due to a reduced difference between abstract nouns and verbs. Conclusions. Through employing a language with impoverished inflectional morphology, and presenting abstract and concrete nouns and verbs in bare forms in two tasks involving semantic processing, we have identified the LpSTG&MTG and LIFG with greater activation for verbs, and left fusiform for nouns. However, the observation that the difference in neural response between nouns and verbs was greater for concrete than abstract items in left fusiform raises the possibility that noun-specific activation originated from higher imageability of concrete nouns than verbs. Nevertheless, verb preference in LpSTG&MTG and LIFG was not modulated by concreteness, unambiguously demonstrating distinctive neural correlates of verb processing even in languages with minimal inflection.

D15 The Neural Correlates of Incremental Structure-Building and Interpretation ***Brennan, J.*** *(1),* ***Pylkkänen, L.*** *(1); New York University, NewYork, NY* – **Introduction:** Understanding how the brain combines words to make complex representations is a basic question for neurobiological models of sentence processing. This task divides into several cognitive computations including those that build sentence structure (syntactic structure-building) and those that compose word meanings together (semantic composition). While a large body of work has elucidated the neural correlates of sentence-level combinatorics broadly construed (1-3), efforts to tease these two computations apart at the neural level are made difficult by the tight relationship between syntax and combinatoric semantic representations. To tease apart syntactic and semantic composition during natural comprehension, without requiring error processing or meta-linguistic tasks, we developed a hypothesis derived from work in computational linguistics that these computations may dissociate when considered as operations that are applied incrementally during normal comprehension (4). We recorded brain activity using magnetoencephalography (MEG) while participants read a story and we then correlated, word-by-word, the number of semantic and syntactic operations predicted by our parsing model with brain activity in order to identify processing associated with these two computations. Computational Model: Our model focused on prepositional phrases, where a standard syntactic and semantic analysis using a context-free grammar could be straightforwardly applied. Developing the parser proposed by (4), we modeled incremental parsing using a left-corner algorithm in which syntactic and semantic rules were interleaved. We then counted the number of syntactic or semantic rules required to parse each word. Methods: Nine participants were presented with a story using serial visual presentation. Subjects answered comprehension questions periodically to assess attention. Cortically constrained distributed source models were used to estimate brain activity time-locked to word presentation in 13 anatomically defined left hemisphere ROIs. Correlations between the parser predictions and brain activity were estimated using hierarchical regression with adjustment for multiple comparisons using simulation. Results: The predictions of the computational model correlated with word-by-word single-trial data in the anterior middle temporal gyrus and the anterior cingulate around 400msec after word presentation. Model-comparison revealed that model fits in both regions were significantly degraded when either syntactic or semantic factors were removed, showing independent contributions from structure-building and semantic composition. No spatial dissociation between the two factors was observed. The spatio-temporal results are consistent with much recent work on syntactic (5) and compositional semantic (6) processing. Most importantly, these findings demonstrate that independent effects of semantic composition and syntactic structure-building are dissociable at the neural level during natural comprehension. Conclusion: We developed a model of incremental interpretation in which structure-building and semantic composition are engaged at different rates during word-by-word comprehension. Testing the model against single-trial brain activity revealed independent correlations with anterior temporal and medial frontal activity, consistent with recent work. Our results suggest that the incremental dissociation between syntax and semantics offers a novel approach to identifying the neural correlates of these two fundamental operations. References: (1) Mazoyer et al. 1993 (2) Humphries et al. 2006 (3) Rogalsky & Hickok 2009; (4) Stabler 1991 (5) Grodzinsky & Friederici 2006 (6) Pylkkänen & McElree 2007

D16 Low-frequency networks for conceptual and syntactic sequencing ***Hancock, R.****(1),* ***Chan, S.****(2),* ***Ryan, L.T.*** *(1)* ***Bever, T.G.****(1); 1. The University of Arizona, Tucson; 2. University of Taipeh, Taiwan* – Patterns of stimulus independent low frequency fluctuations (LFFs) in BOLD signal have been associated with general processing contexts (e.g. language) induced by different, but related tasks (Lohmann et al, 2010). We describe a refinement of language-related LFF networks into lexical/conceptual and syntactic networks based on two sequencing tasks that required silently reordering and repeating

words in either conceptual (pine-tree-plant) or syntactic ([the girl] [upset] [the mother]) order. The corresponding LFFs associated with a left BA44 seed show greater correlated activity in the superior frontal gyrus and angular gyrus for the conceptual task compared to the syntactic task. For the syntactic task, greater low frequency correlations were found in the left caudate and bilateral middle frontal gyrus (Figure 1). These differences are consistent with the results of BOLD comparisons of processing semantic and syntactic violations (Friederici et al, 2003).Additionally, individual variability in LFFs in right-handed subjects was partially explained by the presence or absence of left-handed family members. We propose that LFFs induced by general linguistic tasks reflect a mixture of these conceptual and syntactic patterns and predict task and individual variability in mixture weights, providing a potentially useful measure of individual bias towards syntactic or conceptual processing in neurolinguistic studies. Friederici, A. D. (2003). The Role of Left Inferior Frontal and Superior Temporal Cortex in Sentence Comprehension: Localizing Syntactic and Semantic Processes. Cerebral Cortex, 13(2), 170-177. doi: 10.1093/cercor/13.2.170. Lohmann, G., Hoehl, S., Brauer, J., Danielmeier, C., Bornkessel-Schlesewsky, I., Bahlmann, J., et al. (2009). Setting the Frame: The Human Brain Activates a Basic Low-Frequency Network for Language Processing. Cerebral cortex (New York, N.Y. : 1991), 20(6), 1286-1292. doi: 10.1093/cercor/bhp190.

D17 Increasing Combinatoric Complexity in MEG

Leiken, K. *(1),* ***Pylkkänen, L.*** *(1); 1. New York University, New York, NY* – Do more "complex" syntactic operations employ the same neural mechanisms as basic ones, or are distinct regions or mechanisms recruited? The present study examines how dependency formation relates to more basic linguistic combinatorial operations. Although both types of computations have been independently studied, there have been few attempts to examine them within the same design. Structures involving long-distance dependencies, such as object relatives (ORs), have been shown in numerous fMRI and PET studies to elicit increased activation in left inferior regions (Grodzinsky & Friederici, 2006). The current study contrasts ORs with simpler composition, and with isolated words using MEG. Method. Our design involved a three-way comparison between isolated verbs, these verbs combined with a subject in an argument saturation construction, and the same verbs embedded inside ORs. To maximally control for the lexical semantics of the verb across conditions, we employed reflexive verbs, which even in their intransitive frame are interpreted transitively. Twenty-two subjects performed a match task on pictures that followed these stimuli (consonant strings controlled for the visual baseline across conditions): (i) Verb: plyhzt rcm ycgl rcm wsjFv bathed (ii)Subject-verb: plyhzt rcm ycgl rcm Sallybathed (iii)OR:plyhzt rcm the dogSallybathed MEG activity was analyzed at the verb using both ROI and whole-brain analyses. Based on prior work relating to basic composition (Bottini et al., 1994; Stowe et al., 1998; Friederici et al., 2000; Vandenberghe et al., 2002; Humphries et al., 2006; Rogalsky & Hickok, 2008; Bemis & Pylkkänen, 2011) and the work on long-distance dependencies (e.g., Stromswold et al., 1996), our ROIs included the left anterior temporal lobe (LATL), ventromedial prefrontal cortex (vmPFC), and inferior frontal gyrus (LIFG). Composition Results. bathed vs. Sally bathed: ROI analyses showed increased LATL and vmPFC activity at 100-200ms after the verb. Whole-brain analyses replicated these results. The whole-brain analyses also revealed significant and sustained Angular Gyrus (AG) activity after the verb. Dependency Results. Sally bathed vs. the dog Sally bathed: Neither ROI analyses nor whole-brain analyses showed increased activation for ORs. bathed vs. the dog Sally bathed: The only positive effect for ORs at the target was an increased AG activation. An exploratory whole-trial ROI analysis showed increased pre-target LIFG activation for ORs (at 900ms to 800ms before the verb). This was mirrored in whole-brain analyses, which around the same time window also showed LATL and vmPFC activity typical of basic composition. Discussion. The present findings for argument saturation replicate the basic composition regions found in Bemis and Pylkkänen (2011), but earlier.Basic composition also showed a robust and long-lasting AG effect, which is consistent with previous findings of increased AG activity for semantic integration (Lau et al, 2008, Humphries et al., 2006, 2007), for sentences over word-lists (Bottini et al., 1994; Bavelier et al., 1997), and for grammatical over orthographic violations (Embick et al., 2000). No additional activation was found for dependency formation compared with basic composition. Thus, no step-wise increase in activation for the three complexity levels was found.

D18 Neural correlates of prosody and plausibility in garden-path processing

Den Ouden, D.B. *(1),* ***Christianson, K.*** *(2),* ***Anderson, C.*** *(3),* ***Dickey, M.*** *(4); 1. University of South Carolina, SC; 2. University of Illinois at Urbana-Champaign, IL; 3. McMaster University, Ontario, Canada; University of Pittsburgh, PA* – **Introduction.** Prosodic and semantic processing have cortically distinct representations from syntactic processing, but these sources of information are assumed to interact during sentence processing. Studies into the neural correlates of (complex) syntactic processing support a left-hemisphere network of cortical and subcortical areas in which activation is modulated as a function of syntactic complexity. These studies mostly use complex syntactic constructions, such as object clefts and passives. There have been few neuroimaging studies of garden-path (GP) processing, while such sentences allow precisely the investigation of the interplay between syntactic word order processing, pragmatics/semantics and prosody. Using fMRI, we investigated the neural signatures associated with reliance on non-syntactic (prosodic, semantic) sources of information in garden-path sentence comprehension. It was hypothesized that (1) activation in a syntactic network will be attenuated with greater degrees of extrasyntactic information (prosody, plausibility) and that (2) the use of these types of information will be reflected in upregulation of activation in areas underlying prosodic and semantic processing, including right-hemisphere

regions. Methods. Nineteen right-handed speakers of English (17 females, mean age 26, range 20-34) listened to auditorily presented sentences, answering written comprehension questions by button press. Data were collected through continuous scanning in an event-related design. Sentence types (1-4) were presented with flat intonation and with normal intonation, i.e. with a natural pause after the embedded clause. 1) While the man hunted the deer ran into the woods (plausible GP) 2) While the man hunted the deer paced in the zoo (globally implausible) 3) While the man hunted the plane flew over the woods (locally implausible) 4) While the man hunted the pheasant the deer ran into the woods (non-GP control) Question: Did the man hunt the deer/plane/pheasant? In addition, participants performed an anomaly detection task on object-cleft versus subject-cleft sentences, presented auditorily in a block design. This task was included in order to independently map regions that show upregulation of neural activation associated with processing of relatively complex sentences. All scanning was performed at 3 Tesla. Results & Discussion. The contrast of object-clefts minus subject-clefts from the block task primarily revealed upregulated activation in left posterior middle temporal gyrus, while other left- and right-hemisphere perisylvian activation, including the left pars triangularis, was below threshold ($z<3.0$). With respect to the main experiment, there was extensive overlap in bilateral superior temporal cortex for main effects of sentence type and main effects of prosody (see Figure 1). The interaction between these effects was associated with activation in left insula, right inferior frontal, and bilateral superior parietal cortex, among other areas. The contrast of prosodic minus neutral intonation was associated with activation in superior temporal and auditory cortex, bilaterally, with more extensive activation in left temporo-occipital cortex. In general, sentence types in which the garden-path interpretation was less plausible were associated with higher processing cost, as reflected in neural activation patterns. These upregulations were largely found outside areas that are classically associated with syntactic processing, suggesting use of additional resources, rather than direct attenuation of the syntactic network underlying sentence parsing.

D19 Damage to left anterior temporal cortex predicts impairment of complex syntactic processing: A lesion-symptom mapping study ***Fillmore, P.*** *(1),* ***Magnusdottir, S.*** *(2),* ***DenOuden, D.B.*** *(1),* ***H. Hjaltason, H.*** *(2),* ***Rorden, C.*** *(1),* ***Kjartansson, O.*** *(2),* ***Bonilha, L.*** *(3)* ***Fridriksson, J.****; 1. University of South Carolina, 2. Landspitali – University Hospital, Reykjavík, Iceland, 3. Medical University of South Carolina, Charleston, SC. – University Hospital, Reykjavík, Iceland, 3. Medical University of South Carolina, Charleston, SC.* – **Background and Purpose.** Sentence processing problems form a common consequence of left-hemisphere brain injury, in some patients to such an extent that their pattern of language performance is characterized as 'agrammatic'. However, the location of left-hemisphere damage that causes such problems remains controversial. It has been suggested that the critical site for syntactic processing is Broca's area of the frontal cortex or, alternatively, that a more widely distributed network is responsible for syntactic processing. The aim of the present study was to identify brain regions that are required for successful sentence processing. Specifically, we narrowed down our investigation to regions that are required for successful parsing of complex syntactic structures with noncanonical word order, which are known to be particularly prone to error in agrammatic production and comprehension. We examined native speakers of Icelandic, a morphologically complex language where syntax is denoted by case marking of nouns as well as subject agreement marking on verbs. Methods. Voxel-based lesion-symptom mapping (VLSM) was used to identify brain regions where injury predicted impaired sentence processing in forty-nine patients with left-hemisphere stroke. Sentence processing was assessed by having individuals identify which picture corresponded to a verbally-presented sentence. Data analysis targeted contrastive behavior on a subset of the sentences, namely impaired processing of sentences with noncanonical word order relative to processing of matched sentence types with canonical word order. Results. The VLSM analysis revealed that impaired sentence processing in an auditory-visual sentence picture matching task was best predicted by damage to a large left-hemisphere temporo-parieto-occipital area encompassing middle and superior temporal gyri, inferior parietal cortex, angular gyrus, superior to inferior occipital cortex and fusiform gyrus, while extending inferiorly to the hippocampus. Specifically impaired processing of noncanonical sentence types, with relative preservation of canonical sentence processing, was associated with damage to the left-hemisphere anterior superior and middle temporal gyri and the temporal pole. These findings were robust, surviving a false discovery rate (FDR) threshold of $p=.05$. Conclusions. The present results show that damage to temporo-parieto-occipital cortex and the underlying white matter predicts impaired performance on an auditory-visual sentence processing task in Icelandic adult stroke patients. This is likely due to the multimodal nature of the sentence processing task, which involves auditory and visual analysis, as well as lexical and syntactic processing. More focal damage to anterior middle and superior temporal gyri predicts specific problems with the processing of complex syntactic structures, which cannot be reduced to task-related factors. Anterior temporal cortex, therefore, appears to play a crucial role in syntactic processing and patients with brain damage to this area are more likely to present with agrammatism than patients in which anterior temporal cortex is spared.

D20 Syntactic Movement in Broca's aphasic patients: An ERP study ***Torres-Agustín R.*** *(1),* ***Rodríguez Camacho M.*** *(2),* ***Silva-Pereyra J.*** *(2),* ***Rodríguez-Agudelo Y.*** *(1),* ***Robles Aguirre F.*** *(1); 1. National Institute of Neurology and Neurosurgery, Mexico; 2. National Autonomous University of Mexico, Iztacala Higher Education Faculty* – Broca's aphasia is a language disorder resulting from injury to the left third frontal convolution (Broca's area) and adjacent areas (corresponding to Brodmann's areas 44 and

45). These patients are classically characterized by an impaired speech production and a reduced morpho-syntax. Although their language comprehension has been described as normal, deficits in the understanding of constructions that require syntactically complex operations, such as NP movement in relative clauses, has been reported in English-speakers with Broca's aphasia. This study aimed to explore the behavioral and electrophysiological characteristics of patients with Broca's aphasia in a sentence-comprehension task with different syntactic-movement distances in Mexican Spanish-speakers. The sample consisted of ten volunteers, five Broca's aphasic patients of the Language Clinic of National Institute of Neurology and Neurosurgery, and five control subjects matching age, gender and education. Subjects were faced with sentences like: "El hombre y la señora buscan al niño que jugaba" (distance 0 / no movement), "El hombre buscó al niño que la señora vio que jugaba" (distance 1), "Llegó el niño al que buscó el hombre y que la señora vio que jugaba" (distance 2). 50% of the sentences ended with a semantic incongruity "El hombre y la señora buscan al niño que volaba". 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 of Event-Related Potentials. Statistically significant differences were found between groups in the number of correct answers ($p<0.05$) for all types of sentences, except for the condition no movement/congruent; the patient's group had more errors. There were also significant differences between groups in the reaction times ($p<0.05$) for all types of sentences; the group of patients had longer times. Regarding the difference in average amplitudes for the N400, were found statistically significant differences only in the condition "distance 1/semantic incongruity" ($p<0.05$); the patient's group had lower amplitudes. These results suggest that Broca's aphasic patients have impaired comprehension of sentences with syntactic movement. This is evident with increasing complexity of these sentences. These findings are probably associated with the results of fMRI studies in which Broca's area is involved with syntactic processing of sentences.

D21 Learning Structural Biases of Novel Verbs: An ERP Study ***Qi, Z.*** *(1),* ***Garnsey, S. M.*** *(1); 1. University of Illinois, Urbana-Champaign, IL* – A wealth of experimental findings suggest the frequency-based accessibility of structural alternatives of particular verbs, also known as verb bias, plays an important role in a comprehender's ability to predict the following words in the sentence and the intended meaning of an utterance [1, 2, 3]. In language acquisition and artificial language learning literature, available behavioral evidence indicates that both children and adults are able to learn the combinatorial facts about a particular verb from linguistic input [4, 5]. However how do language users learn verb bias? Little is known about the brain distribution over the course of verb bias learning. The current experiment investigates continuous electrophysiological dynamic underlying the learning process of new frequency-sensitive verb bias to explore how human language system adapts to new statistical linguistic information. EEG was recorded while participants read sentences containing novel verbs in a rapid serial visual presentation with 500 msec of SOA. All the training sentences provide strong context promoting either modifier or instrument interpretation of the sentence ending structure as in sentences (1) and (2). -1 The farmer dakked the corn with /using the big tractor… -2 The gladiator norged the lion with / that has the golden mane… In instrument-training sentence (1), it is obvious that the tractor is an instrument for an unknown action dakking, while in modifier-training sentence (2) mane is clearly a property of the lion rather than an instrument used in the unknown action norging. Half of the training sentences included ambiguous with phrases, while the other half substituted the unambiguous using or that has in place of with. Each participant completed a brief training session with 64 sentences evenly distributed in four conditions across two blocks. Each novel verb was only presented in one of the four training structures. Electrophysiological evidence suggests implicit learning over the time course of verb bias training. In the disambiguating noun region, mean amplitudes of N400 elicited by instrument nouns (e.g. tractor) are reliably reduced relative to those elicited by modifier nouns (e.g. mane, Fig-1). Post-hoc analysis revealed that this attachment effect mainly existed between the ambiguous conditions containing with phrases, rather than between the unambiguous conditions with using and that has phrases (Fig-2). On one hand, the reduction of N400 in instrument-ambiguous training trials may reflect the confirmation of readers' prediction about an upcoming instrument based on the newly learned verb bias. On the other hand, readers did not have to learn the verb specific information in the unambiguous training, given the available disambiguating information from using and that has phrases. Individual difference in familial left handedness appears to predict different learning strategies. When reading the sentences containing ambiguous with phrases, individuals with all right-handed relatives showed an attachment effect transformed from an N400 response in the first block to a P600 response in the second block (Fig-3A & B). In contrast, no P600 effect was observed in individuals with left-handed relatives. These results suggest at least for some subjects, learning verb bias involves the transition from semantic to syntactic processing. The current experiment suggests an experience-dependent plasticity of language system, which continuously collects statistical information from linguistic input. Future experiment with testing sentences designed to contradict the trained bias will provide more evidence to address when and how people use the newly learned verb bias during conflict resolution.

D22 Effects of second language proficiency in late learners on neural organization for syntactic processing indexed by ERPs and fMRI ***Pakulak, E.*** *(1),* ***Dow, M.*** *(1),* ***Neville, H.*** *(1); 1.University of Oregon, Eugene, OR* – Several ERP and neuroimaging studies have reported that neural organization for syntactic processing is altered by delays in age of acquisition (AOA) as short as 4-6 years (e.g.,Wartenburger

et al., 2003; Weber-Fox & Neville, 1996).However, as such delays in acquisition are typically associated with lower language proficiency (e.g., Johnson & Newport, 1989), it is difficult to assess whether differences in AOA or proficiency lead to these effects.In a previous ERP study of syntactic processing using auditorily presented phrase structure violations, we examined late learners of English matched for proficiency with a group of monolingual native speakers.Findings suggested that late learners recruited different neural mechanisms to achieve a level of proficiency similar to native speakers:violations elicited both an early anterior negativity and a posterior positivity (P600) in the monolingual group, but only a P600 in the bilingual group (Pakulak & Neville, 2011).These results were supported by findings from a fMRI study using the same paradigm (Pakulak & Neville, 2009).Here we continue this investigation by using ERP and fMRI data gathered from the same participants:two groups of native German speakers who began acquiring English between 11-13 years of age and who vary in second language proficiency.In the ERP paradigm, syntactic violations elicited a significant P600 effect in both groups, suggesting that the recruitment of more controlled processes is less sensitive to proficiency differences.In the higher proficiency group violations also elicited a significant bilateral negativity over anterior sites that was maximal over right hemisphere medial sites.Consistent with some previous ERP evidence (e.g., Weber-Fox & Neville, 1996), these findings suggest that some neural resources indexed by anterior negativity effects may be recruited by late learners with increases in proficiency.However, distributional differences suggest that these resources may differ from those recruited by native speakers. This is supported by data from the fMRI paradigm:while only in the higher proficiency group did violations elicit activation in left inferior frontal gyrus (LIFG), this activation was more anterior than LIFG activation to the same violations in a group of native speakers matched for proficiency with the higher proficiency late learners.Future studies examining late learner groups with wider ranges of second language proficiency will shed further light on the relative contributions of AOA and proficiency to neural processes supporting language.

D23 Multi-Voxel Pattern Analysis of Noun and Verb Differences in Visual and Ventral Temporal Cortex

Boylan, C. *(1),* ***Trueswell, J.*** *(1),* ***Thompson-Schill, S. L.*** *(1); 1. University of Pennsylvania, Philadelphia* – Recent evidence suggests that a probabilistic relationship exists between the phonological/orthographic form of a word and its lexical-syntactic category (specifically in nouns vs. verbs) [1]. Moreover, this so-called form typicality of a word with respect to its syntactic category has been found to modulate the M100 visual response in MEG [2]. Dikker et al. (2010) hypothesized that predictions about upcoming lexical-syntactic categories (nouns vs. verbs) give rise to form-based estimates in visual cortex even as early as primary visual cortex (V1).We tested this hypothesis by conducting multi-voxel pattern analysis (MVPA) over V1 and left ventral temporal (VT) cortex (including the so-called "visual word form area") when subjects were predicting, but crucially not viewing, nouns and verbs. This allowed us to investigate prediction effects in these two ROIs without any bottom-up orthographic input. We used the brain data to classify the prediction of nouns vs. verbs in both sentence and non-sentence contexts. In our first experiment, subjects (n=4) viewed sentences with low lexical cloze probability but high selectivity for either noun or verb completions (48 of each, where sentence completions were normed over 75 participants in a separate web-based study). Instead of seeing the sentence-final word immediately, subjects would search for an appropriate sentence completion in a series of noisy images and indicate when an appropriate word was discernable. In a second experiment, subjects (n=4) were presented with lexical-syntactic category cues (i.e. "Noun" or "Verb") instead of sentences and were also cued for particular noun-typical nouns and verb-typical verbs for search in noise. Analyzing only those volumes collected when subjects predicted a word but saw pure noise, we implemented a simple neural network with an input layer consisting of the best 200 voxels in each ROI [3]. This was trained on three runs, using a conjugate gradient descent backpropagation algorithm [4], and tested on a fourth run in a leave-one-out 4-fold cross-validation procedure. Within-subject classifiers were sought for sentence-context noun-vs.-verb prediction (experiment 1), category-cued noun-vs.-verb prediction (experiment 2), and individual form-typical word prediction (experiment 2). Mean classification performance of nouns vs. verbs in sentence contexts (experiment 1) was significant for all subjects in VT (mean: 61%, chance = 50%) and for one subject in V1.Mean classification performance of non-sentence, lexical category-cued predictions (experiment 2) was significantly above chance in VT in two out of four subjects, but not in V1. Finally, the individual word classifier (experiment 2) consistently predicted the correct token more often than an incorrect token in both V1 and VT, and, moreover, in VT, a given noun was more often confused with another noun than with a verb, and vice versa. The sentence-context prediction results suggest that syntactic cues are sufficient to drive top-down predictions of word form features in VT, and possibly also in V1 of some subjects. Furthermore, the within-category confUSbility in VT of the individual word predictions, for which lexical category was not necessary to predict the cued word form, suggests that retrieval of lexical category information may be automatic during word prediction. References. 1.Farmer, T. A., Christiansen, M. H., and Monaghan, P., 2006. Phonological typicality influences on-line sentence comprehension. Proc Natl Acad Sci US 10332, 12203-12208. 2.Dikker, S., Rabagliati, H., Farmer, T. A., & Pylkkänen, L., 2010. Early occipital sensitivity to syntactic category is based on form typicality. Psychological Science 1;215, 629-34. 3.McDuff, S.G.R., Frankel, H.C., Norman, K.A. 2009. Multivoxel Pattern Analysis Reveals Increased Memory Targeting and Reduced Use of Retrieved Details during Single-Agenda Source Monitoring. Journal of Neuroscience 292: 508-516. 4.Polyn, S.M., Natu, V.S., Cohen, J.D., Norman, K.A., 2005. Category-specific cortical activity precedes retrieval during memory search. Science 310:1963–1966.

D24 Interactions between verb subcategorization and syntactic priming: Evidence from self-paced reading and event-related potentials ***Brothers, T.*** *(1),* ***Ledoux, K.*** *(1),* ***Gordon, B.*** *(1); 1. The Johns Hopkins Medical Institutions* – Previous studies have shown that the repetition of syntactic structure across prime and target sentences can improve comprehension of targets relative to primes. This syntactic priming effect is much more robust when the main verb is also repeated between prime and target sentences, a phenomenon known as the lexical "boost". In the present study, syntactic priming effects in sentence comprehension were investigated using both self-paced reading and event related potentials (ERP). Sentences with difficult, reduced relative (RR) clauses were presented in prime-target pairs, with the same verb repeated across prime and target.A corpus analysis of verb subcategorization information was used to identify verbs that either highly predicted the upcoming RR clause ("The woman burdened by her parents…") or poorly predicted an upcoming RR ("The soldier pleaded by his wife…"). Across two experiments, garden path effects (as indexed by longer reading times and larger P600 amplitudes) were smaller in sentences containing high relative clause frequency (HRCF) verbs. These results replicate the finding that verb subcategorization information can be immediately accessed to aid in sentence comprehension. Additionally, syntactic priming effects differed between the two verb groups.In the first experiment, self-paced reading times were reduced in target sentences relative to prime sentences, but only when the pair contained a low relative clause frequency (LRCF) verb. In the ERP experiment, syntactic priming resulted in reduced P600 amplitudes to target sentences, but, again, only for LRCF verbs that poorly predicted the upcoming garden path. These results suggest that the lexical boost to syntactic priming may occur via the statistical updating of verb subcategorization information. According to this theory, exposure to a syntactic prime sentence can immediately shift a verb's subcategorization preferences, and this newly updated information can then be accessed to aid comprehension of the target. This theory differs from other proposed explanations for syntactic priming in that it incorporates both implicit learning mechanisms and the importance of verb subcategorization frames.

D25 Probabilistic cues to grammatical category representations in the human brain ***Arciuli, J.*** *(1),* ***Moseley, E.*** *(2),* ***McMahon, K.*** *(3),* ***de Zubicaray, G****. (3); 1. The University of Sydney, Sydney, Australia; 2 The University of Washington, St Louis; 3 The University of Queensland, Brisbane, Australia* – All languages possess morpho-syntactic cues to grammatical class (e.g., via syntactic constraints of word order, use of inflections, etc). There is emerging evidence that there are also probabilistic orthographic cues that distinguish nouns from verbs operating at the level of the single word (e.g., Arciuli & Monaghan, 2009). Importantly, these cues derive from segmentation processes that are blind to morphology. Moreover, they operate independently of pragmatic/semantic distinctions that have been the major focus of neuroscience-oriented research into grammatical category distinctions (e.g., action versus object words; Crepaldi, Berlingeri, Paulesu, & Luzzatti, 2011). The present study investigated these probabilistic cues to grammatical category at the beginnings and endings of multisyllabic words previously identified by a large-scale corpus analysis using both behavioural methods and functional magnetic resonance imaging (fMRI). Participants performed a simple lexical decision task on pseudorandomized lists of nouns and verbs comprising consistent or inconsistent beginning or ending cues juxtaposed with nonwords. Results revealed a main effect for ending cues in reaction times (RTs) associated with differential left premotor cortex activity. A three-way interaction (grammatical class x beginning consistency x ending consistency) was found both for error rates and activity in the left anterior insula/frontal operculum, posterior insula, and supramarginal gyrus, and in the right posterior superior temporal gyrus. The results suggest that probabilistic cues to grammatical class do operate at the single-word level, and that processing of these cues is associated with differential activity in brain regions known to mediate articulatory-motor representations in speech production. This may be consistent with proposals that comprehension is accomplished via predictive mechanisms that use the speech production system (e.g., Pickering & Garrod, 2007). References: Arciuli, J. & Monaghan, P. (2009). Probabilistic cues to grammatical category in English orthography and their influence during reading. Scientific Studies of Reading, 13, 73-93. Crepaldi, D., Berlingeri, M., Paulesu, E., & Luzzatti, C. (2011). A place for nouns and a place for verbs? A critical review of neurocognitive data on grammatical-class effects. Brain & Language, 116, 33-34. Pickering, M.J., & Garrod, S. (2007). Do people use language production to make predictions during comprehension? Trends in Cognitive Sciences, 11, 105-110.

D26 Time frequency analysis of null arguments and anaphoric violations ***Pierce, L.J.****(1),* ***Oshima-Takane, Y****.(1),* ***Kanayama, N****.(2),* ***Nakano, H****.(3),* ***Genesee, F****.(1); 1. McGill University, Department of Psychology, Montreal, QC, Canada, 2. The University of Tokyo, Graduate School of Arts and Sciences, Tokyo, Japan, 3. Saint Mary's University, Department of Psychology, Moraga, California, US* – The present study examines frequency band activity in the brain to different types of violations in English: the omission of direct object arguments in sentences (syntactic violation) and the repetition of lexical items in place of expected pronouns (anaphoric violation). Previous research using event-related potentials (ERPs) has demonstrated that object omissions, but not repeated lexical items, elicit an early and prolonged omitted stimulus potential (OSP) (Nakano et al., submitted). This was proposed to reflect both the detection of a syntactic disruption (P300 response), as well as more complex structural reanalysis (P600 response). One way to better determine the processes underlying this component, as well as to examine subtle differences between violation types, is to examine correlates in the frequency domain. For example, frequency analysis has been used to show that frequency band activity

underlying the P300 component differs depending on whether a stimulus (e.g., tone) is omitted or deviant (Ba ar-Eroglu et al., 1992). In this study delta and theta activity, reflecting decision-making and surprise, were observed 0-250 ms following stimulus omission. In contrast, deviant stimuli elicited later and prolonged (250-500 ms) theta activity, reflecting signal detection and attentional processes. In more complex linguistic stimuli object omissions and anaphoric violations may also show these subtle distinctions. Furthermore, frequency analysis may be used to better understand the processes underlying the complex OSP component. To examine this, electroencephalogram (EEG) activity was recorded while English monolingual participants (n = 18) listened to 66 pairs of context sentences, e.g., "The apples on the tree are ripe now," followed by a response sentence with or without a violation. Response sentences ended with either a pronoun, e.g., "Maybe we should pick them" (control condition), a repetition of the lexical item "Maybe we should pick the apples" (anaphoric violation), or an omitted argument, e.g., "Maybe we should pick ∅" (object omission). Delta (0-4 Hz), theta (4-7 Hz) and alpha (8-12 Hz) frequency bands were analyzed for all electrode sites in early (0-200 ms), mid (200-500 ms), and late (500-800ms) time windows. At 0-200 ms omissions (compared to the other conditions), elicited increased delta activity across electrodes, increased theta activity at posterior sites, and increased alpha activity at right frontal sites (all $p < 0.05$). At 200-500 ms both omissions and anaphoric violations elicited increased theta at right frontal and posterior sites, which remained through 500-800 ms (all $p < 0.05$). Increased alpha at frontal sites was also evident for omissions at 500-800 ms ($p < 0.05$). The present study showed that (a) frequency activity differs between omissions and anaphoric violations in complex linguistic stimuli, and (b) object omissions elicited activity similar to that observed to perceptual omissions (i.e., tones), but with some differences. Namely, omissions elicited prolonged theta as well as increased alpha activity. Processing of linguistic omissions thus reflects more than just omission detection. Theta and alpha are both associated with attention and memory processes (e.g., Klimesch et al, 1993), thus reflecting the reanalysis aspect of the OSP component.

CONCEPTUAL/SEMANTIC/DISCOURSE PROCESSING

D27 Neural correlates of sentence comprehension in adolescents ***Stewart R. A.*** *(1),* ***Pisupati A.S.*** *(2),* ***Davis N.*** *(2),* ***Rosenberg L.*** *(1),* ***Young K.M.*** *(1),* ***Ryan M.*** *(1),* ***Pekar J.*** *(1),* ***Rimrodt S. L.*** *(2),* ***Cutting L. E.*** *(1,2); 1. Kennedy Krieger Institute, Baltimore, MD; 2. Vanderbilt University, Nashville, TN* – Previous studies have provided insights into the functional neurobiology of word recognition in adolescents; however, fewer studies have focused on neural correlates of sentence comprehension in adolescents. Differentiating between these processes is particularly important in adolescents at or near the developmental stage where focus shifts from learning to read (identification and recognition) to reading to learn (comprehension). This study focused on examining activation patterns underlying sentence comprehension versus word recognition in these readers, while also investigating activation effects of specific aspects of sentence comprehension (syntax versus semantics). Thirty-one typically developing readers (14F, 17M, ages 9-14) completed an fMRI reading task.Two types of experimental stimuli were used. The first type included sentences that were three, five, or seven words long, presented one word at a time; sentences were classified as meaningful (containing no errors) or nonmeaningful sentences (containing either syntactic or semantic errors). The second type included lists of words and pseudowords, with three, five, or seven items per list. Participants viewed each stimulus in its entirety and decided, via button response, if any errors (for sentences) or pseudowords (for word lists) were present.Participants included in analyses completed 4-6 full runs (30 stimuli presentations per run) with at least 65% accuracy. Data were analyzed using SPM5, with group models obtained for each stimulus type (words; meaningful sentences; semantic error sentences; syntactic error sentences). As shown in Figure 1, comparison of meaningful sentence and word list stimuli included prominent increased activation for sentence stimuli in left middle temporal gyrus (MTG). Increased activation for word stimuli was observed in a variety of areas, including left inferior parietal, superior parietal and fusiform gyri, consistent with previous findings implicating these areas in visual word recognition processes. Compared to word lists, increased activation for sentences with semantic errors was observed in left middle and superior temporal gyri; no prominent areas of activation were observed in the syntactic error sentences as compared to word lists. This study examined the role of word and sentence-level processing in older children.While previous studies demonstrated that word and sentence level processing show overlapping networks, this study examines not only overlapping networks, but also those uniquely associated with each type of processing; examination of this issue in children is particularly salient to understanding developmentally relevant areas required for sentence processing that are not required of word level processing, and vice versa. Areas of activation specific to words were largely in fusiform regions, while those specific to sentences were in left MTG. These results align with previous findings, which have revealed that sentences place more demands on left MTG than isolated words do.The distinct fusiform activation for words is consistent with findings showing that this area is particularly tuned for recognizing words. Additionally, semantic processing (tapped by sentences with semantic anomalies) showed almost identical overlapping areas to those associated with processing meaningful sentences.Together these findings suggest a more central role of semantics in comprehension for readers as the focus changes to emphasize comprehension over word recognition.

D28 Constructing conversation: fMRI intersubject correlations during communication ***Menenti, L.*** *(1),* ***Garrod, S.C.*** *(1); 1. University of Glasgow, Institute for Neuroscience*

and Psychology, Glasgow, United Kingdom – Conversation partners develop common ground to understand each other. This may depend on common brain activation patterns and these patterns may differ depending on the content of the conversation. In this study we investigated whether spoken communication about a spatial layout would a) elicit common brain activation patterns in speakers and listeners and b) would do so in areas specifically involved in spatial processing. Six speakers were recorded in the MRI scanner while describing two different maps of a zoo, a difficult and an easy one. Speakers memorized the map beforehand and described it from memory during a four minute scanning session. Twelve listeners were then scanned using fMRI while listening to these descriptions. Their task was to reconstruct the map of the zoo based on the description. We computed intersubject correlation maps for each condition compared to rest in two ways. In the listeners, we calculated for each voxel for each participant the correlation with the mean of the two other listeners who heard the same description. In preliminary analyses, we first computed voxel-by-voxel correlations between each pair of listeners hearing the same description. We then calculated paired-sample T-values over the whole group by comparing each subject's correlation map during the description and during rest and conducted randomization tests by permuting the assignment of runs to conditions. This allows finding common patterns of correlations across completely different time series. We found significant correlations in both the easy and difficult conditions in bilateral auditory areas and in bilateral superior parietal lobule (BA 7). The latter were more extensive in the difficult than easy condition. Synchronization in auditory cortex for auditory stimuli has previously been found (Stephens et al., 2010). BA 7 is known to be involved in spatial imagery. By showing that this area is doing the same thing at the same time in different listeners listening to the same spatial description, and that this holds across different descriptions, we show that the content of a conversation leads to modality specific representations in relevant brain areas in real time. Stephens GJ, Silbert LJ, Hasson U (2010) Speaker-listener neural coupling underlies successful communication. Proceedings of the National Academy of Sciences of the United States of America 107:14425-14430.

D29 Functional community structure for discourse comprehension and gesture processing ***Andric, M.*** *(1),* ***Small, S.L****. (1,2); 1. The University of Chicago, IL; 2. University of California, Irvine, CA* – **Objective:** During face-to-face conversation we concurrently take in numerous information sources that register at multiple levels. For example, embedded in a surrounding visual context, we might perceive a speaker, his or her auditory verbal message, and the gestures that accompany what s/he says. As a highly connected system, the brain manages all of this information interactively to enable successful communication. However, the functional systems that achieve this are not well documented by typical fMRI results that focus narrowly on isolated spatial locations emphasizing feature-specific responses. Here, we ask whether certain brain areas respond in a similar way when people perceive natural discourse that allows them to be described as functional communities (Kaiser, et al. 2010; Meunier, et al. 2009). In this study, we examine how the brain's functional connectivity may be organized into densely connected sub-systems, i.e., how brain areas are organized functionally into interactive parts. METHODS We showed 18 people videos of a woman talking about various topics like how to drive a car and how a piano differs from a violin. These videos were 57 s to 2 m 46 s long. During the videos we recorded fMRI BOLD signals across the whole brain (34 slices; TR=1500 ms). We correlated all fMRI time series collected during video presentation (i.e., every voxel with every other voxel). From this, we created a binary adjacency matrix where a correlation (r) between voxel pairs was marked as 1 if r ≥ 0.25 or 0 if r < 0.25. We then partitioned the brain into functional subunits, or communities, given by the strength of their modularity, that is, the density of links inside a community compared to links between communities (Blondel, et al. 2008; Newman and Girvan 2004). To examine how brain activity related to these functional communities we built two general linear models. One assessed brain activity for discourse comprehension, and the other activity for gesture processing. RESULTS We found that brain function during audiovisual discourse comprehension partitioned into four principal communities (Figure 1): 1) Visual; 2) Default Mode; 3) Parieto-premotor; and 4) Temporo-frontal. To see how brain activity in processing an audiovisual discourse related to these communities we then generated maps for discourse comprehension and gesture processing. We found that whereas the Temporo-frontal community captured brain activity for discourse comprehension, the Parieto-premotor community encapsulated brain activity for gesture processing. CONCLUSIONS We used a data-driven approach to show that brain function during audiovisual discourse comprehension has a characteristic community structure. In doing so, we identified densely connected sub-systems that captured the functional anatomy involved in audiovisual discourse and gesture processing in a way that relates the brain's connectivity to task-related impulse responses. Thus, we were able to associate particular comprehension processes to communities identified in other contexts (Meunier, et al. 2009), and to subdivide previously identified task-related functional systems (Golland, et al. 2008).

D30 The Use of Implicit Measures to Assess Receptive Vocabulary Knowledge in Individuals with Autism ***Gangopadhyay, I.*** *(1)* ***Ledoux, K.*** *(1)* ***Bosley, L.*** *(1)* ***Gordon, B.*** *(1); 1. The Johns Hopkins University School of Medicine, Baltimore, MD* – **Introduction:** An important question about nonverbal individuals with autism is whether their lack of expressive ability is necessarily accompanied by an equally severe deficit in receptive language.Little research has addressed this question because of the difficulty of testing low-functioning participants and the insensitivity of most behavioral methodologies.We have previously used eye movements (EMs), pupillary dilation (PD), and event-related potentials (ERPs) as measures of receptive vocabulary knowledge in normal adults, in whom self-report and behavioral

accuracy served as measures of comparison.Here, we use the same measures to assess receptive vocabulary knowledge in low-functioning individuals with autism, and in two control groups: normally developing children and high-functioning individuals with autism. Methods: The group of normally developing children included 20 participants (ages 5-17).Participants with autism included three lower-functioning, low-verbal males (ages 17-23) and four higher-functioning, verbal males (ages 8-29).For the lower-functioning participants, caregivers completed checklists used to determine words expected to be known receptively by the participants; unknown stimuli were drawn from a pool of items developed for other subject populations.Participants completed a) a forced choice recognition task (EM and PD), where four pictures were presented on a computer screen, along with an auditory token that named one of the pictured objects; and b) a congruity task (ERP), where single pictures were shown on the computer screen, accompanied by an auditory token that did or did not match the name of the pictured item. Results: Normal children showed a pattern of results similar to that observed previously for normal adults: EMs were faster for pictures that matched the auditory word, but only for known words. End-of-trial fixations were on the named picture more frequently for known words.PD from baseline was greater in the unknown condition.Additionally, an N400 congruency effect was observed for known words, but not for unknown words. The results for participants with autism showed greater individual variability.The low-functioning individuals with autism showed results on at least one of the three measures that were similar to the normal adults and the normally developing children.The EM and PD results of the higher-functioning individuals with autism also looked similar to those of the normal adults and normal children.However, for the ERPs, the difference between the congruent and incongruent known conditions was much smaller than that seen for normal adults or normally developing children, if it was observed at all.There was a large difference between the waveforms to known and unknown words, however. Conclusions: The three measures (EM, PD, ERP) differentiated known from unknown words, but in potentially different ways for the three different participant groups.Differences among the high- and low-functioning autism participants may reflect different developmental language trajectories among these participants.Importantly, our implicit measures may prove to be useful measures of single-word comprehension in otherwise "nonverbal," low-functioning individuals with autism, a group whose language abilities have been difficult to assess.

D31 The differentiation of semantic categories during acquisition of novel words ***Fargier, R.*** *(1),* ***Ploux, S.*** *(1),* ***Paulignan, Y.*** *(1),* ***Reboul, A.*** *(1) and* ***Nazir, T.A.*** *(1); 1. UCBL-CNRS FRE 3406, Institut des Sciences Cognitives, Bron, France* – Recent evidence supports the idea that concepts' coding and generation require the joint operation of modality-specific brain regions. This distributed view of conceptual representation is thought to reflect the sensory-motor experiences through which concepts are acquired. Current debate focus on the existence of an abstract hub that link the different modality-specific brain regions to form the semantic categories. Clarifying the dynamics of the acquisition of novel concepts would help advancing this issue. To this end, we designed an associative learning task and monitored the emergence of different semantic categories. Participants were trained during two consecutive days to associate novel verbal stimuli to either object-directed hand/arm movements (movement category) or visual animated images (image category). The arbitrary associations "verbal stimuli – movement" and "verbal stimuli – visual object" were counterbalanced between subjects. The participants' task was first to listen to the verbal stimuli alone (in a pretest session) and then to learn both types of associations in a training session. Finally, they had to listen again to the verbal stimuli alone shortly after the training session (1st test session) as well as after a night of sleep (2nd test session). Correlations between participants (according to the semantic categories) were made using a computational method, the correspondence factor analysis (CFA). Applied on ERPs-segments, the CFA determines factors that contribute to the largest variance between the conditions tested. The results obtained with the CFA consist of the identification of regions of interest (electrodes but also temporal intervals) that explain the organization of the data through a system of orthogonal axes. We found that while prior to learning correlations of ERPs-segments did not distinguish the semantic categories, at the 1st test session a clear dissociation appeared between verbal stimuli that were associated during training to movements from those associated to visual objects. The dissociation between the two categories became even stronger at the 2nd test session. Moreover, the CFA indicated that the movement-category was captured by centro-parietal electrodes (commonly associated with movement processing) whereas the image-category was captured by parieto-occipital sites (typically involved in visual processing). Coherent with previous research that showed dissociation between real noun and action verb processing as early as 200 ms post word onset, the present differences were observed 200-300 ms following word display. Our results show that after learning, word meaning guided the correlation in the ERPs-segments. In line with the embodied cognition framework, word meaning seems to be grounded in sensory-motor experiences. Through the learning-dependent differentiation of these semantic categories, our data further support the distributed view of conceptual representation. Moreover, we show that correspondence factor analysis provides an interesting tool to identify the contribution of various factors in ERP data.

D32 Body Part Representations in Action Verb Processing and Naming: What Happens in Aphasia? ***Faroqi-Shah, Y*** *(1); 1. University of Maryland* – There is growing psycholinguistic and neuroimaging evidence that the cortical systems for language and action interact. That is, motor representations are accessed during semantic processing of action words and words referring to manipulable objects (Pulvermuller, 2005; Tettamanti et al., 2005). For example,

fMRI studies found that while processing action verbs such as lick, kick, and pick activate the mouth, leg, and hand regions of the motor cortex respectively. The present series of four experiments extended this research on embodied semantics by investigating the following: 1) Does processing of an action verb influence subsequent processing of another somatotopically related (i.e. same body part) action verb (due to lateral inhibition of overlapping somatotopic neural networks)? 2) Does this pattern differ in aphasic individuals with a severe verb naming impairment? 3) Is there an effect of somatotopy in naming of action verbs in persons with and without aphasia? To our knowledge, no published study has addressed any of these questions. Methods. Eighty right-handed native English speakers (Mean age for Experiments 1,2,3: 19.7years; Mean age for Experiment4: 59.6years) and six aphasic individuals with a verb naming deficit (Mean age: 60.4years) participated. All aphasic participants had a left hemisphere stroke, nonfluent agrammatic speech with Broca's aphasia and demonstrated greater deficit in verb compared to noun naming (33.3% versus 80.1% accuracy). Experiments 1-3 investigated verb processing using a speeded visual lexical decision. Stimuli were each with arm/hand, face/mouth or leg involvement (total=68) matched for psychometric properties and bodypart association ratings. In Experiments 1 & 2, verbs were presented in the following prime-target conditions: 1 Baseline (xxxx[prime]>>kissing[target]), 2 congruent body part (licking>>kissing), 3 incongruent body part (clapping>>kissing), 4 pseudoword fillers (crawling>>ziring). The stimulus onset asynchrony between prime and target was 200 and 700ms respectively in Experiments 1 and 2. Experiment 3, the primes were bodypart drawings used in the above four conditions (SOA=200ms). Experiment 4 investigated speeded action verb naming of videos. Results & Discussion. Due to the 500word limit, statistical values are provided only for Experiment1 in cases where the findings were consistent across experiments1-3. Aphasic participants were significantly less accurate and slower than unimpaired participants (Experiment1: 92.3% vs. 98.6%; Mean(SD)=1386(507) vs. 813(281) milliseconds; Experiment4: 25.5% vs 87.2%; $t(20)<.05$). For reaction time data, ANOVA revealed main effects of group and condition in all four experiments (Experiment 1: $F[1,18]=23.4$, $p<0.000$; $F[3,46]=13.4$, $p<0.000$). Lexical decision RTs were slower for congruent compared to baseline (Unimpaired $t(18)=36.5$, $p<0.000$; Aphasic $t(5)= 4.7$, $p<0.01$) and incongruent conditions (Unimpaired $t(18)=20.1$, $p<0.00$; Aphasic $t(5)= 15.7$, $p<0.000$) only for Experiments 1 & 2. In verb naming, there was a main effect of group and bodypart type ($F[2,60] =14.68$;$p < 0.001$) with RTs for face verbs significantly faster than RTs for leg and hand/arm verbs ($p < 0.001$). In summary, we found 1) interference in successive processing of verbs (but not pictures) with overlap in bodyparts (smaller interference in longer SOA). The failure of interference effects with bodypart pictures and greater interference with congruent somatotopic verb primes at shorter SOA favors the view that actions are mentally simulated when verbs are processed (Bergen et al., 2010), not just their body part representations are activated (Pulvermuller, 2005). 2) Individuals with aphasia show the same interference pattern, suggesting that bodypart representations ARE processed by these individuals, although with lower accuracy/speed. Hence inadequate activation of bodypart representations may not underlie their verb naming deficit. 3) face verbs are named faster than other verbs, consistent with prior somatotopic data on verb processing (Pulvermuller, 2005). This final finding is the first to show somatotopic influences in language production (at least to our knowledge) and suggest that the same action representations may be activated for production as for processing of action verbs. These findings have implications for our understanding of language processing theories (embodied semantics, situated cognition, etc.) and our understanding of neural impairments in individuals with left hemisphere damage.

D33 The influence of written distractor words on brain activity during overt picture naming ***Michele T. Diaz*** *(1),* ***Larson J. Hogstrom*** *(1); 1. Duke Institute for Brain Sciences* – **Objective.** Language production requires multiple stages of processing and each of which may recruit distinct cortical regions. For example, picture naming requires visual object recognition, semantic retrieval, lexical selection, phonological retrieval, and articulation. Written distractors can be combined with picture naming to examine factors that influence language production. Picture-word interference generally occurs when a written distractor is categorically related to the target image, while phonologically related distractors have been found to speed picture naming. Although picture naming has been extensively examined with behavioral measures, only a limited number of experiments examined the brain regions that support overt language production. Our objective was to examine how various types of distractors influence brain activation. We included four categories of distractors: words from the same semantic category, words that were a part of the object to be named, words that began with the same sound, and unrelated words. We hypothesized that semantically-related distractors would produce interference, while phonologically-related words would produce facilitation. Previous behavioral research suggested thatwords with a part-whole relationship may produce facilitation, but this has not been previously investigated with fMRI. Methods. Sixteen, right-handed, native English speaking, young adults participated in this event-related fMRI study. Participants were asked to name a line drawing while ignoring a distractor word that was superimposed on the image (SOA = 0ms). Written distracters were categorically related to the target, in a part-whole relationship with the target, phonologically related to the target, or unrelated to the target. Continuous MRI scanning was completed on a 3.0 Tesla GE scanner with an eight-channel head coil. We collected high-resolution structural images and inverse-spiral functional images. FSL was used to for preprocessing and statistical analyses. All activations were cluster corrected ($p<.01$). Response times (RTs) and accuracies were collected during the

fMRI session via an MR-compatible microphone. Results. RT analyses showed a significant main effect of distractor type ($F(3, 56) = 31.76$, $p < .0001$). Relative to unrelated words, pairwise comparisons revealed that categorically-related distractors were named significantly slower, part-whole distractors were named significantly faster, and phonologically-related words were not statistically different from unrelated words. All naming conditions showed bilateral activation in traditional language regions including superior and middle temporal gyri and inferior frontal gyrus. The part-whole condition revealed less activation than the unrelated condition in bilateral cuneus and precuneus. Despite significant behavioral effects, the categorically-related condition showed no significant fMRI differences compared to the unrelated condition. The phonologically-related condition showed greater activation than the unrelated condition in bilateral angular and supramarginal gyri and subcortical regions including bilateral caudate. Conclusions. Behavioral and fMRI measures for the part-whole condition suggest facilitation. Moreover the location of the fMRI effect suggests that this facilitation may have a perceptual basis. The additional recruitment of bilateral parietal cortex in the phonological condition is consistent with previous research that has implicated these regions more generally in phonological processing. Overall, our general finding of bilateral activation during picture naming also emphasizes the importance of the right hemisphere in overt language production.

D34 When the leash constrains the dog: Neural correlates of associative interference during sentence production ***Sass, K.*** *(1,3),* ***Muehlhaus, J.*** *(1,3),* ***Habel, U.*** *(1,3),* ***Heim, S.*** *(1,2,3); 1. RWTH Aachen University, Aachen, Germany; 2. Jülich, Institute of Neurosciences and Medicine (INM-1), Jülich, Germany; 3. JARA - Translational Brain Medicine* – The production of language is one of the most complex and most amazing skills in humans. However, the neural basis and processes behind speech production are still a matter of debate - especially regarding the comparison of different types of utterance formats. Moreover, increasing evidence demonstrates that two types of semantic relations play an important role during conceptual processing and lexical access: categories and associations. While the first were extensively investigated, associations gain more and more attention as it has been shown that both relations play complementary roles in concept formation and that is mandatory to distinguish between them when cognitive processes are investigated. However, during speech production the effects and processing of associations are highly debated. Hence, with the current study we had the aim to investigate the neural correlates of single word and sentences influenced by associations. A classical picture word interference task was used to investigate single word production during fMRI measurement with 18 native German speakers. For sentence production, an adapted version of the picture-word interference task was used. 16 new subjects were asked to formulate a sentence with a fixed structure in response to two target pictures (e.g., "the car is to the left of the trousers") while ignoring a distractor word that was either unrelated or related to the first (motor) or second noun (belt) of the sentence (see also Sass et al., 2010). For single word production, speech latencies revealed facilitation for associations on a behavioral level. On a neural level, enhanced activation for related over unrelated in mainly left fronto-temporo-parietal regions (incl. IFG, MTG, IPC) were found. The opposite contrast (unrelated > related) revealed signal changes in the left anterior cingulate cortex, the caudate nucleus and bilateral occipital regions. For sentence production, the first behavioral data indicated a shifted effect, i.e., interference. The preliminary fMRI data highlighted neural activation of bilateral inferior parietal (for the second noun: related > unrelated) and left fronto-temporal regions (for the first noun: unrelated > related). The results showed that associations are active during speech production. During single word production, they lead to facilitation that might be caused by an automatic spread of activation between related concepts. On a neural level, the neural changes reflect perceptual as well as conceptual/lexical processing of the picture-distractor pairs. In contrast, for sentence production associatively related distractors induce interference for the first noun. Neurally, similar regions seem to be activated but sentences recruit more bilateral and widespread left-lateralized areas that might reflect more strategic semantic search and attention mechanisms. Hence, semantic associations lead (a) to facilitation at conceptual level during single word production and (b) to interference at lexical selection level during sentence production, i.e., the effect shifts from conceptual to lexical due to inclusion of context. Accordingly, these findings support the assumption of an associative influence at conceptual as well as at lexical level of speech production ("swinging lexical network"; Abdel Rahman and Melinger, 2009). References: Abdel Rahman, R., Melinger, A., 2009. Semantic context effects in language production: A swinging lexical network proposal and a review. Language and Cognitive Processes 24, 713-734. Sass, K., Heim, S., Theede, K., Sachs, O., Krach, S., Kircher, T., 2010. Why the leash constrains the dog: Investigating the impact of semantic associations and distractor modality on sentence production. Acta Neurobiologiae Experimentalis 70, 435-453.

D35 The many timings of semantic interference during word production ***Llorens, A.*** *(1,2),* ***Trébuchon-Da Fonseca, A.*** *(1),* ***Riès, S.*** *(2),* ***Alario F.-X.*** *(2)* ***Liègeois-Chauvel, C.*** *(1); 1. Aix-Marseille Université & INSERM UMR 751; 2. Aix-Marseille Université & CNRS* – **Objectives:** Production of oral language requires the selection of words to express ideas. In behavioral studies, a primary tool for investigating this so-called "lexical access process" is the blocked naming paradigm [1]. Participants are slower at producing words in semantically homogeneous blocks (vs. semantically heterogeneous blocks). Previous attempts at investigating the spatio-temporal brain dynamics underlying this task and effect have led to somewhat mixed conclusions [2; 3; 4]. Here we attempted to clarify this debate by performing advanced spatial processing of electro-encephalographic (EEG) data recorded during thisnaming paradigm. Methods. Twenty healthy native speakers named pictures in homogeneous blocks,

comprising items from a single semantic category (e.g. animals), or in heterogeneous blocks, comprising items from multiple semantic categories. The EEG data were spatially filtered using a Laplacian transformation to improve spatial (and hence temporal) resolution of the surface cortical activities under scrutiny. In addition, we analyzed the responses within a larger post-stimulus window than in previous studies (two seconds), hence providing a chance to observe late occurring effects. Results. Consistent with previous reports, naming latencies were significantly longer in homogeneous than in heterogeneous blocks. The homogeneity manipulation also affected the electrophysiological data. An effect was present around 250 ms post-stimulus in left posterior electrodes. It was also observed later, around 400 ms, this time over a larger part of posterior left hemisphere. Finally, and most importantly, the latest component of the effect was observed around 650 ms in the same posterior regions but also in anterior electrodes, bilaterally (see fig). Conclusions. The timing of the first two electrophysiological components are consistent with [2]. The third late component (~650 ms) has not been previously reported, to our knowledge. It could reflect word selection or response preparation processes critical for the production of spoken output. The timing of these three components can be compared to the timing estimates for processing stages derived by [5] on the basis of the LRM model of lexical access [6]. Firstly, 250 ms is thought to correspond to lexical access, presumably at the occipito-temporal junction. Secondly, 400 ms is linked to phonological processing; somewhat consistently, this component occurs in left temporo-parietal sites in our data. Finally, 650 ms is linked to verbal production (i.e. articulation). In this context, the late effect of homogeneity could seem unexpected. However, the involvement of bilateral frontal sites in our data suggests that this component may reflect functionally earlier processes, such as variable degrees of conflict among alternative candidates [7] and variable degrees of inhibition of irrelevant responses [8]. Overall, the semantic homogeneity manipulation may not tap a single stage, but may rather percolate in a cascaded fashion through much of the language production system. [1] Damian et al., 2001, Cognition [2] Janseen et al., in press, Neuroimage [3] Maess et al., 2002, J Cogn Neurosci [4] Aristei et al., in press, J Cogn Neurosci [5] Indefrey & Levelt., 2004, Cognition [6] Levelt, et al., 1999, Behav Brain Sci [7] Schnur et al., 2009, PNAS [8] Xue et al., 2008, Cereb Cortex

D36 Towards the Unification of the N400 in Lexical Access and in Sentence Processing ***Gomes, J. N.*** *(1),* ***Soto, M.*** *(1),* ***França, A. I.*** *(1),* ***Gesualdi, A. R.*** *(2); 1. Federal University of Rio de Janeiro, UFRJ; 2. Federal Center of Technology of Rio de Janeiro, CEFET-Rio* – ERP Studies first appeared in linguistics with the N400, a negative wave whose amplitude increased at 400ms after frustration of a linguistic expectation during processing: 'I prefer my coffee with socks'. Today, such neurophysiology studies are recognized as a crucial tool in tracking the architecture of language, revealing through precise theoretical hypotheses, a detailed chronology of the computations involved in lexical access and sentence processing. Prime-target studies of lexical access often relate it to two factors: (i) lexical frequency, or (ii) phonological similarity versus morphological identity: spin-spinach versus spin-spinning. In contrast, processing studies propose that the N400 is a measure of syntactic integration, since even for words out of syntactic context there would be a spontaneous underlying structural configuration. Our goal was to reevaluate these two hypotheses - lexical predictability or syntactic structure - through a design, which maintains the same target in five conditions presented randomly while volunteers were monitored by an EEG: (i) prime and target related by the same semantic field (nose-ear); (ii) prime and target that can easily be put together in a phrase (earring-ear; earring for the ear); (iii) high-predictability of word in sentence (I went to the pharmacy to pierce my ear); (iv) low predictability of word in sentence (I went to the hairdresser to dye my ear); and (v) unrelated prime and target (mat- ear). The N400 findings point to the unification of lexical and syntactic processes around the syntactic hypotheses.

D37 Eye Movements and the Temporal Unfolding of the SemRep Semantic Representation in Scene Description ***Lee, J.*** *(1),* ***Yang, B.*** *(1),* ***Arbib, M.*** *(1,2); 1. University of Southern California, CA; 2. USB Brain Project* – Arbib & Lee (2008) proposed a graph-like semantic structure, SemRep, as a spatially anchored semantic representation retrieved from the perceived visual scene so structured that it lays the groundwork for a computational model that produces verbal description by performing a type of a graph matching task. The current study presents time-locked eye movement and verbal data on the temporal unfolding of descriptions of visual scenes which test hypotheses on how SemRep is built from the perceived visual information and how it influences the choice of constructions for the produced utterances. More specifically, we hypothesize that the vision system interprets the scene in terms of subscenes. The notion of subscene is proposed as the executive window of attentional processes. A subscene is basically an area covered by entities of the scene under the current attentional focus, built up by various spanning processes from related elements of the scene. Subscenes can be organized and processed according to their conceptual hierarchy while attentional focus travels across the hierarchy by zooming in/out and shifting. SemRep is built or updated for the currently attended subscene. The language system, modeled by Template Construction Grammar (Arbib & Lee, 2008), assembles constructions from the SemRep and reads them out to produce utterances. We hypothesized that the strategy of attentional focus deployment and formation of a SemRep and utterances provides an integrative framework for apparently different strategies in which preparation of sentential structure and the preparation of each constituent are interleaved (e.g. Gleitman et al., 2007; the Perceptual Guidance view) or separated in an orderly fashion (e.g. Griffin & Bock, 2000; the Structural Guidance view). In order to test the hypothesis, an eye-tracking experiment was conducted with a total of 15 university students with native English proficiency. Tasks and scenes were

designed to induce subscenes with highly contrasting spanning coverage as scene descriptions, so as to provide parameterized criteria for analyzing the correlations between the organization of event components and the produced sentential structures,. The experiment consists of two types of tasks in which subjects describe the scene: subjects were asked either to describe a scene as quickly as possible (the quick case) or to describe the scene in well-formed and grammatically correct sentences (the form case). Also, we used natural scenes with roughly two types of event settings – e.g. scenes with explicit action-related events such as simple transitive actions and scenes with a complex event setting that presents implicit interactions among the entities. Supporting evidence for the hypothesis and implications of the findings are discussed.

D38 Simple Composition in Reading, Listening, and Production: An MEG Investigation ***Bemis, D.*** *(1),* ***Pylkkänen, L.*** *(1); 1. New York University, New York, NY* – One of the central goals in the cognitive neuroscience of language is to understand the relationship between the brain mechanisms recruited for auditory and visual comprehension on the one hand and comprehension and production on the other. Here we report the first ever investigation into the brain bases of basic linguistic combinatoric processing that uses the same paradigm across visual and auditory comprehension as well as production. Using a simple picture identification paradigm during an MEG recording, we isolated neural activity evoked by the construction of simple two word phrases (e.g. "red boat") during reading, listening, and production. We show that the left anterior temporal lobe (LATL), which has been hypothesized to reflect combinatorics on the basis of previous comprehension studies (e.g. [1], [2]), is equally recruited during composition in all of these tasks. In our comprehension study, subjects either read or heard descriptions of an object and were asked to judge whether a subsequent picture matched the preceding description. In the critical, combinatorial task, subjects were presented with a simple noun (e.g. "boat") preceded by either an unpronounceable consonant string (e.g. "xhl") (or pink noise in the auditory version) or a color adjective (e.g. "red"). They then determined whether a following colored shape matched the preceding linguistic items. In a separate list task, designed to control for the processing of multiple lexical items, the adjectives were replaced by length-matched nouns (e.g. "cup") and subjects had to determine if the following shape matched any preceding word. Evoked neural activity was then analyzed at the presentation of the matched nouns in each condition. In the production study, subjects named either colored shapes (e.g. "red boat") or shape outlines (e.g. "boat"). To control for the production of multiple lexical items, subjects also named color swatches containing two colors (e.g. "red, blue"). In this study, evoked neural activity preceding the vocal response was analyzed. A permutation, cluster-based ROI analysis (see [3]) on distributed source activity during the critical time periods showed significantly more activity in the LATL during the comprehension and production of simple noun phrases (e.g. "red boat") compared to controls. This result held for both comprehension modalities, with the auditory effect occurring both after and for a longer duration than the visual effect (c.f. [4]). Additional combinatorial effects were also seen in the angular gyrus during comprehension (c.f. [5]) and the ventro-medial prefrontal cortex during production (c.f. [6]) These results strongly suggest that the LATL plays a fundamental role in combining simple linguistic elements into more complex mental representations during both auditory and visual comprehension as well as production. We found significantly more activity in this region during the comprehension of both written and spoken phrases compared to lexically matched, non-combinatorial controls and during the production of simple phrases compared to phonologically and lexically matched list controls. Future work can now build on this basic set of findings in order to develop a more complete understanding of the different facets of combinatory processing during comprehension and production. [1] Mazoyer et al. (1993) JCN [2] Friederici et al. (2000) CC [3] Maris & Oostenveld (2007) JNM [4] Marinkovic et al. (2003) Neuron [5] Humphries et al. (2007) NeuroImage [6] Bemis & Pylkkänen (2011) JoN

D39 From words to emotion via body motion: a role for the motor system in binding abstract meaning ***Moseley, R. L.*** *(1),* ***Carota, F.*** *(1),* ***Hauk, O.*** *(1),* ***Mohr, B.*** *(1,2),* ***Pulvermüller, F.*** *(1); 1. MRC Cognition and Brain Sciences Unit, Cambridge, UK; 2. Anglia Ruskin University, Cambridge, UK* – Contemporary theories of semantics suggest that word meaning is embodied in the brain in the connections between word form circuits in language areas and perceptual object representations in the ventral stream. This view, however, fails to explain representation of abstract concepts, including emotion words such as "hope" or "loathing". Whilst their meaning relates to emotional brain systems in the limbic system, it is unclear how the link between an internal body state and a word form can be learnt. In one view, motor activities expressing emotion (e.g. scowling) are crucial for learning correspondences between emotional body states and word forms. This hypothesis predicts that emotion words activate brain systems for emotion-expressing body parts: the face and arm motor and premotor cortex in the dorsal stream. To test this hypothesis, we compared the brain activation evoked by emotion words to that brought about by face- and arm-related action words in a tachistoscopic silent reading task during fMRI scanning. Whilst control items (including a hashmark baseline and a comparison group of animal words) failed to activate precentral areas, significantly different topographies emerged for the three experimental word categories across the motor system ($F(28, 476) = 1.571$, ε = 0.808, $p < 0.05$). Semantic networks for emotion words were found to include classical limbic areas such as the cingulate, orbitofrontal cortex, insula and basal ganglia, and to overlap strongly with arm- and face-related words in activating effector-specific areas in motor and premotor cortex. A regions of interest analysis confirmed the somatotopic pattern reported in previous literature with

greater activity for arm words in dorsal motor system, greater activity for face words in ventral motor system, and comparable activity for emotion words in these same effector-specific motor sites alongside stronger emotion word than action word activity in prefrontal cortex. These results were confirmed for highly abstract emotion words with low imageability and without overt action connotations. We conclude that, similar to the role of actions in action verb processing, activation of frontocentral motor systems is the embodied manifestation of this link between visible emotional behaviour and abstract concepts and reflects the semantic binding of sign and meaning for abstract words denoting internal states. Actions expressing internal states bridge the gap between word and meaning for emotion words, thus supporting a theory of meaning acquisition whereby word meaning is learnt from contextual (action) use (Wittgenstein, 1953; Tomasello, 2005) and indicating substantial involvement of motor systems in language and meaning acquisition for both concrete AND abstract items.

D40 When concepts go quiet: A link between impaired knowledge of sound words and atrophy of auditory association cortex in logopenic progressive aphasia ***Bonner, M.F.*** *(1), and* ***Grossman, M.*** *(1); 1. University of Pennsylvania, Philadelphia* – Functional neuroimaging investigations of semantic memory suggest that the meanings of concrete words rely in part on feature representations in perceptual and motor association areas of cortex. However, given the correlational nature of these functional neuroimaging studies, it is important to look for corroborating evidence in studies of patients with cortical lesions. Such studies can determine whether these perceptual and motor association areas of cortex are necessary for representing word meanings. We tested this theory of concrete word semantics in patients with logopenic progressive aphasia (LPA), a neurodegenerative condition associated with superior temporal cortical atrophy affecting auditory association cortex. We hypothesized a semantic impairment in LPA patients for words with strongly associated auditory features. We predicted that the degree of this impairment would correlate with the degree of atrophy in auditory association cortex. An auditory lexical decision task was employed using words with strongly associated features in three modalities: Auditory (n=40), Motor (n=40) and Visual (n=40). LPA patients (n=10) were compared with healthy, age-matched controls (n=22). We examined cortical atrophy in LPA using voxel-based morphometry of structural MRI data and performed a regression analysis to look for correlations of cortical atrophy with impaired performance on auditory words (measured by subtracting auditory word accuracy from average accuracy on other word categories).We related this regression analysis to functionally defined auditory association cortex using data from an fMRI study of healthy participants processing complex, meaningless sounds. LPA had significantly lower accuracy than controls for Auditory words (LPA: M=91.0%, SD=9.3; controls: M=99.1%, SD=1.6; p<.001), but did not differ from controls on Motor (LPA: M=95.8%, SD=7.6; controls: M=98.9% SD=1.8) and Visual words (LPA: M=94.3%, SD=9.1; controls: M=98.3%, SD=3.7). Within LPA, Auditory word accuracy was impaired relative to Motor and Visual words (p<.05), but Motor words did not differ from Visual words, emphasizing the selective deficit for Auditory words in LPA. Structural MRI analyses revealed that LPA patients had cortical atrophy in temporal and parietal cortices affecting auditory association areas (see figure). A regression analysis demonstrated that relatively impaired performance for auditory words correlated with atrophy in a region of middle temporal gyrus, which was determined to be a part of functionally-defined auditory association cortex. We found a selective impairment in LPA for words with strongly associated auditory features. These patients have disease affecting auditory association areas in the superior temporal lobe, as demonstrated with structural MRI analysis. We found that LPA patients were impaired on Auditory words relative to healthy controls as well as in comparison to their own performance on other word categories. This selective impairment for auditory words correlated with atrophy in middle temporal gyrus, overlapping with functionally defined auditory association cortex. These results accord with the auditory short-term memory impairment and typical locus of disease in LPA. These results are also consistent with sensory-motor theories of semantic memory that are based largely on functional neuroimaging findings. Here we provide critical, converging evidence from a patient population that concrete word meanings rely in part on sensory-motor feature representations in modality-specific association cortices.

D41 The Pyramids and Palm Trees Test, the Kissing and Dancing Test, and tests on other semantic attributes: further evidence from the Chinese population ***Chenxi He*** *(1),* ***Qihao Guo*** *(2),* ***Xiaoliang Wen*** *(1),* ***Zaizhu Han*** *(1),* ***Yanchao Bi*** *(1); 1. Beijing Normal University, Beijing, China; 2. Huashan Hospital, State, Shanghai Medical College, Fudan University, Shanghai, China* – Accumulating research has shown that the semantic representation has a multi-dimensional structure including various types of knowledge. Popular semantic assessment batteries such as the Pyramids and Palm trees Test (PPT) and the Kissing and Dancing Test (KDT) were constructed along a subset of semantic dimensions such as the associative relationship. The purpose of the present study was to assess whether they provided comprehensive evaluation of the semantic knowledge, and to develop normative data for the Chinese adaptations of PPT, KDT and other semantic tests that probed different aspects of semantic knowledge. Due to the large cultural differences between China and western countries, we first adapted PPT and KDT by not only excluding culturally inappropriate items, but also adding items that were specifically suited to Chinese populations. Then we compared ninety-six Chinese-speaking healthy adults' performances on them to three other semantic tests. The new tests were constructed using the same structure to PPT/KDT except that the targets and responses were related by taxonomic (Object taxonomy matching, OTM),

functional (Object function matching, OFM), and manipulative (Object manipulation matching, OMM) similarities respectively, rather than object/action associative relationship along which PPT/KDT were constructed. To elucidate the response patterns across the different semantic tests, we carried out both correlation analyses and dissociation statistics. We observed significant correlations among all tests on the group level (rs' range: 0.28-0.76, all ps < .05). On the other hand, on the individual case level, there were ten cases showing various types of dissociations across the several tests, as evaluated by single dissociation detection method developed by Crawford and Garthwaite (2005; ps < .05). That is, participant who exhibits good performance on one test may well be inferior to normal distributions on other types of semantic knowledge. To identify the appropriate categorization of the normative data along sociodemographic indices, we carried out regression analysis to examine which of the sociodemographic variables influence semantic performances. The results revealed that education level significantly influenced the performances on OTM ($p < .05$) and OMM ($p < .05$) and the age variable significantly predicted the score of OMM ($p < .05$). These two variables modulated each other in predicting the performance on PPT - Chinese adaptation ($p < .01$). We did not observe any gender effects. In light of the regression results, we stratified the normative data according to age (20-55, 56+) and years of education (3-12, 13+) for each test. These results suggest that comprehensive semantic assessments in clinical and research settings should include items probing multiple aspects of semantic knowledge. The other outcome of the study is that we adapted the PPT and KDT to the Mainland China population and collected normative data for them and other three tests.

D42 Orthographic, phonological and semantic dynamics during ambiguity resolution:an fMRI investigation ***Bitan, T.*** *(1),* ***Kaftory, A.*** *(1),* ***Leib, A.*** *(1),* ***Markus, A****. (1),* ***Eviatar, Z.*** *(1)* ***Peleg, O.*** *(1); 1. University of Haifa, Israel* – Reading ambiguous words confronts the reader with the challenge of accessing and selecting from multiple semantic representations based on a single orthographic representation. The conflict between multiple representations is often resolved by relying on contextual information. Hence, previous neuroimaging studies have focused on the process of integrating ambiguous words with their context, resolving the semantic ambiguity. In the current study we aim to examine the process of accessing multiple semantic representations separately from the effect of contextual information on the resolution of semantic ambiguity. A further goal was to examine whether phonological ambiguity encountered in semantically ambiguous words affects the pathways used to access semantic representations and select the meaning appropriate for the context. Toward this aim we examined activation patterns using fMRI in homographs with a single phonological representation (homophones, e.g. 'bank') as compared to homographs with multiple phonological representations (heterophones, e.g 'tear'). The abundance of heterophonic homographs in Hebrew (due to the partial representation of vowels in standard writing) provides an opportunity for this study. 23 adults were scanned during a semantic relatedness judgment task on pairs of Hebrew nouns. The first word in the pair was either a homograph or an unambiguous word, with half of the homographs having a single phonological representation (homophones) and the other half are heterophones. The second word in each pair ('the context') was always unambiguous, and was either related (to the dominant or secondary meanings in case of homographs) or unrelated to the first word. The inclusion of partial trials, in which only the first word was presented, enabled to distinguish activation for reading the homograph from its integration with the context. Our results show that: 1) The presentation of heterophones compared to homophones or to unambiguous words resulted in activation in left inferior frontal gyrus (IFG)pars opercularis (BA 44/9), suggested to be involved in segmentation phonology (Fig.1a). 2) In contrast, homophones did not differ from unambiguous words, and showed greater activation than heterophones in left angular gyrus (BA 39), implicated in orthographic-to-semantic conversion, and left IFG, pars orbitalis (BA 47) implicated in semantic selection (Fig1b). These results suggest that while for heterophones access and selection of lexical representations rely on phonological processing, homophones rely more on orthographic-to-semantic conversion and semantic selection. 3) Activation in regions associated with semantic access (left middle temporal gyrus) during the integration of the homographs with the dominant or secondary context, show opposite patterns for homophones and heterophones.These results suggest that for heterophones the ambiguity may be resolved at the phonological level, resulting in greater load on semantic selection later on, when the unexpected secondary meaning is presented. In contrast, for homophones, both meanings may be accessed and maintained throughout the trial, resulting in easier access to the secondary meaning, but increased demands for selecting the dominant meaning. Altogether our results show that semantic access and the resolution of semantic ambiguity depend on the phonological status of the candidate representations.

D43 Different temporal lobe regions support processing of lexical, compositional and discourse-level semantics ***Costanzo, M.*** *(1),* ***Xu, J.*** *(1),* ***Braun, A. R.*** *(1); 1. National Institutes of Health, Bethesda, MD* – "The impact of linguistic context – the ways in which meaning is differentially encoded in words, sentences or narratives – can provide insights into how conceptual information is organized in the brain. While it is clear that the temporal lobe plays a crucial role in semantic access, it is likely that different temporal regions are engaged as increasingly richer and more detailed levels of meaning are processed at the levels of lexical, compositional and discourse-level semantics." "To address this issue within a single experiment, we used event-related BOLD fMRI with an ISI that made it possible to examine responses to open class words read by subjects in three linguistic contexts – as individual random word lists; in complete but unconnected sentences; and within coherent narratives.Words in each condition

were matched for length, frequency, imageability and concreteness; sentences in narrative and sentence conditions were matched for syntactic complexity. Our results revealed context-dependent temporal lobe responses when each condition was compared to a common baseline, and were confirmed by hierarchical contrasts (sentences-words and narratives-sentences): the processing of open class words presented in isolation was associated with activation of the left fusiform gyrus (BA37); processing of matched sets of words presented within sentences was associated with a reduction in the extent of fusiform activity and recruitment of middle temporal gyri (MTG, BA 21) extending in both anterior and posterior directions.Processing of comparable words at the discourse level was associated with minimal fusiform responses, a reduction in the extent of MTG activity and selective activation of the cortex of the temporo-parietal-occipital junction (TPO, BA 39/19). While responses in the fusiform gyrus for individual words were detected only in the left hemisphere, middle temporal and temporoparietal responses for sentences and narratives were bilateral. The role of the fusiform gyrus in semantic processing is well established.It is interesting that responses here were strongest when words were presented in isolation, but are significantly reduced for sentences, and virtually absent for narrative.Robust fusiform responses might be reliably elicited in experiments that are restricted to the lexical semantic level.When open class words are integrated with richer semantic contexts, on the other hand, they may be processed in complementary networks that engage additional portions of the temporal lobe.At the level of compositional semantics, when words are incorporated into sentences, the strongest activations were found in the MTG – in posterior regions classically related to language, and anterior regions in which the effects of compositionality have more recently been established.At the discourse level, when sentences are tethered into a coherent narrative, open class words elicit responses in temporoparietal regions that may be involved in synthetic and integrative processes related to the construction of a situation model. " Context dependent progression of temporal lobe responses from basal to middle temporal to temporoparietal cortex suggests that patterns of cerebral activity that emerge when language is used in arguably more ecologically valid contexts may be missed in experiments limited to the use of simpler linguistic stimuli.

D44 An EEG time frequency analysis of noun-object and verb-action identification ***Delarosa, B.*** *(1),* ***Maguire, M.****(1),* ***Sides, L.*** *(1)* ***Magnon, G.****(1); 1. The University of Texas at Dallas,TX* – One of the most important features of semantic knowledge is reference, or the ability to associate known words with the correct objects and actions in the environment. This process includes two stages, word comprehension (e.g., nouns and verbs) and referent identification (objects, actions), which are often studied in isolation. Previous time-frequency studies have found that theta (4-8hz) power increases index lexico-semantic retrieval of individual words (Bastiaansen et al., 2005, 2008), and topographical differences in gamma power increases differentiate nouns and verbs (Pulvermuller et al., 1999). Studies regarding object identification, devoid of particular word referents, have focused on changes in gamma band (>30 Hz) activity (see Tallon-Baudry & Bertrand, 1999 review). In this study we use time frequency analysis to study the neural networks associated with object and action reference. Specifically, we hypothesize that there will be increased neuronal recruitment for action reference compared to object reference because verbs as a word class are more abstract and refer to a wider range of references than nouns; subsequently, more higher-order cognitive processes will be required (Maguire et al., 2010). Thirty-one right handed, English speakers completed an EEG task, in which they listened to a word followed by a picture and then pressed buttons to indicate if the label matched the picture or not. The pictures were still images normed to elicit specific verbs (Stark, 1994). There were 52 items in each of four conditions (noun/ verb congruent, noun/verb incongruent). Each picture was used once per each condition acting as its own control. Data were analyzed using a STAT-PCA (Ferree et al, 2009) which tests for differences between tasks using an ANOVA from which only significant differences are submitted to the sequential PCA (spectral, spatial, and temporal) for data reduction. The end result is a set of factor "triplets", derived through PCA, which identify the spectral, spatial, and temporal distribution of significant differences between conditions of interest. As expected, when the word was presented, verbs elicited an increase in power in the theta band over the motor cortex compared to nouns, which indicates the differential use of motor cortex in the lexico-semantic retrieval of verbs (Bastiaansen et al., 2008). Significant differences between congruent and incongruent word-picture pairs were found in the gamma power (around 48 Hz) over occipital areas between 400-500 msec.Importantly, there was a pronounced gamma power increase in the left occipital region for the verb incongruent condition as compared to the other three conditions (See Figure 1). Such changes in power are often related to increased top down processing (Pulvermuller et al, 1997; Tallon-Baudry & Bertrand, 1999). We argue that the reason for this difference is related to the abstract nature and range of meanings conveyed in verbs compared to nouns. Although many studies have shown that object nouns are more concrete than action verbs (Bird et al., 2001), these findings exhibit the implications of such semantic differences in object and action identification and provide new information about the oscillatory dynamics underlying semantic processing.

D45 When Moses built the Ark: ERP evidence for qualitative cross-linguistic variation in the neural processing of semantic illusions ***Tune, S.*** *(1),* ***Schlesewsky, M.*** *(2),* ***Bornkessel-Schlesewsky, I.*** *(1); 1. University of Marburg, Germany; 2. Johannes-Gutenberg-University Mainz, Germany* – When processing linguistic input, we not only combine individual words to form complex meanings, but also assess whether the state of affairs described is in accordance with our real-world knowledge. While obvious semantic anomalies (e.g. He spread the warm bread with socks, [1]) are easily recognised and known to elicit an N400 response, another type of semantic anomaly related to the

Moses Illusion [2] is difficult to detect and therefore frequently missed. This relatively low detection rate for so-called borderline anomalies appears to be related to the fact that the anomalous word, though locally implausible, exhibits a close semantic fit to the global context. A recent ERP study on English borderline anomalies (BAs) [3] compared neurophysiological responses to correctly detected and missed anomalies. While neither showed an N400 effect in comparison to plausible controls, detected BAs engendered a a late positivity. In view of systematic cross-linguistic differences in the electrophysiological response to another type of semantic anomaly, namely semantic reversal anomalies [4], the present auditory ERP study on German BAs examined whether they show similar variation. For maximal comparability, the stimuli were adapted German translations of the materials used in the English experiment (1). (1) Example from [3]; present study used German translation A North American jumbo jet was forced at gunpoint to land in Canada, experts were quickly on hand to help. First of all the authorities' initial {negotiations/communications} with the scared and desperate hostages, helped calm the situation. While the critical word (in bold) has a close semantic relation to the global context, it only fits with one of the two optional local context words (in italics). Participants rated the plausibility of the second sentence and whenever they detected an anomaly, they were asked to identify and explain it. In contrast to the English results, the German data show a biphasic N400 - late positivity pattern for detected implausibilities compared to missed anomalies and plausible controls. Strikingly, this qualitative cross-linguistic distinction is the same as that observed for English vs. German reversal anomalies, thus suggesting systematic and profound underlying differences in the neural implementation of the two languages. This proposal is further supported by the finding of a late positivity for pronoun binding in Dutch [5], a language which patterns with English in the processing of reversal anomalies in contrast to an N400 - positivity pattern for German [6]. We suggest that these distinctions relate to the degree to which a language is sequence-dependent in interpretation, i.e. exploits the order information naturally present as language unfolds over time. [1] Kutas, M., & Hillyard, S.A. (1980). Biol Psych,11. [2] Erickson, T.D., & Mattson, M.E. (1981). J Verb Learn Verb Behav, 20. [3] Sanford, A.J. et al. (2011). J Cog Neurosci, 23. [4] Bornkessel-Schlesewsky, I. et al. (2011). Brain Lang, 117. [5] Lamers, M.J.A. et al. (2008). BMC Neurosci, 9. [6] Schmitt, B.M. et al. (2002). Cog Brain Res, 14.

D46 Online monitoring of the impact of language processing on motor processes: prehensile grip-force measures during passive listening of manual action words and sentences ***Aravena, P.*** *(1),* ***Delevoye, Y.****(3),* ***Frak, V.*** *(2),* ***Deprez, V****.(1),* ***Paulignan, Y.****(1),* ***Cheylus, A.****(1),* ***Nazir, T.*** *(1) 1. CNRS UMR 5015, Institut des Sciences Cognitives, Bron, France; 2. Institut de Réadaptation Gingras-Lindsay de Montréal, Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain, Université de Montréal, Québec; 3. Laboratoire URECA, UFR de Psychologie, Université Lille Nord de France, Lille, France.* – A large number of recent behavioural studies have established that processing linguistic descriptions of motor actions affect overt motor behaviour. For instance, when participants are asked to make sensibility judgments on sentences that describe action toward the body ("Mark gave the book to you") or away from the body ("You gave the book to Mark"), they are faster to respond when the response requires an arm movement in the same direction as the action described by the sentence. These and related findings have been taken to suggest that sentences are understood through sensorimotor simulations of the objects and actions being described. Yet, the fact that behavioural paradigms typically capture language-induced motor effects at latencies that are beyond latencies for lexical access is frequently used to challenge this assumption. Unfortunately, experimental techniques utilized to avoid this temporal problem are highly complex and may not be always ecologically sound (functional magnetic resonance imaging, electroencephalography, etc.). Moreover, these high temporal resolution techniques cannot provide information as to where in the motor hierarchy (from planning to execution), and how far neuronal similarities between actual action and linguistically represented actions may extend. The development of simpler techniques adapted for measuring online motor-language interaction is needed. In the present study we aim to introduce a novel experimental tool, a grip-force sensor (ATI mini-40) that allows online measures of the effects of language processing on motor behaviour. We used this device in a series of experiments to measure the activation of hand muscles during passive listening. Our stimuli consisted of spoken action (e.g., write) and non-action words (e.g., star) presented first in isolation and then, in contexts, in respectively affirmative (e.g., At the gym, Fiona is lifting dumbbells vs. Above the mountain, Leonard sees an eagle flying), negative and intentional sentences. Participants held the grip-force sensor with arm extended and eyes closed. Data analyses were focused on the prehensile force component that was measured from the onset of the target word. Both in isolated and in sentence contexts, significant differences in grip-force between verbs and nouns were observed. Grip-force increased when the target word was a verb but not when it was a noun. In the isolated-word condition this difference started to become significant at around 200ms after onset and in sentence context at around 270ms. The greater grip-force observed during manual action verb processing suggests that language-induced motor activity can involve later states of a motor performance, recruiting cortico-spinal circuits as well as muscular fibres. Indeed, passive listening was sufficient to detect partial activation of executive stages of a motor performance pattern, although no motor task associated to the linguistic process was required. Overall, the present findings demonstrate that this novel experimental paradigm can be profitably used to study the online processing of the interaction between the motor system and language in a very simple and ecological manner. By correlating grip-force and electrophysiological data, we propose this novel technique as an online monitoring-tool for elucidating new

aspects of the interplay between motor and linguistic systems.

D47 N400m does not differ between phonological, semantic or morpho-syntactic processing ***Bettus, G.*** *(1,2),* ***Dhond, R.P.*** *(3),* ***Kovacevic, S.*** *(1),* ***Sherfey, J. S.*** *(1),* ***Halgren, E.*** *(1),* ***Marinkovic, K.*** *(1); 1. UCSD, San Diego, CA; 2. INSERM U751, Marseille, France; 3. MGH/HMS/MIT Martinos Center for Biomed. Imaging, Massachusetts Gen. Hosp., Boston, MA* – Studies using fMRI have found that distinct cortical areas are activated by the phonological, morpho-syntactic and semantic aspects of words. This study addressed whether these differences could be observed with MEG, by comparing responses evoked across three matched tasks requiring phonological processing (RH: determining if the presented word rhymes with a target), semantic processing (SZ: determining if the presented word refers to something that would fit in a breadbox), or morphosyntactic processing (VB: determining if the presented word would end in '-ed' if placed in the past tense). In all paradigms, the word was presented visually for 300ms and half of the words repeated multiple times. Repetition was crossed with targetness. In all tasks, repetition resulted in faster reaction times (t-test, comparison between new and repeated words within RH, SZ and VB task: $p<0.001$) and modulation of the MEG between 350 and 500ms (frontal, temporal and parietal areas). This modulation corresponds to the well-studied N400m component, and MRI-constrained source localization estimated generators in or near Broca's Wernicke's and ventral temporal language areas (Marinkovic et al., Neuron. 2003, 38(3):487-97). The location, timing, and task correlates of the N400m suggest that it may reflect the activation of task-relevant information. Twelve healthy males participated in MEG/EEG recordings. 306 channels of the MEG and 64 channels of the EEG were obtained with a whole-head device (Electa-Neuromag). Head position relative to the MEG sensors was held constant by individualized permanent bitebars. At the group level, we compared response patterns for the 3 tasks for the repetition effect (repeated ANOVA for time window between 350 and 500 ms) and did not observe reliable task-dependent differences of N400m. In conclusion, the topography of the N400m, and presumably its underlying cortical generators, does not differ across tasks accessing phonemic, semantic or morphosyntactic information. This remarkable finding may indicate that the N400 process automatically activates all types of information associated with a word, with post-access processes drawing upon this information to guide the response to the task at hand. In this view, the dissociation between MEG and fMRI results would result from fMRI revealing post-access activity following the N400. Alternatively, the N400 process may only reflect modulation but not activation. In this case, the fMRI results would reflect neuronal activation (for example seen in local field potentials as high gamma power) that is not seen with MEG.

D48 Transcranial direct current stimulation speeds up automatic word retrieval ***Bosley, L.V.*** *(1),* ***Vannorsdall, T.D.*** *(1),* ***Andrejczuk, M.*** *(1),* ***Reese, K.*** *(1),* ***Schretlen, D.J.*** *(1), and* ***Gordon, B.*** *(1); 1. The Johns Hopkins University, Johns Hopkins University School of Medicine, Baltimore, MD* – **Introduction**: It has been hypothesized that on verbal fluency tasks, retrieving clusters of related words uses automatic processes, while searching for a new cluster uses more effortful, controlled processes.For category fluency tasks, automatic semantic relations are thought to be dependent upon the dominant (left) temporoparietal region, while effortful, controlled processes are a product of the dominant dorsolateral frontal region.Transcranial direct current stimulation (tDCS) is a form of noninvasive electrical brain stimulation in which anodal stimulation over a cortical region generally appears to increase processing capabilities of the region, while cathodal stimulation decreases those capabilities. We have previously presented data demonstrating that tDCS may modify automatic and controlled aspects of word retrieval in healthy adults, with left frontal stimulation, and with quantity of production as the measure.In the current study, we examined the effects of left posterior temporal stimulation, and measured both productivity and the speed of item-to-item production.We hypothesized that anodal stimulation in this region might improve the automatic, rather than controlled, component of word retrieval. Methods: Twelve healthy right-handed adults received 2 mA of anodal and cathodal stimulation in counterbalanced order and separated by a 90-minute washout period. Stimulation was delivered for 30 minutes via a constant current stimulator through 7.6x7.6-cm sponge electrodes with the active electrode placed over the T5 (left posterior temporal region).The other electrode was placed over the right biceps.At the end of each period of stimulation, subjects completed four 60-second fluency trials consisting of letter (letters S and P) and category cues (animals and supermarket items). Responses were audio recorded.Overall productivity as well as the numbers of clusters and switches were tallied according to the Hopkins Verbal Fluency Scoring system.Time intervals between words (inter-word intervals) were measured using spectrographs of the audio recordings and then classified as occurring either between or within clusters. **Results:** The inter-word interval increased over the course of each 60-second verbal fluency trial. Overall, inter-word intervals within clusters ($M=1.3$, $SD= 1.6$) were briefer than those occurring between clusters ($M=2.5$, $SD=2.4$) during both letter and category-cued fluency and under both anodal and cathodal conditions ($t(2608) = 15.742$, $p<.001$). Also, anodal stimulation was associated with faster clustered word retrieval than cathodal stimulation during the second quarter (seconds 16-30) across all four verbal fluency tasks ($p=.01$). While there was an overall trend toward increased productivity, faster retrieval under anodal stimulation did not translate to significantly increased word generation. Conclusions: In healthy adults, anodal stimulation over the T5 region was associated with faster word retrieval within semantically and phonologically related clusters relative to cathodal stimulation. Although this trend occurred throughout the minute, the time difference was statistically significant only during the second quarter (the point at which the rate of responding tends to begin slowing down for most participants).This increased speed of word retrieval did not translate into greater productivity.We conclude

that the use of tDCS could enhance efficiency of word retrieval among persons with intact semantic networks and reduced speed of lexical retrieval.

D49 Body part-specific representations of semantic noun categories ***Carota, F.*** *(1),* ***Moseley, R.*** *(1),* ***Pulvermüller, F.*** *(1); 1. Medical Research Council, Cognition and Brain Sciences Unit, Cambridge, UK* – The functional link between object-concepts and lexico-semantic representations is a debated issue in cognitive neuroscience. As concrete nouns denote physical entities in the world, the neural encoding of their meaning is typically associated to the ventral visual stream for object processing in ventrolateral temporal cortex. However, motor system somatotopic activation to action words, sensitive to the effector of the specific action a word refers to, suggests that word meaning processing relies crucially on action knowledge and action contexts. Here we aimed at exploring the role of sensory and motor knowledge in the cortical processing of semantic noun categories, referring to animals, food and tools. A question of interest is whether, in analogy to motor system activation to action words, similar motor mechanisms in the dorsal stream underlie the semantic processing of concrete nouns that are indirectly linked to action, but imply semantic knowledge about actions performed on referent objects. Tool- and food-related words refer to objects that afford hand and mouth action, respectively. We therefore predicted differential activation of cortical motor systems by tool and food words but not, or to a lesser degree, by animal words which do not relate conceptually to actions. We adopted a passive task, in which subjects were requested to silently read nouns that referred to tool-, food- and animal-related words. Event-related fMRI was used to obtain brain responses to the three semantic noun categories. Stimuli were selected according to their semantic properties, as assessed empirically using semantic ratings, and matched for a range of psycholinguistic variables. Results show ventral-stream activation in temporal cortex along with category-specific activation patterns in both ventral and dorsal streams, including sensorimotor systems and adjacent prefrontal cortex. Precentral activation reflected action-related semantic features of the word categories. Left-precentral activation of the motor system – dominating, respectively, in face and hand cortex - was found for food and tool words – which, respectively, afford mouth and hand actions – but not for animal words unrelated to actions.

Consistent with their motor connotations, tool words also activated right cerebellar areas. In addition, food words sparked left-orbitofrontal cortex, possibly reflecting aspects of their emotional-affective meaning, whereas activity observed in left inferior temporal and fusiform areas indexed visual information about referent objects. In sum, sensorimotor brain activation to concrete nouns reflects semantic representation of actions to be performed on, and afforded by, referent objects. Our findings is consistent with the view that referential word meaning and the linkage of words in their action contexts is laid down in semantic circuits distributed throughout the cortex reaching into sensory and motor systems. The different topographies of these circuits reflect information about referent objects, their action implications, or affordances, and relevant semantic word properties.

D50 Beyond Broca's and Wernicke's areas: The roles of visual, motor and affective systems in narrative comprehension ***Chow, H. M.*** *(1),* ***Mar, R. A.*** *(2),* ***Braun, A. R.*** *(1); 1. NIDCD/NIH, Bethesda, Maryland; 2. York University, Toronto, Ontario* – Accumulating evidence has shown that, in addition to the classical language regions in the left hemisphere, successfully comprehending the meaning of narrative involves an extensive brain network. Recently, the embodied view of language proposed that comprehension can be seen as a simulation of the described situation based on our perceptual, motor and emotional experience, and predicted that sensorimotor and affective areas in the brain would be involved in comprehension. This prediction has received support from word and sentence comprehension studies, but little is known about the contributions of modality-specific systems during discourse comprehension. Are they modulated by different types of story content? How do they interact with language areas in the brain? How does our past experience contribute to comprehension? To answer these questions, we composed 18 stories, each consisted of 3 paragraphs. The first paragraph contained either vivid descriptions of a scene (12 stories; Perception condition) or no such description (6 stories; Control). The second paragraph contained numerous descriptions of a protagonist's actions (12 stories; Action condition) or had no such description (6 stories; Control). The last paragraph described happy or sad events (12 stories; Emotion condition) or had no such description (6 stories; Control). Control paragraphs while they contained minimal descriptions of scenes, actions and emotion, provided reasonable beginnings, continuations or endings to the stories. The blood oxygen level dependent responses of 24 participants were measured using functional magnetic resonance imaging while they were listening to the stories. After the experiment, they were asked to rate how much past experience they have with the scenes, actions and emotional events described in the stories. In accordance with the embodied view of language comprehension, modality-specific areas were recruited for different types of content. When compared to Control conditions, paragraphs with vivid descriptions of scenes were associated with significant activations in bilateral visual association areas; paragraphs with extensive descriptions of body movements were associated with significant activations in the somatosensory cortex and the dorsal premotor cortex, and emotionally-charged paragraphs were characterized by significant activations in the left amygdala, the orbital frontal gyri, the medial prefrontal cortex, the posterior cingulate cortex and the superior temporal sulci. Moreover, the connectivity between the LIFG and visual areas, and the LIFG and sensorimotor areas were modulated in the Perception and Action conditions respectively. The LIFG has been shown to

play an important role in integrating information from different modalities (Willems et al., 2009). It is possible that the LIFG integrates simulated information from modality-specific areas in order to build a coherent and vivid mental representation of the situations described. Interestingly, participants' experience with the stories' emotional content modulated activity in the posterior cingulate cortex and the medial prefrontal cortex, areas associated with autobiographical memory. This suggests that autobiographical memory may contribute to the comprehension of emotional content in stories.

D51 Theory of Mind and Other Theories: The Role of the Temporo-Parietal Junction in Semantic Processing ***Leshinskaya, A.*** *(1)* ***Caramazza, A.*** *(1); 1. Harvard University, Cambridge, MA* – We tested the hypothesis that the temporo-parietal junction (TPJ) plays a role in not only theory of mind, but also other theories about animate beings, such as reproduction, disease, natural selection. Theories were defined as conceptual knowledge involving abstract constructs (beliefs; species; evolution) that take part in caUSl explanations (Keil, 1998; Gopnik & Wellman, 1999). We used functional magnetic resonance imaging (fMRI) to test the notion that the TPJ is involved in processing both mental theories and biological theories over and above observable attributes. During fMRI scanning, participants read sentence pairs which required the retrieval of each kind of knowledge. For example, scenarios about beliefs influencing actions (He didn't see his puppy take the shoes. He searched for them in their usual spot) were contrasted with scenarios about physical traits (Once the puppy got under the couch, he wasn't able to follow it). Scenarios about biological theory (Some species of moth live on tree trunks. Most of these species are brown) were contrasted with scenarios about physical traits (The butterfly was covered in dust. It looked no different than a moth). All conditions were equated for difficulty. The bilateral TPJ was localized with a standardized theory of mind task (Dodell-Feder et al, 2011; Saxe & Kanwisher, 2003) It was found that while the right TPJ exhibited a preference only to mental theories (active more for mental theories than physical traits of people), the left TPJ exhibited a preference for both kinds of theories, evidenced by a greater response to biological theories than physical traits of animals, as well as a greater effect for mental theories above physical traits of people. This confirms a specific locus for mentalizing, but also suggests a broader function for the left TPJ, perhaps for more general biological theorizing. This result furthermore supports a principled, general distinction between the semantic processing of observable and explanatory knowledge of animate beings.

D52 The representations of sensory-motor word features during a semantic association task ***Price, A.*** *(1),* ***Bonner, M.*** *(1),* ***Peelle, J.*** *(1),* ***McMillan, C.*** *(1), and* ***Grossman, M.*** *(1); 1. The University of Pennsylvania, Philadelphia* – **Objective:** How are the processes that we use during the comparisons of semantic associations related to our sensory perceptions of the world? Our study aims to investigate whether semantic associations involve perceptual-motor recruitment, in addition to executive resources recruited for semantic comparisons. We used an fMRI word matching experiment to examine the role of visual, motor and auditory features involved in word associations. **Methods:** During a BOLD fMRI study, young healthy participants (n=18) viewed word triads on a screen and responded by button press to indicate which of the two word choices on the bottom matched the word on top, in a paradigm similar to Pyramids and Palm Trees. Word sets had strongly associated features (determined by norming study) in one of three modalities: Motor (e.g., fork: chopsticks or drumstick; n=22), Visual (e.g., carrot: potato or lightbulb; n=22), and Auditory (e.g., thunder: rocket or downpour; n=22). An Abstract word condition (e.g., saga: epic or proxy; n=22) and pronounceable pseudowords (n=22; matching for letter similarity) served as baselines. Conditions were matched for word length and frequency. Functional localizers identified visual, motor and auditory regions within participants. **Results:** Motor words recruit regions associated with motor planning and execution (including primary motor cortex). Visual words recruit regions associated with visual perception in ventral temporal cortex. Auditory words recruit regions of auditory association cortex. Comparing all real words (motor, visual, auditory, and abstract combined) to the pseudoword baseline revealed significant activation in the middle and inferior frontal cortices, posterior fusiform gyrus, inferior temporal gyrus, and posterior superior temporal gyrus. **Conclusion:** These results support the hypothesis that word meanings involve motor, visual, and auditory feature knowledge in modality-specific association cortices. These results also provide evidence that middle and inferior frontal gyrus as well as posterior superior temporal gyrus play a role in word comparisons that involve competition between different semantic concepts.

Poster Session E

Friday, November 11 3:20 - 4:50 pm
Senate, Capitol C, and Capitol C Pre-Function

ANATOMY

E1 Structural and functional connectivity of the anterior temporal lobe ***Gesierich, B.*** *(1),* ***Henry, M. L.*** *(1),* ***Galantucci, S.*** *(1,2),* ***Papinutto, N.*** *(1,3),* ***Kramer, J.*** *(1),* ***Miller, B. L.*** *(1) ,* ***Seeley, W.W.*** *(1),* ***Gorno-Tempini, M. L.*** *(1); 1. University of California San Francisco, San Francisco; 2. Scientific Institute and University Hospital San Raffaele, Division of Neuroscience, Institute of Experimental Neurology, Milan, Italy; 3. University of Trento, (CIMeC), Trento, Italy* – **Objective:** The purpose of this study was to identify the structural and functional networks connecting the anterior temporal lobe (ATL) in the human brain in vivo.

Functional imaging in healthy controls, and neuropsychological findings in patients suggest involvement of the ATL in semantic memory but also in emotional processing. Anatomical studies on brain tissue show that the medial part of the ATL is of transitional, phylogenetically older cortex. The most lateral portion is instead neocortical and in non-human primates connects to multimodal sensory regions.We hypothesize that in the human brain the lateral ATL will be connected to the language network. Here we test this hypothesis using structural and functional neuroimaging connectivity techniques. Methods: We used diffusion tensor imaging (DTI) and probabilistic tractography in 31 neurologically normal subjects. One eight minute, task-free fMRI scan was obtained in 98 subjects. DTI connectivity-based parcellation of the ATL was performed based on the probability of each voxel in the ATL to connect to the occipital lobe (OL) and orbitofrontal cortex (OFC) of the ipsilateral side. DTI results revealed two ATL regions: one lateral area predominantly connected to the occipital lobe and one medio-ventral area predominantly connected to orbito-frontal areas. We used these two DTI derived regions-of-interest as "seeds" to identify fMRI maps of all brain voxels whose functional time series are significantly correlated with that of the seed. For each seed, the z-scores of correlation coefficients were calculated on the single subject level. Resulting z-score images were entered in a second level random effects analysis. Results: Functional connectivity maps for both medial and lateral DTI-derived ATL seeds showed overlap in the OFC, the insula, the hippocampus and the parahippocampal gyrus. The connectivity of the medial anterior part of the ATL was restricted mainly to this system and extended into the gyrus rectus, subgenual frontal area and the brainstem. The lateral ATL also connected to ventral occipito-temporal cortex, lateral MTG and STG, and the angular and inferior frontal gyri . The precuneus, middle cingulum, and medial frontal regions were also connected with the lateral ATL. Medial and lateral ATL connections were present bilaterally. Discussion and Conclusion: The finding of distinct functional connectivity patterns for subareas within the ATL supports the differential involvement of these regions in behavior and cognition. The medial area, mainly comprising proisocortex and paleocortex, is presumably involved in behavioral and emotional functions. On the other hand, the lateral ATL region is also part of a network that connects visual and auditory association areas with regions implicated in phonological and orthographic processing. This finding, in conjunction with research indicating semantic impairment in individuals with lateral ATL damage, suggests a role for this region in semantic memory.

E2 Gray matter correlates of variation in adult reading skill ***Chiarello, C.*** *(1),* ***Felton, A.*** *(1),* ***Vazquez, D.*** *(1),* ***Leonard, C.M.*** *(2); 1. University of California, Riverside, CA; 2. University of Florida, McKnight Brain Institute, Gainesville, FL* – **Objectives:** Reading ability is an unequally distributed skill in the population. Yet, to our knowledge, no prior large-scale investigation has examined neuroanatomical correlates of typical adult reading. Hence, it is unclear whether regional differences in cortical volume are associated with variability in normal reading skill. A recent review of voxel-based morphometry (VBM) dyslexia studies of word and nonword reading reported gray matter differences between dyslexics and controls in posterior temporal/parietal, bilateral occipito-temporal, and cerebellar regions [4]. A voxel-based lesion study of word and nonword oral reading observed lesion-symptom correlations in pre- and post-central gyri, middle and inferior frontal gyri, middle temporal, and parietal and occipital cortex [2]. These findings imply that a widespread network of gray matter regions may be critical for normal reading, but do not reveal whether similar regions are associated with normal variability in reading skill. Further, neuroanatomical correlates of reading comprehension remain unexplored. To address these issues, the current study utilized VBM to evaluate gray matter correlates of reading ability in 200 university students. **Methods:** Participants (100 male, 100 female) completed word identification (oral word reading), word attack (oral nonword reading), and passage comprehension subtests from the Woodcock Johnson Reading Mastery Test [6] and underwent a structural MRI scan. We performed whole-brain voxel-based analyses of gray matter volume. We co-registered, averaged, flipped and segmented two volumetric MRI scans with SPM8 before normalization into symmetrical study-specific space with DARTEL, modulating and smoothing output with an 8 mm kernel [1]. Separate regressions examined the relation between each reading subtest and gray matter volume, with total gray matter volume covaried. We report regions that survive peak-level corrections for multiple comparisons (family-wise error) across the whole brain at $p < 0.05$, with individual voxels thresholded at $p < 0.001$. **Results:** Better reading was associated with increased cortical volume in Broca's area (MNI: -45, 21, 10) for word identification, left lateral and medial parietal/occipital cortex (-18, -79, 43; -3, -72, 52) for word attack, and bilateral visual cortex (6, -88, 30 – see attached figure) for passage comprehension. There was a trend for better reading to be associated with reduced cortical volume in motor regions (precentral gyri, caudate) and right temporal and parietal cortex, $p < .001$, uncorrected. No area accounted for more than 13% of the reading skill variance; correlations with traditional temporal language regions and the cerebellum were not found. **Conclusions:** Different reading skills were associated with somewhat different patterns of gray matter variation. We did not observe reading skill correlations with superior temporal or cerebellar regions, areas that are frequently activated during reading tasks [3,5], and that may structurally differentiate dyslexic and normal readers [4]. Our results better resemble voxel-based lesion findings, implying that correlates of individual differences in normal reading skill may reflect areas that are critical for mature reading ability, and not necessarily those implicated in developmental reading impairments. The results suggest that reading skill ⎯supported by widely distributed cortical networks and differing across individuals⎯ is predictably associated with volumetric differences in specific cortical regions. **References:** [1] Ashburner, J. (2007). A fast diffeomorphic

image registration algorithm. Neuroimage, 38, 95-113. [2] Cloutman, L.L., Newhart, M., Davis C.L., Heidler-Gary, J. & Hillis, A.E. (2011). Neuroanatomical correlates of oral reading in acute left hemispheric stroke. Brain & Language, 116, 14-21. [3] Fiez, J.A., & Petersen, S.E. (1998). Neuroimaging studies of word reading. Proceedings of National Academy of Sciences, 95, 914-921. [4] Richardson, F.M., & Price, C.J.(2009). Structural MRI studies of language function in the undamaged brain. Brain Structure and Function, 213, 511-523. [5] Turkeltaub, P.E., Eden, G.F., Jones, K.M., & Zeffiro, T.A.(2002). Meta-analysis of the functional anatomy of single-word reading: Method and validation. NeuroImage, 16, 765-780. [6] Woodcock, R.W. (1998). Woodcock Reading Mastery Test-Revised Normative Update (WRMT-R). Circle Pines, MN: American Guidance Service, Inc.
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E3 Dissociating gray and white matter neural integrity in chronic aphasia ***Bahrani, E.*** *(1),* ***Harvey, D.*** *(1),* ***Hamilton, A.C.*** *(1),* ***Ellmore, T.M.*** *(2), and* ***Schnur, T.T****. (1); 1. Rice University, Department of Psychology, Houston, TX, US., 2. The University of Texas Health Science Center, Department of Neurosurgery, Houston, TX, US.* – Diffusion tensor imaging (DTI) and tractography methods provide a measure of the structural connectivity of white matter fiber tracts which connect gray matter cortical regions. One way to understand which brain regions and connections are necessary for language is to calculate whether damage in white and gray matter predicts language behavior. However, it is difficult to tease apart the independent contributions of white and gray matter to behavioral processes because damage occurs concurrently to both. To reveal whether white matter damage occurs independently of gray matter damage in participants with acquired language deficits (aphasia) as a result of left hemisphere stroke, we correlated white matter integrity with damage in language-related cortical regions in 11 chronically aphasic participants. We calculated the percent damage in five left hemisphere regions important to language: the temporal pole, superior, middle, and inferior temporal gyri, and left inferior frontal gyrus (LIFG). We used deterministic tractography to estimate the integrity of three white matter tracts that connect these cortical regions. The uncinate fasciculus (UF) connects the anterior temporal lobe (ATL) with the medial/lateral orbitofrontal cortex. The inferior longitudinal fasciculus (ILF) projects from the occipital-temporal junction through the central portion of the temporal lobe. The inferior fronto-occipital fasciculus (IFOF) connects the occipital-temporal junction with Brodmann Area 47 in the LIFG. (We could not define the arcuate fasciculus because 9 of 11 participants had lesions encompassing the arcuate). To dissect the tracts, we placed seed regions at known anatomical tract terminations using a two-region approach. Tract integrity was estimated using fractional anisotropy (FA) values. We correlated gray matter region damage with integrity of the tracts that run near them. In our patient sample, LIFG damage (range 0-41%, mean 15%) did not correlate with damage to the white matter tracts terminating near it (UF and IFOF, p's > .45). However, temporal lobe damage is correlated with the integrity of tracts that pass through it (see Figure 1), except for the IFOF ($p > .36$). Specifically, increased damage to the superior (range 0-92%, mean 40%) and middle (range 0-64%, mean 25%) temporal gyri is related to decreased FA values in the ILF (p's = .04 and .05). Increased damage to the temporal pole (range 0-11%, mean 2%) is related to decreased FA values in the UF ($p = .006$). That temporal lobe and not LIFG damage predicts tract integrity may be because the largest lesions occurred in the temporal lobe (overall lesion size predicts temporal lobe ($p = .02$), but not LIFG damage ($p > .50$)). Thus, in a typical aphasic group language behavior can be independently predicted by LIFG damage or the integrity of the tracts that terminate near it. However, because of the size of the lesions in the temporal lobe we cannot distinguish between the independent contributions to behavior from gray and white matter. Overall, these results suggest that for the study of white-matter tract and behavior relationships in aphasic speakers, it is important to verify the distribution of brain lesions in the patient sample.

COGNITIVE AND EXECUTIVE PROCESSING

E4 Strategic decision-making mechanisms support the resolution of doubly-quantified sentences ***McMillan, C.*** *(1),* ***Coleman, D.*** *(1),* ***Clark, R.*** *(1),* ***Grossman, M.*** *(1); 1. University of Pennsylvania, Philadelphia, PA* – Quantifiers like "all" and "a" are very frequent in daily language and their meanings are well understood.However, when quantifiers co-occur in the same sentence (e.g., "All the dogs jumped into a lake") the interpretation is often ambiguous: collective (e.g., dogs jumping into a single lake) or distributive (e.g., dogs each jumping into different lakes).While "all" typically prefers a collective interpretation, this preference decreases as the size of the object in the sentence decreases. We propose a two-component model for resolving quantifier ambiguity.First, neural mechanisms known to support quantifier comprehension including parietal cortex are hypothesized to support core language resources.Second, decision-making mechanisms are hypothesized to contribute to resolving conflict between potential interpretations: dorsolateral prefrontal cortex (DLPFC) is hypothesized to support a probabilistic mechanism that evaluates the likelihood of each interpretation; and orbital frontal cortex (OFC) is hypothesized to support the evaluation of the "risk" associated with misinterpreting a sentence.In two experiments we presented participants with doubly-quantified sentences (as above), unambiguous baseline sentences (e.g., "All the dogs jumped in the same lake") and a picture verification task.We manipulated the size of the object (e.g., puddle, pond, lake) and whether the picture illustrated a collective or distributive interpretation.In Experiment 1 we evaluated behavioral variant frontotemporal dementia (bvFTD) patients, who have decision-making limitations due to disease in DLPFC and OFC but relatively preserved language.bvFTD patients did not differ in performance relative to healthy seniors (HS)

for unambiguous sentences suggesting that bvFTD patients do not have a language impairment.bvFTD patients endorsed the distributive interpretation more than HS suggesting they may have difficulty appreciating the risk associated with endorsing a less-preferred interpretation due to frontal cortex disease. In Experiment 2 we evaluated healthy adults using fMRI.We observed activation of OFC when participants were presented with distributive interpretation pictures relative to collective interpretation pictures.This is consistent with our hypothesized "risk" mechanism.We also observed a parametric modulation of DLPFC activation that increased in activation as the object size decreased, which is consistent with a probabilistic mechanism. Together, these experiments establish converging evidence for a two-component model of language processing that includes core-language and strategic decision-making mechanisms.

E5 Developmental Changes underlying Calculation: an fMRI Study ***Evans, T. M.*** *(1),* ***Flowers, L. D.*** *(1),* ***Napoliello, E. M****. (1),* ***Einbinder, E.*** *(1),* ***Eden, G. F.*** *(1); Georgetown University Medical Center* – Previous studies have implicated a bilateral fronto-parietal network mediating arithmetic calculations (Nieder and Dehaene, 2009). This network has been shown to vary depending on age. For example, one study conducted in 8-19 year olds showed activation in bilateral frontal regions to decrease with age, while activation in left parietal regions increased with age (Rivera et al. 2005). However, while age-related increases in the left parietal lobe have been replicated, other studies have found no evidence of age-related decreases (Kucian et al. 2008, Davis et al. 2009), leaving the issue of the neurodevelopmental trajectory for arithmetic calculations elusive. During the acquisition of fMRI data, 25 typically developing subjects performed single digit calculations (addition and subtraction) and indicated by left/right button press whether the solution was correct. In a control condition, two of the operands were replaced with pseudofont characters, and subjects indicated if the characters were identical. A group map for all subjects of calculation > control conditions ($p<0.001$, cluster-level FWE corrected $p<0.01$) revealed activity in left inferior parietal lobe, superior and middle frontal gyri and right insula and cingulate cortices. We then conducted comparisons between adults (n=13, age 18 – 25 years) and children (n=12, age 7 – 15 years) and found activation during calculation in the midline cuneus and right superior parietal lobe to be significantly greater in children ($p<0.0001$, cluster-level FDR corrected $p<0.05$). While this result is inconsistent with previous findings (Menon et al. 2005, Kucian et al. 2008, Davis et al. 2009), the right parietal difference between the groups is consistent with the developmental trajectory reported for abstract processing of non-symbolic quantity (Cantlon et al. 2006). Lastly, correlation analyses were conducted between percent signal change during the calculation task (constrained to those regions identified in the overall group map for calculation>control) and behavioral measures of math proficiency (Woodcock Johnson Calculation, Math Fluency, Applied Problems, Broad Math and Math Calculation Skills). Activation in right middle frontal gyrus was negatively correlated with Math Fluency (r= -0.47), Broad Math (r= -0.45) and Math Calculation Skills (r= -0.53), giving further support to the notion that as mathematical proficiency develops, frontal regions are involved to a lesser extent (Menon et al. 2005). Together our results indicate that activity in right superior parietal lobe is modulated by age in tasks involving quantity, whereas math performance is related to activity in frontal cortex.

E6 Individual Differences in Executive Function Modulate Within- and Cross-Language Lexical Ambiguity Resolution: Evidence from Eye Movement Measures of Bilingual Reading ***Whitford, V.*** *(1),* ***Titone, D.*** *(1); 1. McGill University, Montreal, QC, Canada* – Consistent with work suggesting fronto-cortical involvement in ambiguity resolution (e.g., Fiez, 1997; Mason & Just, 2007; Thomson-Schill, Aguirre, D'Esposito, & Farah, 1999), prior monolingual research on homonyms (e.g., bank = financial institution or riverside) has shown that individual differences in executive function modulate lexical ambiguity resolution (e.g., Miyake, Just, & Carpenter, 1994; Wagner & Gunter, 2004).In the current study, we investigate whether this relationship extends to bilingual ambiguity resolution. We conducted an eye movement study of bilingual reading based upon Schwartz, Yeh, and Shaw (2008), who used lexical decision to examine uniquely English homonyms, and homonyms whose subordinate meanings were also Spanish cognates (cognate-homonyms).When homonyms were primed by their subordinate meanings, RTs were much slower for uniquely English homonyms than for cognate-homonyms.Thus, the subordinate bias effect (SBE) differed for the two word types, presumably because cross-language activation of subordinate meanings in the L1 increased their relative dominance during L2 processing.While this study is a compelling demonstration of cross-language effects during bilingual processing, it is unknown whether these effects extend to natural reading, or whether they are modulated by context or individual differences in executive function. In our study, French-English bilinguals (n=48) read English sentences containing uniquely English homonyms (e.g., coach: dominant meaning is sports trainer; subordinate meaning is vehicle), or cognate-homonyms, where subordinate meanings were French-English cognates (e.g., cabinet: dominant meaning is kitchen cabinet; subordinate meaning is governmental body, identical in French).Sentences varied in their prior subordinate bias (George glared at the /cabinet or republican cabinet/, and convinced them to overturn the illegal fiscal policy).All participants completed an executive function battery (working memory, inhibitory capacity).We predicted the effects of executive function to be greatest when the likelihood of cross-language activation was maximal, thus, for French-English bilinguals with low L2 proficiency (Abutalebi & Green, 2007). Consistent with Schwartz et al., gaze durations on target words were longer when a context biased the subordinate meaning, but only for uniquely English homonyms.Thus, cognate-homonyms did not exhibit a SBE.Moreover, suppression of the dominant,

context-irrelevant meanings of homonyms, as reflected by the decreasing size of the SBE, was significantly correlated with increased inhibitory capacity.For uniquely English homonyms, increased inhibitory capacity based on AX-CPT performance correlated significantly with a decreased SBE across all bilinguals. For cognate-homonyms, however, increased inhibitory capacity based on Simon task performance correlated significantly with a decreased SBE, but only for low L2 proficient bilinguals. The results suggest that within- and cross-language lexical ambiguity resolution interact during bilingual L2 reading.Interestingly, the results suggest that the processes involved in bilingual lexical ambiguity resolution draw on executive function resources, in particular inhibitory capacity, similar to what has been found previously for monolingual processing, and perhaps to an even greater extent for bilinguals having low L2 proficiency.

E7 The differential effect of working memory on sentence processing and responding to the comprehension probe ***Newman, S.*** *(1),* ***Seo, R.*** *(1), Malaia, E. (1); Indiana University* – **Objective:** The goal of this study was to explore the role of working memory (WM) in sentence processing. There has long been controversy regarding when and how WM is involved in sentence processing. Many studies have linked the inferior frontal gyrus (IFG) and inferior parietal regions to WM. Given that the IFG has also been linked to syntax, it is unclear whether the region's involvement is due to WM or syntax. We have attempted to clarify this issue here. Methods. 50 participants (34 female, age = 22.42.9) completed a sentence comprehension task in which they were presented with conjoined active and object-relative sentences (5sec) followed by a fixation (6sec) and a comprehension probe (5sec). A measure of WM was obtained, the reading span. fMRI data analysis was performed using SPM8 with the sentence and probe phases being analyzed separately. Reading span was used as a regressor in the second-level analysis. Results. Reading span was correlated with behavioral measures, both reaction time (RT) and error rate: RT ($r = -0.23$, $p = 0.01$) and error ($r = -0.28$, $p = 0.002$). When examining the fMRI data, interestingly, there was no overlap between the regions correlated with reading span during sentence reading compared to responding to the comprehension probe. During sentence reading, reading span was correlated with one region, the posterior cingulate (PCC; MNI coordinates: -8, -44, 6; k=108; z=3.55), but only for the object-relative sentences (Figure A). During the comprehension probe two regions, the superior aspect of the IFG (MNI coordinates: -50, 26, 26; k=92; z=3.65) and the pre-supplementary motor area (SMA; MNI coordinates: -6, 16, 56; k=20; z=3.33), revealed significant correlations with reading span during both conditions (Figure B). Conclusions. The results observed here suggest that different WM systems may be linked to reading/ decoding the sentence compared to responding to a probe. During sentence reading WM capacity was correlated with the PCC. The PCC/precuneus activation has been linked to retrieval of event schemata from episodic memory during real-world event segmentation1, and language comprehension2.During language processing, each verb can trigger an event boundary, leading to an update of the WM representations of the event model. WM capacity has been shown to influence the strategy used to process object-relative sentences3 - low capacity participants process information as soon as it is available, and then revise the event schema while low capacity participants delay activation of an event schema until all arguments for each verb are present, thus avoiding event model revision in garden-path conditions. This suggests that the correlation observed for object-relatives may be due to differential event schema activation. Conversely, the probe involved the IFG and pre-SMA; regions linked to control processes of WM4. This suggests that while both sentence and probe processing evoke memory resources, those resources are quite different. References. 1. Zacks, et al. (2007). Current direction in psychological science, 6:80-84. 2. Yarkoni, et al. (2008) Neuroimage, 41:1408-25. 3. Malaia, et al. (2009). Brain and Language, 108:145-58. 4. Burgess & Braver (2010). PLoSone, 5:e12861- e12861.

E8 Discourse production and comprehension following left anterior medial prefrontal and anterior cingulate lesion ***Balasubramanian, V.*** *(1); 1. Seton Hall University, South Orange, NJ* – **Introduction:** Prefrontal cortex (PFC), by virtue of its location and massive neural connectivity with other regions of the brain, is able to exercise control over higher order cognitive functions, also known as executive functions, and associated linguistic-communicative functions that are uniquely human. Although the lateral frontal/prefrontal cortex lesion and the resultant disorders of language and executive function have been extensively investigated (Frankel, Penn, & Ormond-Brown, 2007), the mesial frontal/anterior cingulated division of the prefrontal cortex and the lesion effect on components of executive function and language use are less well explored. The mesial frontal and anterior cingulated cortex are reportedly associated with selective attention/supervisory attentional systems and working memory (De Nil et al, 2000; Lenartowicz & McIntosh, 2005; Posner & Raichle, 1994). This study attempts to account for symptoms related to language and cognition following anterior cingulate gyrus lesions within the currently developing concepts of 'networks of the brain' (Sporns, 2011). The current study explores the cognitive and higher level language functions in a case with lesion to the left mesial prefrontal and anterior cingulated gyrus. Method: JG, a 64 year old male, and a resident of a long-term rehabilitation hospital with a medical diagnosis of subarachnoid hemorrhage served as the subject of the current study. A CT scan examination revealed left hemisphere lesions in the anterior inferior medial frontal lobe, cingulate gyrus, posterior inferior frontal gyrus, anterior callosal margin. Clinical neuropsychological evaluation of JG revealed moderate to severe impairments in several areas of mental functions including orientation, intellectual functioning, directional orientation and visual perception, verbal learning, and immediate and delayed memory for stories. Extensive clinical language evaluation was indicative of normal performance on

Boston Naming Test and moderate impairment in Controlled Oral Word Association Test. On language comprehension tasks (Token Test), JG's performance was in the low normal range. He showed the tendency to interpret idioms and abstract statements in a concrete manner. In the current study, JG was administered tests related to higher level language functions: The experimental tasks utilized in this study include 1) Discourse Comprehension Test (DCT), 2) Discourse production task (DPT) which involved immediate recall of propositions from the stories presented, and 3) Linguistic Ambiguity Comprehension Test (LACT) which assessed comprehension of lexical (LA), surface structure (SSA), and deep structure (DSA) ambiguities. Results and discussion:The results of the present study indicated that 1) JG's overall scores of 16 on the DCT was well below the scores (37.4) reported for normal controls, 2) on DPT task his recall of the propositions in three stories has ranged between 0% and 20%, and 3) on LACT, JG's scores were as follows: LA= 5, SSA = 3, and DSA = 1 which were well below the scores reported for normal controls (LA =10, SSA = 7.75, and DSA= 9.50). The emerging approaches to the 'networks of brain' could offer a coherent explanation in terms of the extent of network changes that might occur on the same side of the lesion as well as on the contra lateral hemisphere.

E9 Mode-Dependent Social Interference in Bilingual Lexical Selection: An fMRI Study ***Wang, Y. P.*** *(1),* ***Dong, Q.*** *(1),* ***Pat, S.*** *(2),* ***Kuhl, P.K.*** *(2); 1. Beijing Normal University, Beijing , P. R. China; 2. Institute for Learning and Brian Sciences, University of Washington, Seattle* – **Abstract:** Bilingual individuals are different from monolinguals. On the one hand, bilingual speakers have to use one brain to process two languages; on the other hand, they are in a monolingual-bilingual continuum. Considering the potential differences between bilinguals and monolinguals, bilinguals might face more difficulties in lexical selection. Several lines of evidence show that bilingual lexical selection is affected by background information. It is well known that language mode, which represents one type of background information, plays an important role in bilingual lexical selection. However, there has been little research into the role of another important type of background information, social information and the interaction between language mode and social information in bilingual lexical selection. Using fMRI technique, the present study explored the role of social information and language mode in bilingual lexical selection by comparing brain activation patterns in bilingual mode and monolingual mode under different social conditions. The results showed that regardless of mode, monolingual or bilingual, incongruent social cues activated the bilateral frontal areas, prefrontal regions and the left ACC. Importantly, regardless of cue congruency, the bilingual mode, when compared to the monolingual mode, induced additional or increased activation in the right frontal areas, left ACC and caudate, the areas related to language control. These results suggest that an incongruent social cue may interfere with lexical selection, and interference-related brain activation depends on language mode.

SYNTAX

E10 Structural processes in language and music are largely non-overlapping in the human brain ***Fedorenko, E.*** *(1),* ***McDermott, J.*** *(2),* ***Norman-Haignere, S.*** *(1),* ***Kanwisher, N.*** *(1); 1. Massachusetts Institute of Technology, 2. New York University, Center for Neural Science* – Neuroimaging and behavioral investigations have argued for overlap in the cognitive/neural mechanisms supporting structural processes in language and music (Patel_et_al.,1998; Koelsch_et_al.,2005; Levitin&Menon,2003; Tillman_et_al.,2003; Fedorenko_et_al.,2009; Slevc_et_al.,2009), with only one recent study suggesting otherwise (Rogalsky_et_al.,2011). However, neuropsychology studies have revealed dissociations between linguistic and musical deficits (Luria_et_al.,1965; Peretz,1993). To address this discrepancy, we examined the neural locus of structural processing in language and music using fMRI in individual subjects. Each participant (n=12) was run on (1) a language "localizer" experiment that included visually presented sentences and strings of pronounceable nonwords and that has been previously shown to identify key frontal and temporal regions implicated in linguistic processing (Fedorenko_et_al.,2010), and (2) a music experiment with four conditions featuring different degrees and aspects of music structure (intact music, music with scrambled note pitches, music with scrambled note onsets and durations, and music with both pitch and rhythm scrambled). Results:language-sensitive regions.In each subject we defined language-sensitive regions (see Fedorenko_et_al.,2010, for method details) and examined the response of these regions to the music conditions (Fig1a). None of the regions showed a significant IntactMusic>ScrambledMusic effect, although several regions showed a trend in this direction. Moreover, the response to the IntactMusic condition in these regions was on average below the level of the Nonwords condition. Results:music-sensitive regions. First, we performed a group-constrained subject-specific analysis (Fedorenko_et_al.,2010) to search for spatially consistent music-sensitive regions across subjects, using individual activation maps for the IntactMusic>ScrambledMusic contrast (thresholded at p<.001). This analysis yielded bilateral anterior superior temporal regions, bilateral regions in mid/posterior STG/MTG, bilateral regions in the premotor cortex, and a medial region in the posterior parts of the SFG spanning both hemispheres. Each of these regions was activated in at least 8/12 subjects individually (the right temporal regions were present in at least 10/12 subjects). We then examined the response of these regions to the structural manipulations of music and language (Fig1b). All regions showed a highly robust IntactMusic>ScrambledMusic effect as measured from data not used to localize the regions. The response to the PitchScrambled and RhythmScrambled conditions fell between the Intact and Scrambled conditions in all of the regions, suggesting that these regions are sensitive to both pitch and rhythm. However, although most of the music-sensitive regions showed a response to the language conditions, none of the regions showed a significantly greater response

to Sentences than Nonwords. Moreover, the right anterior temporal region (previously implicated in musical processing; e.g.,Peretz_et_al.,1994) and the right posterior temporal region did not respond to the language conditions more than to the ScrambledMusic condition. These data show a robust dissociation between cortical regions that support high-level linguistic and musical processing.These results are consistent with the patient literature, but inconsistent with previous neuroimaging, ERP and behavioral studies that have argued for overlap between domains. We speculate that the previously observed overlap effects originate not within language- or music-sensitive regions discussed above, but rather in the domain-general regions of the fronto-parietal network that have been argued to support a wide range of goal-directed behaviors (e.g.,Duncan,2001).

E11 Subliminal facilitation of predictive effects on syntactic processing in the left frontal region: An MEG study ***Iijima K.*** *(1, 2),* ***Sakai K. L.*** *(1, 3); 1 University of Tokyo, Komaba, Japan; 2 Japan Society for the Promotion of Science, Tokyo, Japan; 3 CREST, Japan Science and Technology Agency, Tokyo, Japan* – Automatic and predictive natures in syntactic processing are crucial to our real-time language comprehension and production. In our previous study, we have reported that the left inferior frontal gyrus (IFG) is involved in predictive effects for the syntactic information of the next-coming verb, which cannot be explained by associative memory or statistical factors (Iijima et al., 2009). In order to elucidate whether the predictive effects are indeed automatic, we incorporated subliminal priming into our minimal-pair paradigm with a syntactic judgment. We hypothesized that a preceding noun phrase (NP) with an accUStive case in object-verb (OV) sentences provided syntactic information of a subliminally presented prime verb, and that a prime verb then facilitated the predictive effects on a target verb, which had the same verb transitivity (i.e., transitive (vt) or intransitive (vi)) as the prime verb. Native Japanese speakers (N = 15) judged grammaticality of two-word sentences, which had either OV or subject–verb (SV) sentence structures. Each sentence consisted of an NP, which was marked with a case particle (-o: accUStive or -ga: nominative), and a verb (vt or vi). After the presentation of an NP, a prime verb, which was always different from a visible target verb, was subliminally presented for 33 ms, using both forward and backward masking of 100-200 ms, followed by a target verb. The prime verb was either congruent or incongruent with the target verb in terms of the verb transitivity, while both the prime and target verbs were semantically related to the preceding NP. Under the neutral condition, a prime noun, which was same as a visible NP, was subliminally presented instead of the prime verb. We found that congruent prime verbs significantly reduced the RTs for OV sentences compared to SV sentences. Moreover, the inverse efficiency (RTs divided by proportion correct) of syntactic judgment was significantly smaller under the congruent than neutral condition only for OV sentences, confirming the priming effect. We measured cortical responses to a target verb with MEG, and adopted a cluster analysis with permutation tests. Consistent with the behavioral effect under the congruent condition, we found significantly enhanced cortical responses to OV sentences in the left IFG (Brodmann's areas 44 and 6) at 150-170 ms after the verb onset, when compared with SV sentences (corrected $P < 0.05$). Moreover, the responses to OV sentences were significantly larger under the congruent than incongruent condition (see Figure). In contrast, we also found significantly reduced cortical responses to OV sentences in the midcingulate cortex (Brodmann's areas 24) at 280-300 ms under the congruent condition, which suggest that conflict or cost of monitoring process was reduced by congruent prime verbs. These novel findings suggest that even unconscious stimuli can facilitate on-going predictive processing of syntactic information in a structure-dependent way, further supporting the automatic and domain-specific natures of syntactic processing in the left IFG. **Reference:** Iijima, K., Fukui, N., & Sakai, K. L. (2009) The cortical dynamics in building syntactic structures of sentences: An MEG study in a minimal-pair paradigm. NeuroImage 44, 1387-1396.

E12 Specialization of the human language areas for the recursive computation of syntactic structures ***Ohta, S.*** *(1,2),* ***Fukui, N.*** *(2,3),* ***Sakai, K. L.*** *(1,2); 1. The University of Tokyo, Graduate School of Arts and Sciences, Tokyo; 2. CREST, Japan Science and Technology Agency, Tokyo ; 3. Sophia University, Tokyo* – The identification of crucial factors for syntax-selective activations has been a key issue in the neuroscience of language. It has been proposed in modern linguistics that Merge and Agree are the two fundamental formal operations in human language. Merge combines adjacent syntactic objects (words or phrases) to form a larger structure, while Agree checks the agreement of linguistic features between a pair of phrases. When Merge and Agree are recursively applied, the hierarchical structures of embedded phrases are automatically generated. To measure the degree of recursive computation, we introduce the novel concept of "degree of embedding" for recursively embedded phrases. To minimize semantic components, we prepared Jabberwocky sentences composed of written pseudowords and actual Japanese grammatical particles alone in the present fMRI study. Each Jabberwocky sentence always consisted of a pairing of a pseudonoun phrase (N) and a pseudoverb phrase (V). We introduced the following sentence conditions: nested sentence (NS), conjoined sentence (CS), and simple sentence (SS). For the NS, an entire sentence was constructed by nesting sentences in the form of [N2[N1V1]V2], where the subscripts denote matching orders; [NiVi] always represents a subject-verb pair of a sentence. For the CS, a whole sentence was constructed by conjoining multiple sentences in parallel in the form of [N1V1] [N2V2]. For the SS, a simple sentence was constructed by adding left or right branches in the form of [(NN1)(VV1)]. To ensure that the participants really constructed the syntactic structures of Japanese sentences under these three conditions, the participants were required to check an agreement between a subject and a verb in a matching task. Given that Japanese verbs lack such features

as number and person, we imposed a matching rule that the last vowel of the pseudoverb root matched the vowel of the subject. In addition to the sentence conditions, we modified the length of sentences: short (S) and long (L) sentences. To verify whether matching orders are sufficiently effective to modulate activation of the language areas, we introduced two string conditions lacking any syntactic structures: reverse-order string (RO; A2A1B1B2) and same-order string (SO; A1A2B1B2), where the first and second halves of a string were labeled as As and Bs, respectively. We observed that the (NSL – CSL) > (SSS – CSS) contrast clearly localized activation in the left inferior frontal (L. F3op/F3t) and supramarginal gyri (L. SMG) (corrected $p < 0.05$) (Figure A). By fitting the models of various factors to activations, we found that "degree of embedding" was the best factor for L. F3op/F3t activation, and that "degree of embedding + Merge/Agree" was the best factor for L. SMG activation (Figure B; overlaid red dots and lines, the values fitted with the estimates of each factor). By directly contrasting Jabberwocky sentences with letter strings, i.e., (NS – SS) > (RO – SO), we demonstrated that the activations in L. F3op/F3t and L. SMG persisted, irrespective of identical matching orders and symbol orders. The present results thus demonstrate that L. F3op/F3t and L. SMG are specialized in the recursive computation of syntactic structures.

E13 Priming at a Distance:Evidence for the Dual-Mechanism Account of Syntactic Priming ***Boudewyn, M.A.*** *(1),* ***Tooley, K.M****. (2),* ***Zirnstein, M.*** *(1),* ***Swaab, T.Y.*** *(1), and* ***Traxler, M.J.*** *(1); 1. University of California, Davis; 2. Beckman Institute, University of Illinois* – Syntactic priming refers to a processing benefit for a given sentence, following previous exposure to a sentence of the same or similar grammatical structure. Current theorizing on syntactic representation and processing proposes that different mechanisms may contribute to observed syntactic priming effects (Tooley & Traxler, 2010). Priming effects may be short lived, due to rapidly decaying activation of processing nodes in a neural network. Alternatively, they may be longer lived, due to persistent changes in the pattern of connections within such a network. Research on speech production indicates that syntactic priming effects can persist for relatively long time-spans (Bock & Griffin, 2000; Bock et al., 2007), suggesting that implicit learning and durable change play a role in syntactic priming in that domain. Behavioral, ERP and neuroimaging studies have all produced evidence for syntactic priming effects during on-line comprehension.Such effects manifest as faster reading times, reduced P600 effects, and repetition suppression (i.e. decreases in BOLD activity) in the left peri-sylvian language network when a syntactically-related prime sentence precedes a target (e.g. Ledoux et al., 2007; Noppeney & Price, 2004; Traxler & Tooley, 2008; Tooley et al., 2009; Weber & Indefrey, 2009). However, in these studies, the target sentences immediately followed their primes. As a result, it is not possible to determine the extent to which the observed effects are caused by short-lived residual activation versus more persistent changes in the underlying syntactic representations. To address this question, in the current study we inserted one or more unrelated sentences between prime and target. In Experiment 1, we used electrophysiological measures of brain activity during online sentence comprehension to investigate the modulation of neural activity to repeated syntactic structures when zero or one unrelated filler appeared between the prime and target. Reductions in the P600 indicated that processing the prime sentence facilitated processing of the syntactic form of the target sentence. Further, the P600 was reduced to a similar degree whether zero or one filler sentences intervened between the prime and the target. Experiment 2, an eye-tracking experiment, produced evidence for syntactic priming when one or three filler sentences intervened between the prime and the target. As in Experiment 1, the magnitude of the priming effects did not differ when one or three sentences separated prime from target. Experiment 3 replicated the priming effect observed in Experiment 2 when three unrelated sentences appeared between the prime and the target. The results of this study show reliable syntactic priming effects during comprehension when no sentences intervene between prime and target and across a lag of up to three sentences. This suggests that two mechanisms are required to explain syntactic priming effects:a short-term residual activation mechanism as well as an implicit learning mechanism that produces durable changes in the pattern of connections underlying syntactic processing. Figure 1: Comparison of the determiner in prime (blue) compared to target (red) sentences, in the zero lag (top) and lag 1 (bottom) conditions. ERPs are time-locked to the preceding word ("by"); the x-axis represents a 1400 ms epoch after stimulus onset. Onset of the determiner is at 500 ms. Negative is plotted up. References Bock, K., & Griffin, Z. M. (2000). The persistence of structural priming: Transient activation or implicit learning? Journal of Experimental: General, 129, 177-192. Bock, K., Dell, G. S., Chang, F., & Onishi, K. H. (2007).Persistent structural priming from language comprehension to language production. Cognition, 104, 437-458. Ledoux, K., Traxler, M.J., & Swaab, T.Y. (2007).Syntactic priming in comprehension: Evidence from event-related potentials.Psychological Science, 18, 135-143. Noppeney, U., & Price, C.J.(2004).An fMRI study of syntactic adaptation.Journal of Cognitive Neuroscience, 16(4).702- 713. Thothathiri, M., & Snedeker, J. 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comprehension.NeuroImage, 46, 1164-1172.

E14 Placing heads in phrases: when bilingual parameters clash ***Erdocia, K.*** *(1),* ***Zawiszewski, A.*** *(1),* ***Laka, I.*** *(1); 1. University of the Basque Country* – **Introduction:** Age-of-acquisition (AoA), proficiency and linguistic distance are crucial factors in the research of the neural basis of bilingualism (Kotz, 2009). Basque-Spanish bilinguals constitute an ideal population to study the impact of these factors because there are bilinguals of all types along those three dimensions, and because Basque and Spanish resemble each other regarding some grammatical properties while they differ regarding others. Both languages have verb agreement, they have different case systems (ergative-absolutive in Basque; nominative-accUStive in Spanish) and opposite values of the head-directionality parameter that determines whether heads are placed at the end of phrases (as Japanese, Subject-Object-Verb type language) or at the beginning of phrases (as English, SVO type). Zawiszewski et al. (2011) show that highly proficient and early Spanish-Basque bilinguals (AoA=3 years old) process verb agreement violations like natives (N400 and P600), whereas the two groups differ when processing ergative case violations (natives showed N400 and P600, non-natives only N400). Objective: We aim to further determine the impact of structural distance between native and non-native grammars in bilingual syntactic processing. To this end, we focus on the opposite value of the head-directionality parameter (word order: VO vs. OV) is processed by Spanish-Basque bilinguals. Methods: In two experiments, two groups of proficient early Spanish-Basque bilinguals (AoA=3y.o.) read sentences in Basque and answered comprehension questions. Three types of sentences were presented: canonical SOV, scrambled OSV, ambiguous sentences that could be interpreted either as SOV or OSV (as in Erdocia et al., 2009). In experiment 1, self-paced reading times were recorded, while in Experiment 2 participants' event-related-brain potentials (ERPs) were recorded. The results of these groups are compared to those of Basque native speakers reported in Erdocia et al. (2009), who performed the same tasks with the same materials. Results: In Experiment 1, similar to native speakers, bilinguals showed higher error rates and longer reading times for OSV than SOV sentences. Additionally, also like natives, ambiguous sentences were read as SOV. In Experiment 2, bilinguals showed a large negativity (200-600ms.) for the initial O of the OSV sentence relative to the initial S; at second position, a frontally distributed negativity (200-400ms.) followed by a P600 was found. At verb position, OSV sentences elicited a larger positivity (700-900ms.) than SOV. Regarding the ambiguous sequences a positivity (600-800ms.) emerged at disambiguation point (the verb) when its meaning forced an OSV interpretation. These ERP patterns differed from those found in natives: at the first phrase, the negative component was longer for non-natives; at second phrase, natives did not show P600 effect; at the verb, the distribution of the positive effect was different for both groups. For ambiguous sentences, natives displayed a broadly distributed negativity, while non-natives showed a positive effect. Conclusions: Although behaviorally natives and proficient-early non-natives are indistinguishable, the neural substrate underlying syntactic computation is not the same, as detected by electrophysiological measures. The different processing strategies revealed by these different ERP patterns suggest that the opposite head-directionality values for L1 and L2 are at the source of the effects obtained.

E15 Working memory span modulates the latency of event-related potential (ERP) responses to gap-filling ***Hestvik, A.*** *(1)* ***Bradley, E.*** *(1),* ***Bradley, C.*** *(1,2); 1. University of Delaware, Newark, DE; 2. Florida International University, Miami, FL* – **Objective:** The objective was to use measure how the time course of gap-filling is affected by individuals' WM span. In a recent study, (Roberts et al. 2007) measured antecedent reactivation at the gap in sentences like Sue saw the hippo to which the tall giraffe gave the sweet tasty orange [GAP] in the jungle yesterday afternoon, and found that only subjects with high working memory (WM) span reactivated "hippo" at the gap position. This raises the question: Do low span subjects fill the gap at all (perhaps requiring more time), or do they interpret via other means? **Method:** 36 University of Delaware undergraduates participated. Based on the Listening Span test (Daneman and Carpenter 1980), they were divided into 15 high span and 21 low span subjects. The ERP experiment presented 64 ungrammatical sentences like "The zebra that the hippo kissed the camel on the nose ran away", compared to a control condition with a relativized adverb,"The weekend that the hippo kissed the camel on the nose, it was raining." (Note: ungrammaticality is not critical; continuations like "The zebra that the hippo kissed the camel for" would still lead to a filled gap effect (Stowe et al. 1991)). Two additional distractor conditions were included, totaling 256 trials. EEG was recorded with 128 channels and time-locked to the onset of the determiner of the filled gap NP. Based on previous findings (Hestvik et al. 2007), we predicted an (early) Left Anterior Negativity at the filled gap, driven by the violation of the expectation of a gap consistent structure after the verb. **Results:** We observed anterior negativities in 150-200ms and 300-500ms time range, and a P600. The negativities were bilaterally distributed rather than left-lateralized, as is often observed (Hagoort et al. 2003). Statistical tests showed main effects of grammaticality and interaction with WM for all three ERPs. Orthogonal contrasts for successive 100ms time bins showed that the AN and the P600 was significant 200ms earlier for the high WM group (see Figure 1). The early AN was only present in the high WM group. **Conclusion:** Low-span subject do fill the gap but are 200ms slower than high span subjects. Both groups exhibit grammaticality ERP responses, which shows that WM plays no role in wellformedness computation (Sprouse et al. to appear), but only affects processing (Kluender and Kutas 1993). Sentence processing involves predictively building tree structures in advance of hearing words (Lau et al. 2006). The current finding suggests high span subjects build larger predicted tree structures in less time, which makes them faster at noticing when a prediction is not met.

E16 Event-Related Brain Potential Indices of Hyper-Actice Gap-Filling ***1. Hestvik, A.*** *(1),* ***Stöhr, A.*** *(1),* ***Kurban, E.*** *(1,2),* ***Seong, J.*** *(1); 1. University of Delaware, Newark, DE; 2. University of Pennsylvania, Philadelphia, PA* – (Omaki et al. under revision) argue, based on self-paced reading time data, that active gap-filling during processing of long-distance dependencies does not take the transitivity status of verbs into account during the initial processing, because they observed a reading time disruption at the underlined verb and the following adverb for both transitive and intransitive verbs in the test conditions (a,c) compared to the controls (b,d) (because empirically, there is no active gap-filling into Wh-islands). a.The city that [the author wroteregularly about] was named for an explorer. b.The city that [the author [who wrote regularly saw]]was named for an explorer. c.The city that [the author chatted regularly about] was named for an explorer. d.The city that [the author [who chatted regularly saw]] was named for an explorer. The reading disruption arises because the attempt to initially place the gap immediately after the verb leads to a semantic incongruity for transitives (you can't "write a city"), whereas for intransitives, the reading disruption arises from a subcategorization violation (you can't "chat" a city any more that you can "chat a story"). Thus, the reading disruptions arise from different underlying properties of mental representations, and should be accompanied by qualitatively different brain responses. The objective of the current study was to test this prediction. Transitives should elicit an N400 semantic incongruity response (Garnsey et al. 1989). Previous ERP studies of subcategorization violations have observed LAN (Rösler et al. 1993), bi-phasic N400-P600 (Osterhout et al. 1994), and N400 (Frisch and Schlesewsky 2001; Frisch et al. 2004). We predicted a LAN/P600 response to a filled gap after an intransitive verb, as it would merely involve an extraneous syntactic category.

34 University of Delaware undergraduates participated in a replication of Omaki et al's Experiment 1, in which subjects read sentences word-by-word self-paced, and answered a comprehension question after each trial, while EEG was recorded. ERPs epochs were time-locked to the onset of the critical verb. 11 subjects with accuracy below 75% or who failed to exhibit a clear visual N170 ERP response were rejected. No significant reading time effect was observed at the critical verb or the spill-over region. (A robust reading time disruption was observed at the end of the subject relative clause in the control condition, which we interpret to be due to a Garden Path effect). A main ERP effect of filled gaps was observed in an anterior negativity in central-to-left anterior electrodes, peaking at around 350ms (Figure 1, panel a). In addition, a modulation of the visual N170 response was observed for transitives but not for intransitives (Figure 1, panel b,c). The main effect ERP supports the claim of hyper-active gap-filling, but the lack of interaction with verb type does not support different underlying mechanisms. However, the modulation of the N170 for transitives can be interpreted as a semantic "visual mismatch" effect. Its absence for intransitives can be taken as evidence that no semantic congruency expectation is violated when a filled gap is temporarily constructed after e.g. "chat".

E17 Exploring the neural bases of dependency resolution using coordination sentences ***Linzen, T.*** *(1),* ***Shetreet, E.*** *(2,3)* ***Friedmann, N.*** *(3); 1. New York University, New York; 2. Children's Hospital Boston, MA; 3. Tel-Aviv University, Tel Aviv, Israel* – **Introduction:** During language comprehension, a noun phrase (NP) that has been introduced in an early position in the sentence often needs to be reaccessed in a later position, where it is not pronounced again. Relative clauses (RC) form a typical example of such dependencies: in the phrase "the man I know", for instance, "the man" functions first as the head of the entire NP and later as the direct object of the verb "know", and thus needs to be reactivated after the verb. Indeed, most neuroimaging studies that investigated structures with dependencies have focused on RCs (e.g., Constable et al., 2004). However, RC dependencies are formed by Wh-movement, and it is unclear whether the brain areas reported in these studies are only related to that particular type of dependency, or to Wh-movement. To test whether some of these brain areas are activated by other types of dependencies, we used coordination sentences that include a dependency, but not Wh-movement. Methods: We compared 2 conditions in an fMRI study: coordination sentences with a dependency (example 1) and matched coordination sentences without a dependency (2). (1) Dependency coordination: Ivan listened to the guitarist and smiled behind Boris. (2) No-dependency coordination: Ivan listened to the guitarist and Boris smiled. The first conjunct in both sentences included a full NP object, because a study of coordination comprehension (Friedmann & Costa, 2010) found that subjects' performance on dependency coordination sentences is similar to their performance on RCs once the dependency crosses over another prepositional phrase (PP). The second PP ("with Boris") was added to the dependency coordination condition so that the two conditions were matched for the number of NPs and the total number of maximal projections (Munn, 1993). The study was conducted in Hebrew, where the syntax of these types of coordinated sentences is essentially identical to English. Fifteen native Hebrew speakers were presented with 64 sentences, 32 of each condition, and performed an irrelevant semantic task throughout the fMRI scan. Results and Discussion: A group level comparison between the dependency and no-dependency conditions revealed increased bilateral activation for the dependency condition in the superior temporal lobe, anterior to the auditory cortex. Superior temporal activations were also found in previous studies comparing structures with dependencies, specifically sentences with RC, to structures without dependencies (e.g., Ben-Shachar et al., 2003; Constable et al., 2004). However, those studies found activations in more posterior areas. It is possible that the superior temporal regions are subdivided with regard to the processing of different types of dependencies. Additionally, we did not find increased activation for dependency coordination in the areas of the inferior frontal gyrus often associated with Wh-movement (Broca's area), indicating that we have successfully dissociated dependency resolution from syntactic operations. In sum, our results add to the existing literature by showing that the superior temporal lobe

is recruited bilaterally during the resolution of dependencies, even in sentences that do not involve Wh-movement.

E18 MEG correlates of grammatical agreement processing in Spanish ***Molinaro, N.*** *(1),* ***Monahan, P. (1),*** ***Barber, H.A.*** *(2)* ***Carreiras, M.****(1); 1. BCBL, Donostia-San Sebastian, Spain; 2. Universidad de La Laguna, La Laguna, Spain* – Grammatical agreement patterns have received increasing attention in the literature focusing on the neurocognitive correlates of sentence comprehension: agreement could be defined as the covariation in the inflectional morphological properties of two structurally related words. Morphologically rich languages (like Spanish) present a large variety of agreement patterns spanning on many feature-dependent dimensions: in this study we focus on number vs. gender agreement patterns. Number features express the numerosity of the entities expressed in the message (mesa - table - vs. mesas - tables) while grammatical gender features do not always have a transparent semantic interpretation (mesa, for example, is arbitrarily feminine). In addition, while number features independently combine with a noun stem, grammatical gender is an invariant property of each noun. Former electrophysiological studies (ERPs) have proved critical insights on the time course of this phenomenon, showing that an agreement dependency is evaluated around 300 ms after the target word presentation: an agreement violation (*El mesa...) elicited an increased left-frontal negative component in this time window compared to a correct construction (La mesa...). Critically, Barber & Carreiras (2005) showed that this Left Anterior Negativity was not sensitive to the type of feature violated, since a Gender Mismatch (*El mesa...) elicited the same effect compared to a Number Mismatch (*Las mesa...). Differential effects were reported only 700 ms after word onset. In this study we analyzed the neurophysiological patterns elicited by Gender and Number Mismatches focusing on the neuromagnetic (MEG) correlates of the detection of these ungrammaticalities (compared to a grammatical Control condition). 17 native Spanish speakers read minimal sentences that could either be grammatical or contain an agreement violation (either Number or Gender). Participants were required to evaluate the grammaticality of each short sentence. The evoked neuromagnetic activity was recorded using a 306-channel whole-head Elekta MEG system. L2-norm solutions (MNE software) constrained to the Freesurfer reconstructed brain of the 17 participants were calculated based on (noise-normalized) sensor-level data. The three critical conditions showed increased activity in the superior areas of the temporal lobe bilaterally, starting around 200 ms. Activity around 300 ms tended to be more left-lateralized in the same areas. The contrast between the different conditions (Ungrammatical vs. Grammatical) showed increased magnetic activity for the Ungrammatical ones starting around 200 ms in the superior temporal areas. Interestingly, the effect was left-lateralized for the Gender-Control comparison while the Number-Control comparison showed increased activity in the homologous areas of the right hemisphere. These findings show brain sensitivity to agreement manipulations already around 200 ms after target word onset. In addition, they suggest that both hemispheres' temporal areas are involved in grammatical agreement processing. Interestingly, mismatch in grammatical gender, a feature tightly connected to each lexical item, increases activity in left superior temporal areas (usually involved in lexical-semantic processing). Number agreement mismatches on the opposite showed increased activity in the homologous right temporal areas, maybe because of their independence from the lexical properties of the target noun. In general, these findings show the differential sensitivity of the brain to qualitatively distinct agreement features. Barber, H. & Carreiras, M. (2005). Grammatical Gender and Number Agreement in Spanish: An ERP Comparison. Journal of Cognitive Neuroscience. 17:1, 137-153.

E19 Neural correlates of unaccUStive and unergative verb processing *Schuchard, J. (1),* ***Kielar, A.*** *(1),* ***Barbieri, E.*** *(2),* ***Thompson, C.K.*** *(1); 1. Northwestern University, Evanston, IL; 2. University of Milano-Bicocca, Department of Psychology, Milan, Italy* – Successful sentence comprehension requires processing information associated with the verb, including the number and type of arguments. UnaccUStive and unergative verbs both require a single argument but differ with respect to the argument structure entailed within their lexical entries. UnaccUStives select for a theme argument, which in sentences undergoes syntactic movement from the object to the subject position. Unergatives only select for an agent, which is base generated in the subject position; hence no object movement is required. The present study investigated the neural correlates of processing unaccUStive and unergative verbs in sentence context using fMRI. Previous fMRI studies indicate that verb argument structure complexity maps onto the brain, with bilateral posterior temporoparietal regions recruited for processing of verbs with a greater number of arguments (i.e., two- and three-arguments versus one-argument) (Thompson et al., 2007; 2010) and left inferior frontal and posterior middle temporal regions activated for verbs with theme versus agentive arguments (Shetreet, Friedmann, & Hadar, 2010). Based on these findings, we hypothesized that the greater syntactic complexity of unaccUStives relative to unergatives would activate bilateral inferior frontal and posterior perisylvian regions. Stimuli included forty sentences with unergative verbs and forty with non-alternating unaccUStive verbs. Half the sentences were semantically plausible (The boy was rising from the bed) and half implausible (The boy was rising from the egg). Thirteen healthy monolingual English speakers performed a semantic anomaly detection task while listening to blocks of sentences with unaccUStive or unergative verbs. Participants also performed blocks of a pitch discrimination control task in which they heard three tones and judged whether the last tone was the same as the first two. Compared to pitch discrimination, processing of both sentence types elicited bilateral activation in anterior and posterior language regions, i.e., superior and middle temporal and inferior frontal gyri (STG, MTG, and IFG, respectively). As predicted, participants exhibited enhanced activations for sentences with unaccUStives relative to sentences

with unergatives. However, significant clusters of activation, differentiating the two sentence/verb types, were located in the right IFG and STG. These results suggest that right hemisphere regions may be required for computing complex verb argument structure. The right hemisphere may also be recruited for complex sentence processing in individuals with aphasia subsequent to language treatment (Thompson et al., 2010) and for a variety of high-level language tasks in healthy individuals (Jung-Beeman, 2005). Thus, the findings of the present study contribute to a growing body of work implicating right hemisphere regions in linguistic processes.

E20 The effects of complement predictability on the processing of verb's complementation options ***Shetreet E.*** *(1,2),* ***Linzen T.*** *(3),* ***Friedmann N.*** *(1); 1. Tel Aviv University, Tel Aviv, Israel; 2. Children's Hospital Boston, Boston, MA; 3. New York University, New York* – It has been shown that the more complementation options a verb has, the greater the brain activations associated with its processing, specifically in the left posterior superior temporal gyrus (LpSTG). Reaction time findings yielded similar results. These findings suggest that once a verb is accessed all of its complementation options are activated. This study examined whether the entire set of complementation options is activated when accessing the verb, even in contexts where it seems unnecessary. To do so, we performed two tests. First, we examined the activation related to verbs with several complementation options that are biased towards one of these options (defined as verbs that appear with one of their options in more than 85% of its appearances in a corpus). We asked whether this strong bias towards a specific option reduces the likelihood of accessing the other options. Namely, whether even in these biased verbs all possible complements are accessed. Second, we tested whether exhaustive access to all complementation options occurs even when the verb is accessed after the complement had already been introduced. That is, we asked whether the early selection of a specific option results in a reduction of the processing load when accessing the verb. We did so using topicalized sentences, in which the complement precedes the verb (and the subject). Our fMRI experiment included, thus, five conditions of Hebrew sentences. Three conditions of Subject-Verb-Object (SVO) sentences included verbs with one complementation option, verbs with multiple options that are biased towards one of them, or verbs with multiple options and no bias. To evaluate the second research question, two conditions included Object-Subject-Verb (OSV) sentences (which are grammatical in Hebrew) with verbs with one option, or with verbs with multiple (unbiased) options. We performed a region of interest analysis of the LpSTG, with the coordinates identified in previous studies of complementation options processing. As in other studies, the processing of multiple-option unbiased verbs yielded higher activation than the processing of one-option verbs. The activation related to the processing of multiple-option biased verbs was even higher than the activation related to the processing of multiple-option unbiased verbs. Additionally, the processing of multiple-option unbiased verbs in OSV sentences showed higher activation than the processing of one-option verbs in this sentence structure, while not showing any difference from the activation related to the processing of multiple-option unbiased verbs in simple SVO sentences. Our results suggest that exhaustive access to the verb's complementation options is always performed with the verb, even when the complement type is already known or is highly predictable.

E21 The Left Hemisphere Alone Cannot Process Sentences That Are Not Easy ***Hyun, J.*** *(1, 2, 3),* ***Obler, L. K.*** *(1, 2, 3),* ***Spiro, III, A.*** *(2, 3, 4),* ***Kim, D-S.*** *(5),* ***Albert, M. L.*** *(2, 3); 1. The Graduate Center of the City University of New York, NY; 2. VA Boston Healthcare System, Boston, MA; 3. Boston University School of Medicine, Boston, MA; 4. Boston University School of Public Health, Boston, MA; 5. Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea* – Research Goal. Processing of multiple negative sentences (like "The left hemisphere alone cannot process sentences that are not easy") requires high-level semantic and syntactic abilities as well as cognitive skills (Goral et al., in press). Such sentences are challenging for everyone, more so for healthy elderly individuals than for younger adults. Hyun et al. (2010) reported bilateral frontal and peri-Sylvian regions linked to processing another challenging syntactic structure: object-relative embedded sentences (like "The reporter that the senator attacked admitted the error"). Here we investigated the extent to which these regions are implicated in processing multiple negatives as well. Methods. Twenty-two healthy native English-speaking, right-handed older adults (mean age = 69.27 (range = 56-79); mean education = 15 years; 11 females) were tested.In addition to structural MRI, participants completed a Multiple Negatives comprehension task, judging whether auditory stimuli were "unlikely" (or "likely") to be true. The Multiple Negatives Task comprised three substructures of increasing levels of difficulty: sentences with No Negative (e.g., "Because the ceiling light is off, the room is dark."), sentences with Single Negative (e.g., "Because the ceiling light is not on, the room is dark.") and sentences with Two Negatives "Because the ceiling light is not off, the room is not dark."). Results. The behavioral results showed that there was a significant sentence-type effect (Wilk's Lambda = .391, $F(2, 20) = 15.59$, $p < .001$). Post hoc analysis (with Bonferroni correction) revealed that participants' performance was significantly lower for Two-Negatives (M = 83.64) than for the No-Negative condition (M= 96.81, $p < .001$) and for Single-Negative sentences (M= 93.18, $p < .05$).There was no difference between No-Negative and Single-Negative conditions (See Table 1). To predict the accuracy for regional volume and thickness, separate multiple regressions were conducted for each of the 13 peri-Sylvian ROIs.None of the ROIs was related to the easiest condition (No-Negative), however, the Single-Negative condition was related to broader areas (left and right total gray matter as well as superior temporal gyrus) than Two-Negative sentences which were associated with more specific areas (planumpolare , mid-temporal gyrus) and cortical thickness (pars orbitalis) (See Table

2). Significance. Similar bilateral cortical regions were associated with older adults' accurate performance on processing multiple negatives to those seen on processing of embedded sentences in Hyun et al. (2010), although some differences between the two syntactic types were evident as well. Clearly our study identifies a number of bilateral language-related regions that enter into sentence comprehension. Planum polare has been linked to auditory language processing (Friederici, Meyer, & von Cramon, 2000); both mid-temporal gyrus and pars orbitalis regions to semantic processing (Binder et al., 1997) and pars orbitalis to working memory (Sabb et al., 2007). References. Binder, J. R., Frost, J. A., Hammeke, T. A., Cox, R. W., Rao, S. M., & Prieto, T. (1997). Human brain language areas identified by functional magnetic resonance imaging. Journal of Neuroscience. 17, 353-362. Friederici, A. D., Meyer M., & von Cramon, D.Y. (2000). Auditory language comprehension: An event-related fMRI study on the processing of syntactic and lexical information. Brain and Language 74, 289–300. Goral, M., Clark-Cotton, M., Spiro, A, Obler, L. K, Verkuilen, J., & Albert, M. (In press). The contribution of set switching and working memory to sentence processing in older adults, Experimental Aging Research. Hyun, J., Obler, L. K., Spiro, III, A., Goral, M., Schnyer, D., Kim, D-S., & Albert, M. L. (2010, Nov). Bilateral hemispheric involvement in sentence processing in older adults. Poster presented at the Neurobiology of Language, San Diego, CA. Obler, L. K., Rykhlevskaia, E., Schnyer, D., Clark-Cotton, M. R., Spiro, A.,3rd, Hyun, J., Kim, D. S., Goral, M., & Albert, M. L. (2010). Bilateral brain regions associated with naming in older adults. Brain and Language, 113, 113-123. Sabb, F.W., Bilder R. M., Chou, M., & Bookheimer, S.Y. (2007). Working memory effects on semantic processing: priming differences in pars orbitalis. Neuroimage, 37, 311-22.

E22 Word, syntax, and context in sign language: An fMRI study ***Inubushi, T.*** *(1)* ***Sakai, K.L.*** *(1); 1. The University of Tokyo, Japan.* – Word, syntax, and context are different in terms of hierarchy in linguistic processes, which combine various elements into another higher level of constructs, i.e., words, sentences, and discourse, respectively. The commonality of these fundamental processes between spoken and sign languages provides us a unique opportunity to reveal the modality-independent and thus universal features of linguistic processes. Although previous neuroimaging studies have shown that these processes in spoken languages elicit some overlapping activation in the left language areas, the hierarchical organization of these regions also critical in sign language have not been fully elucidated. Here, we conducted an fMRI experiment with three linguistic tasks that required explicit decisions about word, syntax, and context, together with a nonlinguistic task to detect the repetition of reversed video-taped images used in the linguistic tasks. The 30 participants (18 females; ages 12-60 years; hearing loss > 75 dB; laterality quotient (LQ) > -10) were all congenitally and profoundly deaf. In the linguistic tasks, the participants judged whether there was an error in video-taped images of signs in Japanese Sign Language (JSL). The stimuli were dialogue sentences articulated by two signers doing 'turn-taking'. In the word and syntax tasks, however, dialogue sentences were randomly re-ordered, so that it was impossible to restore contextual information of the original dialogue. Error stimuli in the word task were manual gestures that were nonwords in JSL. Error stimuli in the syntax task included violation in tense, person, word order, etc. Error stimuli in the context task were contextually anomalous words, which belonged to the same grammatical category as the phrases they replaced. The nonlinguistic task controlled both basic stimuli and task requirements, and lacked any processing of sentences. Compared with the nonlinguistic task, the word task significantly elicited bilateral, but left-dominant activation in the lateral premotor cortex (LPMC, Brodmann's area 6) and dorsal inferior frontal gyrus (IFG, Brodmann's areas 44/45), as well as in the anterior cingulate cortex (ACC) (Figure A) (FWE corrected $p < 0.05$). In the syntax task, this left frontal activation extended to the left ventral IFG (Figure B); in the context task, the activation extended more ventrally to Brodmann's area 47 (Figure C). The syntax task also elicited activation in the left angular gyrus (AG), and the context task elicited bilateral, but left-dominant activation in AG and the middle temporal gyrus. In both the left IFG and AG, the activations in context vs. nonlinguistic tasks were negatively correlated with the difference in behavioral score of the two tasks, i.e., d'(context task) - d'(nonlinguistic task) ($p < 0.05$), even if the effects of age, LQ, and gender were taken into account. These results suggest that more cortical regions are recruited for hierarchically higher processes, and that the skilful signers can efficiently save the activations of the left IFG and AG to accomplish contextual decisions. We establish for the first time that the left LPMC and IFG subserves syntax in signs as well, demonstrating the existence of universal grammar in both spoken and sign languages.

E23 Distinguishing the respective roles of the MTG and IFG in language comprehension with rTMS ***Acheson, D. J.*** *(1,2),* ***Hagoort, P.*** *(1,2); 1. Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands; 2. Donders Institute for Brain, Cognition, and Behavior* – Previous research has demonstrated an anatomical dissociation between brain regions supporting the storage of lexical-syntactic information in long-term memory from those supporting the integration/unification of this information in sentence comprehension. Snijders et al. (2009, Cerebral Cortex) compared word-class ambiguous words (e.g., noun/verb ambiguous words like run) to unambiguous control words (e.g., jacket) in the context of two behavioral tasks that either did or did not require unification (i.e., reading random lists of words vs. sentence comprehension). Results showed that while regions of the left, middle temporal gyrus (MTG) were sensitive to the ambiguity of the material regardless of the task, regions of the left inferior frontal cortex (IFG) only showed an ambiguity effect for sentences. As a follow-up to this initial investigation, the present study utilizes repetitive transcranial magnetic stimulation (rTMS) to test whether the MTG and IFG are caUSlly involved

in the storage and unification of lexical-syntactic information respectively. Eye-movements were recorded while subject's read sentences and answered comprehension questions for material that either did or did not contain a temporary word-class (noun/verb) ambiguity. Sentences were constructed in such a way that the ambiguous word would initially activate both noun and verb readings, followed by material that disambiguated the word. Thus, each ambiguous sentence contained an ambiguous and a disambiguating region. In order to test whether the MTG and ITG are caUSlly involved in the representation and unification (respectively) of lexical-syntactic information, an off-line rTMS protocol was used. Brain regions were defined according to the group activation in Snijders et al. (2009). Continuous theta burst stimulation (cTBS) was applied over the IFG and MTG on separate days (at least one week apart) at 80% of each subjects active motor threshold for a period of 40 seconds (600 pulses). Following stimulation, subjects performed the sentence reading task for 30 minutes (60 target sentences and 120 filler items). We predicted a Sentence Type (ambiguous vs. disambiguous) X Sentence Region (ambiguous vs. disambiguating) X TMS Brain Region (IFG vs. MTG) interaction, whereby stimulation of the MTG would primarily affect processing at the ambiguous region and stimulation of the IFG would affect the process of disambiguation. Initial results (N=10) indicate that rTMS to the IFG slowed sentence reading overall relative to stimulation of the MTG, with no differences in overall comprehension accuracy. In addition to this main effect, reading times showed that the magnitude of the ambiguity effect (ambiguous – unambiguous) was larger after stimulation of the IFG relative to the MTG in the disambiguating region, suggesting that stimulation of the IFG interfered with the process of disambiguating the sentence material. Although the ambiguous region did not show any effects of rTMS on reading times, stimulation of the MTG led to a bigger difference in regressive movements into the region relative to stimulation of the IFG. These results thus provide some caUSl evidence in favor of a functional dissociation between the MTG and the IFG in the storage and unification (respectively) of lexical syntactic information.

E24 Role of Broca's area in sentence comprehension: a lesion study ***Rogalsky, C.*** *(1),* ***Tomkovicz, V.*** *(1),* ***Shivapour, S.*** *(2)* ***Hickok, G.*** *(3); 1. University of Southern California, Brain & Creativity Institute, Los Angeles, CA; 2. University of Iowa, Iowa City, IA; 3. University of California Irvine, Irvine* – Broca's area has been a focal point for research on the neural basis of sentence comprehension for several decades.Much of this interest stems from the pattern of comprehension found in Broca's aphasics, agrammatic comprehension, in which performance is at chance level for non-canonical (object-first), semantically reversible sentences while canonical (subject-first) sentences yield near ceiling performance.However, damage to Broca's area alone does not cause Broca's aphasia.This raises doubts regarding the link between agrammatic comprehension and Broca's area dysfunction.Here we investigate this issue directly in two ways: (i) by assessing the sentence comprehension performance of patients with radiologically confirmed lesions to Broca's area and (ii) by examining the lesion distribution of patients with agrammatic comprehension.The subject pool consisted of 41 patients with focal left or right hemisphere lesions due to ischemic stroke or anterior temporal lobectomy.From this pool, 7 patients with lesions involving most or all of Broca's area (Figure, left) and 8 patients with agrammatic comprehension (Figure, right) were identified.As part of a larger language assessment battery, comprehension of active, passive, subject-relative and object relative constructions was assessed using a 3AFC sentence-to-picture matching as well as a plausibility judgment task. Results. Only 2 of the 7 subjects with Broca's area lesions exhibited agrammatic comprehension as assessed with the AFC matching task and even these two patients performed more than 2 s.d. above chance (d' = 0) on the non-canonical sentences in the plausibility judgment task (d' = 2.12 for both patients on object relatives).Both of these patients had some superior temporal involvement.Three of the 7 cases had lesions that involved most of Broca's area but did not extend into the posterior parietal or temporal lobe; none of these patients exhibited agrammatic comprehension on either task (80% or better on object relatives). Average performance of patients with lesions involving Broca's area is presented in the Figure, left graphs.Of the 8 patients with agrammatic comprehension as determined on the 3 AFC matching task, only 2 had Broca's area involvement, but again one of these patients had superior temporal involvement and the other had posterior parietal-temporal involvement.The remaining 6 cases had lesions involving posterior parieto-temporal lobe (2), anterior temporal lobe (2), anterior temporal lobe + insula (1), middle temporal gyrus (1). The agrammatic comprehension pattern was found only on relative clause structures in the 3 AFC task; no differences were noted in performance on active versus passive sentences (Figure, right upper graph).Overall performance on the plausibility judgment task was substantially better even on the object relative sentences (mean d' = 2.91, well above chance; Figure, right lower graph). Conclusions. Damage to Broca's area does not predict agrammatic comprehension as damage restricted to Broca's area and immediate vicinity did not result in agrammatic comprehension.Agrammatic comprehension is associated with a wide variety of left hemisphere lesions including large fronto-parietal, temporal-parietal, posterior middle temporal, and anterior temporal regions.Further, agrammatic comprehension is task dependent rather than reflecting a fundamental computational deficiency.

E25 The Dynamics of Complex Morpholexical Processes: Revealed by Searchlight Representational Similarity Analysis of MEG/EEG Data ***Su, L.*** *(1,2),* ***Fonteneau, E.*** *(1,2),* ***Wingfield, C.*** *(2),* ***Marslen-Wilson, W.*** *(1,2); 1.University of Cambridge, UK; 2. MRC Cognition and Brain Science Unit, Cambridge, UK* – **Introduction:** Although the neural basis of speech comprehension has been a growing focus for neuroimaging research, detailed neural models of morpho-

lexical processing are notably absent. Here we explore how the underlying properties of lexical constituents are computed in neural networks situated in bilateral fronto-temporal brain regions that have been previously associated with speech comprehension (c.f. Bozic, M. et al. 2010 and Marslen-Wilson et al. 2007). In particular, we target on the critical process occurs at around Inflectional Recognition Point (IRP). Methods. A novel method that reveals the fine grained structure of neural computation (with centimetre and millisecond precision) has been developed based on the Representational Similarity Analysis (RSA) of MEG/EEG data in source space using searchlight techniques. RSA is a variation of Multivariate Pattern Analysis (MVPA), which has been successfully applied to fMRI data (Haxby et al., 2001; Kriegeskorte et al., 2006; Haynes and Rees, 2006). RSA is based on the pattern-information that is naturally embedded in multi-channel recording of neural activations. 17 healthy, right-handed native English speakers have participated in the experiment. Combined MEG and EEG data was collected at MRC's Cognition and Brain Sciences Unit using a 306-channel Vectorview MEG and 70-channel EEG system. We pre-processed the data with minimum-norm estimation (MNE; Hämäläinen and Ilmoniemi, 1994) with three-compartment boundary-element forward model from structural MRI (3T), and then computed a distributed-source solution combining both MEG and EEG scalp information. After pre-processing, we computed similarity structures that summaries the dynamic patterns of neural activation over space and time. The primary data type that encodes such similarity structure is the representational dissimilarity matrix (RDM). Each entry in an RDM is the correlation-distance between activation patterns elicited by a pair of experimental conditions, e.g. with and without inflection. We then drew neuroscientific inferences from a second level of analysis that compares data RDMs to theoretical models, which were characterized by a set of theoretical model RDMs. These models describe different dimensions of lexical complexity, and form a hierarchical structure. At this step, a spatio-temporal searchlight algorithm combined with nonparametric statistics looks for neuro-computational signatures that are correlated with these models. Results. A bilateral neural network including both frontal and temporal lobes has been indentified using this method. In particular, we are able to separate different neural representations across space and time within the above neural network. Each representation is associated with information embedded in a particular aspect of morpholexical processes. In particular, the processing of inflectional morphemes starts around IRP, and the processing of stem starts well before this point. Conclusions. Our results revealed a dynamic and holistic view of morpho-lexical processing and potentially provide a system level account of neural processing for speech comprehension. In contrast with reductionism, the searchlight RSA combined with time resolved neuroimaging techniques such as MEG/EEG rigorously integrates multiple neuro-psychological components and result in a relatively complete picture of the large-scale interaction in the brain.

E26 Plural attraction in attachment ambiguity ***Lee, E.-K.*** *(1),* ***Garnsey, S. M.*** *(1); University of Illinois, Urbana-Champaign, IL* – In English, subjects and verbs agree in number. However, speakers sometimes produce attraction errors in which a verb agrees in number with some other noun in the sentence rather than the subject noun[1,2]. Wagers et al. (2009)[3] argue that the confusion that leads to plural attraction arises at the point of trying to identify the verb's subject in the memory representation of the sentence so far. However, it remains unclear whether a search for the subject is triggered whenever a verb is encountered, or only when features of the verb do not match those predicted for it based on the features of the subject noun. This study examines mechanisms underlying agreement processing using temporary attachment ambiguity. Each experimental sentence was manipulated for whether it was disambiguated toward a low (1a,b) or high (1c,d) attachment interpretation and whether the attractor noun was plural (1a,c) or singular (1b,d). -1 a. The reporter shocked the advisors of the politician who was at the meeting. b. The reporter shocked the advisor of the politicians who were at the meeting. c. The reporter shocked the advisor of the politicians who was at the meeting. d. The reporter shocked the advisors of the politician who were at the meeting. Sentences were presented in word-by-word fashion in the center of the screen while event-related brain potentials were recorded. After each sentence, participants judged its acceptability. Most previous studies have shown a preference for low attachment in English sentences like (1)[4], with the relative clause modifying the low noun. If retrieval of the subject's number occurs only when the prediction about the verb's number is contradicted, there should be no attraction effects in the low attachment structure because the verb agrees with the low noun as expected. In contrast, if subject retrieval occurs whenever verbs are encountered, there should be plural attraction effects in sentences with both kinds of attachment. Because two nouns that are both syntactically legal subjects strongly compete to control agreement, features like plurality have a better chance to interfere with agreement processing in both kinds of attachment structures. Consistent with the low attachment preference for English, we found a P600 effect 500-900ms after the onset of the relative clause verb when it disambiguated toward the high attachment structure. The effect of attractor number appeared as a frontal negativity 300-900ms after verb onset, with greater negativity at prefrontal electrode sites when the attractor noun was plural than when it was singular. This pattern suggests that the plural attractor noun increased the demands imposed by having to select among multiple candidates for subject status[5]. However, this effect did not interact with attachment type, ruling out the prediction-based account. The results support the view that agreement processing always involves a cue-retrieval process in which the features of the subject are re-accessed at the verb. In temporarily ambiguous structures like (1), the retrieval mechanism results in interference from a plural attractor, which leads to confusion about which noun is the subject, even though verb number fully disambiguates attachment. References. [1] Bock, J. K. &

Eberhard, K. M. (1993). Meaning, sound, and syntax in English number agreement. Language and Cognitive Processes, 8, 57-99. [2] Bock, J. K., & Miller, C. A. (1991). Broken agreement. Cognitive Psychology, 23, 45-93. [3] Wagers, M., Lau, E.F., & Phillips, C. (2009). Agreement attraction in comprehension: Representations and processes. Journal of Memory and Language, 61, 206-237. [4] Cuetos, F., & Mitchell, D. C. (1988). Cross-linguistic differences in parsing: Restrictions on the use of the Late Closure strategy in Spanish. Cognition, 30, 73-105. [5] Van Berkum, J. J. A., Brown, C. M., & Hagoort, P. (1999). Early referential context effects in sentence processing: Evidence from event-related brain potentials. Journal of Memory and Language, 41, 147–182.

CONCEPTUAL/SEMANTIC/DISCOURSE PROCESSING

E27 Neural differences in metaphor processing modulated by modality ***Schmidt, G. L.*** *(1),* ***Drew, A.*** *(1),* ***Miller, E.*** *(1); 1. Hope College, Holland, MI* – While some researchers cling to amodal explanations of the semantic system in the brain, it is becoming increasingly clear that our conceptual system must be embodied at least to some extent. This is consistent with the view that semantic representations of words are processed in neural regions similar to where perception of the related concepts (e.g. visual or auditory) is processed (Thompson-Schill, 2003). This sensory-motor grounding may also extend to the metaphoric meanings of the words (Gibbs, 2006). For example, words depicting actions recruit motion-processing areas of the visual system (Wallentin et al., 2005). A fruitful next step would be to explore the graded nature of the embodiment of concepts whereby concepts and words are embodied to differing degrees along a gradient (Chatterjee, 2010). For example, it may be that semantic representations of literally and metaphorically used words extend to neural regions related to their modality in such a graded fashion. Our objective was to explore this idea using the N400, a negative-going event-related potential (ERP) component 400 ms post stimulus which is a gauge of semantic processing difficulty. We expected that both figurativeness and modality would alter the scalp distribution of the N400, suggesting that both of these factors mediate the neural basis of semantic processing. We used a highly controlled set of literal, metaphorical, and anomalous sentences ending in words from two modalities, audition and motion (Cardillo et al., 2010). This resulted in literal auditory ("The interruption was a loud knock"), metaphorical auditory ("His emails were an insistent knock"), literal motion ("His gait was a confident swagger)" and metaphorical motion ("His yacht was a rich swagger") sentences, as well as anomalous sentences. Twenty right-handed native English speakers categorized the visually presented sentences as literal, metaphorical, or anomalous. The N400 response to the last word of the sentence was calculated by averaging electroencephalographic (EEG) recordings at 64 scalp sites and based on the area under the curve from 300 to 400 ms post-stimulus. Significant findings included a main effect of sentence type, an interaction between sentence type and electrode site, and an interaction between sentence type, electrode site, and modality. Motion metaphors created a different N400 scalp distribution than motion literal sentences, a difference that did not exist for auditory metaphors. These results support different neural instantiations modulated by modality, providing support for sensory-motor views of language. The findings also suggest that any work on the neural basis of language comprehension must take into account specific semantic attributes such as modality. The lack of such control in the past may account for discrepant findings across studies.

E28 Tracking Neural Coding of Perceptual and Semantic Features of Concrete Nouns ***Sudre, G.*** *(1),* ***Pomerleau, D.*** *(2),* ***Palatucci, M.*** *(1),* ***Wehbe, L.*** *(1),* ***Fyshe, A.*** *(1),* ***Salmelin, R.*** *(5),* ***Mitchell, T.*** *(1); 1. Carnegie Mellon University, Pittsburgh, PA; 2. Intel Labs, Pittsburgh, PA; 3. Aalto University School of Science, Espoo, FI* – We report results employing magnetoencephalography (MEG) and machine learning techniques to investigate the flow of perceptual and semantic information in the half second during which the brain processes the meaning of a concrete noun. Important information about the location of neural activity related to the representation of nouns in the human brain has been revealed by past studies using fMRI. However, the temporal sequence of processing from sensory input to concept comprehension remains unclear, in part because of the poor time resolution provided by fMRI. We used two different MEG experiments in this study. In the first task, subjects answered 20 questions (e.g. is it alive?) about the properties of 60 different nouns prompted by simultaneous presentation of a pictured item and its written name. In the second experiment, subjects were shown 1000 different words and they performed a 1-back identity task. Our results show that the neural activity observed with MEG encodes a variety of perceptual and semantic features of stimuli at different times relative to stimulus onset, and in different cortical locations. Our MEG-based classifier was able to distinguish between two different concrete nouns that it had never seen before with 90% accuracy (mean over subjects). The overall flow of neural activity observed in the tasks was similar to what has been shown in the literature regarding processing of words and pictures. Our present results demonstrate that there are clear distinctions between the time course of MEG activity and that of decodable semantic information. Perceptual features were decoded earlier in time than semantic features, and features related to animacy were decoded consistently across paradigms and subjects. Furthermore, these results show that it is possible to decode a wide range of semantic and perceptual features using MEG data even when the experimental paradigm does not require explicit semantic processing. We believe this type of approach and the accompanying machine learning methods form the basis for further modeling of the flow of neural information during language processing.

E29 Resting-state fMRI reveals the neural basis of individual differences on object color knowledge processing ***Wang, X.*** *(1),* ***Han, Z.*** *(1),****He, Y.*** *(1),* ***Bi, Y.*** *(1) 1. Beijing Normal University, National Key Laboratory of Cognitive Neuroscience and Learning, Beijing, China* – Neuropsychological and functional neuroimaging studies have linked the object color knowledge to regions in the occipital and temporal lobes (Kellenbach et al.,2001; Martin & Ungerleider, 1995; Miceli et al., 2001; Pulvermuller et al.,2006; Simmons et al.,2007). In the current study, we explored the neural mechanisms of color knowledge representation in terms of intrinsic or spontaneous brain activity patterns. Specifically, we correlated participants' mean amplitude of low-frequency fluctuations (mALFF), an index of the intensity of regional spontaneous brain activity, and behavioral performances on object color knowledge tasks to identify brain regions whose resting-state activities are related to object color knowledge. Behavioral and resting-state functional MRI data were collected from 39 healthy participants with normal color perception, aged from 26 to 70. All participants completed a color verification task, where a color patch was matched onto one of two black-and-white pictures, and a color attribute judgment task, where a verbal statement about color properties was matched with one of two object names. The z-scores of participants' accuracies on these two tasks were averaged as a composite score for color knowledge. Similar composite scores from tasks on other types of object conceptual features including form, motion, and sound were also collected to test the functional specificity of the observed regions. Regions significantly correlated with performance on color knowledge were first identified through a whole-brain correlation analysis between regional mALFF values and color composite scores across participants, with age, years of education and sex regressed out as covariates. For the significant regions of interest, we further examined the correlation between the regional mALFF values and other object features' scores to evaluate whether the regions were specific to color knowledge representation. In the whole brain analysis, right lingual gyrus (Peak MNI coordinates, 21, -72, -3; k=29; R=0.60) and right middle temporal gyrus (peak MNI coordinates, 69, -45, 3; k=49; R=0.68) were found to have their mALFF significantly correlated with the color composite score. ROI analysis further demonstrated that the mALFF of these regions did not correlate with other types of conceptual knowledge. Our findings that intrinsic properties of lingual and middle temporal region were related to color knowledge processing were highly consistent with the previous task-based fMRI and neuropsychological studies, further consolidating the importance of these two regions in representing object color properties.

E30 Characterizing the Role of the Left Anterior Temporal Lobe in Combinatory Processes ***Westerlund, M.*** *(1),* ***Pylkkänen, L.*** *(1); 1. New York University, New York* – **Introduction:** The past few decades of neurolinguistic research have underlined the importance of the left anterior temporal lobe (LATL) as part of the language processing network (Hickok & Poeppel, 2007). The LATL shows increased activity to sentences as compared to unstructured word lists (e.g. Stowe et al., 1998), as well as during basic structure-building operations (e.g. Bemis & Pylkkänen, 2011, Brennan et al. 2010), results consistent with the idea that the LATL supports general combinatoric operations (Hickok & Poeppel, 2007). However, these results also conform to a narrower hypothesis, suggested by Baron and Osherson (2011), that the LATL is specifically involved in conceptual combination. This experiment aimed to disambiguate these two hypotheses by employing a theoretical framework within linguistic theory (e.g. Heim & Kratzer, 1998) that contrasts two different types of combinatory operations: predicate modification, which builds complex properties from simple ones, and thus serves to operationalize the definition of conceptual combination, and argument saturation, which involves the satisfaction of a word's requirement for an argument. In order to ensure that the results were maximally generalizable, we investigated three different types of predicate modification: the composition of adjectives and nouns (e.g. "black sweater"), of adverbs and verbs (e.g. "runs quickly"), and of adverbs and adjectives (e.g. "very funny"), and three types of argument saturation: the composition of verbs (e.g. "eats meat"), prepositions (e.g. "in Italy"), and determiners (e.g. "Bilbo's ring") with their noun arguments. Design & Method. Target words were visually presented to 14 native English speakers during magnetoencephalography recording sessions, either in a combinatory context (within a predicate modification or argument saturation phrase, e.g. "in Italy") or in a non-combinatory context (preceded by an unpronounceable consonant string, e.g. "xq Italy"). To monitor attention, in 20% of trials subjects were required to match the meaning of a third word to the preceding one-word or two-word phrase. Neural activity was measured from the onset of the target word (e.g. "Italy) in all conditions, such that the activity elicited by combinatory and non-combinatory operations was measured at the same lexical items. The LATL was the region of interest for analysis. Results. Non-parametric cluster-based analyses (Maris & Oostenveld, 2007) of distributed L2 minimum norm activity elicited by the target words identified a significant interaction from 276 to 307 ms ($p < 0.05$) in the LATL, in which there is more combinatory than non-combinatory activity for predicate modification but not for argument saturation. Analyses of sub-conditions suggest that this pattern holds across sub-types of predicate modification and of argument saturation. Conclusion. Our results allow us to rule out the hypothesis that the LATL is involved in composition in some general way, as opposed to computing more specific semantic operations, which is in line with the narrower hypothesis suggested by Baron and Osherson (2011). The results also demonstrate that this pattern is generalizable across several types of such operations.

E31 Neural distinctions between categories of abstract and concrete words: A multi-voxel pattern analysis ***Breining, B.*** *(1),* ***Rapp, B.*** *(1); 1. Johns Hopkins University, Baltimore, MD* – **Objective:** Category membership is an important

principle of semantic organization.Evidencefortheneural basis of semantic categories comes from both neuropsychological reports of category-specific semantic deficits (e.g. Capitani et al, 2003) and neuroimaging findings of neural areas sensitive to particular semantic categories (e.g. Devlin et al., 2002).Past research has focused on categories of concrete concepts, largely ignoring issues of category representation for abstract concepts. Here, we used a multi-voxel pattern approach to examine neural responses to categories of abstract and concrete words (a) to determine if there are neural distinctions between abstract categories and, if so, (b) to compare the neural substrates supporting abstract categories to those supporting concrete categories. Methods. During fMRI scanning, ten participants viewedwritten nouns from two concrete categories (fruits and tools) and two abstract categories (units of time and crimes). Examples of abstract words included DECADE (unit of time) and THEFT (crime).Words were matched across categories on lexical frequency, length, concreteness, and orthographic and phonological overlap and neighborhood density.Participants performed a semantic categorization task (e.g., "Press the button if the word is an animal") to ensure attention to word meanings on all trials.Only filler items not included in the analysis required a button-press response.Each word from the 4 categories of interest was repeated 36 times.Analysis utilized a multivariate representational similarity searchlight method (Rothlein & Rapp, 2011; Kriegeskorte, Mur, & Bandettini, 2008).For each 3x3x3 voxel searchlight region in each participant, an observed similarity structure was extracted by correlating the beta weights for each possible pair of words.The observed similarity matrix was then compared to two theoretically-predicted similarity matrices, one for abstract and another for concrete words.For each matrix, the predicted similarity structure was one in which the activation patterns for pairs of words from the same category (e.g. APPLE and CHERRY) was more similar than for words from different categories (e.g. APPLE and HAMMER). This analysis identified brain regions in which the observed similarity structure was significantly correlated with the predicted similarity structure, finding neural regions that distinguished between categories of abstract words and regions that distinguished between categories of concrete words.Cluster-size thresholding was used to correct for multiple comparisons.Results were then combined across participants to identify voxels showing consistent, significant effects across participants. Results & Conclusions. Importantly, we identified neural areas that differentiated between abstract categories, indicating that abstract words are neurally instantiated in a manner that represents abstract category distinctions. Interestingly, there was little overlap in the regions involved in distinguishing between the abstract and the concrete categories, indicating a different topography for the representation of abstract and concrete semantic information.In this regard, we found that substrates distinguishing the concrete categories were largely left lateralized in posterior regions.In contrast, the substrates distinguishing the abstract categories were more broadly distributed, with greater bilateral activation involving both anterior and posterior regions.This work also serves to illustrate how multi-voxel pattern analysis can be used to investigate detailed questions of semantic representation. References. Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003).What are the facts of semantic category-specific deficits?A critical review of the clinical evidence.Cognitive Neuropsychology, 20, 213-261. Devlin, J. T., Moore, C. J., Mummery, C. J., Gorno-Tempini, M. L., Phillips, J. a, Noppeney, U., et al. (2002). Anatomic constraints on cognitive theories of category specificity. NeuroImage, 15, 675-85. Kriegeskorte, N., Mur, M., & Bandettini, P. (2008). Representational similarity analysis - connecting the branches of systems neuroscience. Frontiers in Systems Neuroscience, 2 , 1-28. Rothlein, D., & Rapp, B. (2011, April).Case-invariant letter representations revealed through multi-voxel similarity analysis. Poster presented at the 2011 Annual Meeting of the Cognitve Neuroscience Society, San Francisco, CA.

E32 N400 is elicited by pragmatic as well as semantic anomalies: a visual-world study of scalar implicatures

Hunt III, L. *(1),* ***Politzer-Ahles, S.*** *(1),* ***Minai, U.*** *(1), Fiorentino, R. (1); 1. The University of Kansas, Lawrence, KS* – Linguists agree that meaning includes both semantic (what is literally entailed by a phrase) and pragmatic (what we can infer from an utterance given the extra-linguistic context) aspects. Quantifiers like 'some' have distinct semantic and pragmatic meanings; while 'some' logically entails 'at least one', it is pragmatically interpreted to mean 'at least one, but not all'. The derivation of this 'not all' aspect of meaning is known as scalar implicature. Linguists disagree, however, about when and how scalar implicature is processed in the brain. According to default approaches, scalar implicature is computed immediately and in all contexts. According to context-driven approaches, scalar implicature is computed only in relevant contexts (contexts in which the applicability of stronger terms is relevant information), and is thus computed at a delay (Noveck and Sperber, 2007). Noveck and Posada (2003) used event-related potentials (ERPs) to test these approaches; however, the lexico-semantic properties of the stimuli were not controlled, complicating the interpretation of those results (Nieuwland et al., 2010). Eye-tracking has also been used, but with conflicting results (Huang and Snedeker, 2009; Grodner et al., 2010). Here we investigate whether the N400, which is an ERP effect associated with semantically anomalous or unexpected stimuli, is sensitive to scalar implicature errors, thus providing a method to test for the presence of scalar implicature computation in varying contexts. We use a visual world paradigm to present participants with stories in which an agent affects a subset of objects, followed by a visually-presented sentence (e.g., "The chef chopped some of the onions in this story") that is (1) true, (2) false or (3) infelicitous with respect to the story. In each story, there are three different sets of objects present (e.g., onions, pickles and cabbages). Sentences are true if in the preceding story the agent affected at least one but not all (specifically, two out of four) of the mentioned objects (e.g., the onions), false if the agent affected none, and infelicitous if the agent affected all. This design controls for the

lexico-semantic properties of the object, since only the pictures differ across conditions, whereas the sentences are identical across conditions. We compare the size of the N400 elicited by the noun in the object position of the target sentences. Preliminary data from 9 participants revealed a broadly distributed significant difference between the true and false conditions (with false being more negative), indicative of a classic N400 effect. A significant difference between the infelicitous and true conditions in the right posterior region (with infelicitous being more negative) was also observed, suggesting an N400 effect with a more restricted distribution. Finally, a broadly distributed significant difference between the false and infelicitous conditions was observed (with false being more negative). Since N400 amplitude is known to index the extent to which participants expected a given word, the observation of an increased N400 for both false and infelicitous critical words in the present study provides evidence that pragmatic as well as semantic information is used to make predictions online about upcoming input.

E33 The spatio-temporal characteristics of intelligible and unintelligible auditory word processing ***Halai, A.*** *(1,3),* ***Parkes, L.*** *(2),* ***Parker, G.*** *(2) and* ***Welbourne, S.*** *(1); 1. (NARU), School of Psychological Sciences, University of Manchester, UK; 2. (ISBE), School of Cancer and Imaging Sciences, University of Manchester, UK; 3. (BII), University of Manchester, UK.* –**Introduction:** During successful auditory word comprehension, we must process incoming sound to identify the phonological features and integrate this with stored semantic representations. Two opposing theories have been proposed to explain word comprehension; the serial (Friederici, 2002) and parallel (Marslen-Wilson, 1987) processing streams. Additionally, neuropsychological and neuroimaging studies have shown that a hierarchy exists, propagating down the temporal lobe (Binder et al., 2000). Neurophysiological studies using electroencephalography (EEG) and magnetoencephalography (MEG) have outlined two components involved in language processing; P100 for phonetic processing and N400-like for semantic processing. Here, electroencephalography (EEG) was used to investigate changes in neurophysiological activity for intelligible and unintelligible auditory presentations of single words. The aim was to identify event-related potentials corresponding to phonological and semantic processing and determine their neural source. Methods. EEG data was collected on 64 electrodes, from 26 subjects. They were passively listening to auditory words. A random block design was used (10 s on/off), where 10 words were presented per block (1 word per second). The four conditions used were: 1) high imageability (40 items) 2) low imageability (40 items) 3) rotated (80 items) and 4) rotated vocoded speech (80 items). Conditions 3 and 4 were acoustic transformations which modulated intelligibility and phonetic content (Scott, Blank, Rosen, & Wise, 2000). In this case, conditions 1 and 2 contained phonetic features and were intelligible, condition 3 contained phonetic features but was unintelligible and condition 4 did not contain phonetic features and was unintelligible. Conditions 1-3 were contrasted with condition 4 to outline phonological processing, whereas conditions 1-2 were contrasted with condition 3 to outline semantic processing. The analysis was conducted on 18 subjects as 2 subjects had more than 5 noisy channels, 2 subjects showed activity around zero volts across the whole epoch and 4 subjects had more than 10% of removed trials due to motion artefacts. The phonological and semantic components were analysed separately and sensors were clustered over the left and right hemispheres. Results. The topography and event-related potentials are shown in Figures 1 and 2. Conditions with phonetic features produced higher amplitudes around 100ms in left ($t(70) = 1.649$, $p = .052$) and right ($t(70) = 1.667$, $p = .050$) sensors, which suggests phonological processing (P100). Conditions with semantic content produced larger negative amplitudes around 500ms in left ($t(52) = -1.880$, $p = .033$) sensors but not in the right ($t(52) = -1.009$, $p = .159$), which suggests left lateralised semantic processing (N400-like). Phonological processing was localised between bilateral posterior and middle inferior temporal regions, whereas semantic processing was localised to the bilateral anterior temporal lobes (ATL) (Figure 3). Additionally, both contrasts revealed bilateral inferior frontal activity (IFG). Conclusions. Auditory word comprehension is suggested to be processed within a serial framework, where the stream propagates from intermediate temporal regions to the ATL. This hierarchical structure is inline with evidence showing increasingly complex speech being processed down the processing stream. The IFG activity could reflect a general language role for speech comprehension and not just semantic control.

E34 Contributions of anterior and posterior left hemisphere regions to semantic processing: Evidence from semantic competition during spoken word recognition in participants with aphasia ***Mirman, D.*** *(1)* ***Graziano, K. M.*** *(1); 1. Moss Rehabilitation Research Institute* – Recent evidence suggests that there may be two complementary semantic systems in the human brain (e.g., Schwartz et al., 2011, Proceedings of the National Academy of Sciences, 108(20):8520-8524). One system, with the anterior temporal lobe (ATL) as a critical hub, primarily captures taxonomic (category-based) relations and is particularly important for semantic processing of individual objects. The other system, with the temporo-parietal junction (TPJ) as a critical hub, primarily captures thematic (event-based) relations and is particularly important for semantic processing of relations among different objects. This proposed dissociation was explored in two experiments using eye-tracking in the visual world paradigm (Tanenhaus et al., 1995, Science, 268(5217):632-634). Participants performed a simple spoken word-to-picture matching task. On each critical trial, participants saw four pictures, one that was the target object, one that was semantically related to the target, and two that were unrelated to the target (location of the objects on the screen was randomized). The relationship between the target and the semantically-related distractor was either taxonomic (member of the same semantic category, e.g., deer - cow) or thematic (Experiment 1: semantically related and not taxonomically related to the target, e.g., monkey - banana; Experiment 2: commonly used with or on

the target object, e.g., saw - wood). There were three groups of participants: individuals with aphasia and lesions restricted to the anterior portion of the left hemisphere (including the ATL and not the TPJ; N=6), individuals with aphasia and lesions restricted to the posterior portion of the left hemisphere (including the TPJ and not the ATL; N=7), and age- and education-matched neurologically-intact control participants (N=15). Activation of semantically related concepts was assessed by comparing the time course of fixation probability for semantically related distractors relative to unrelated distractors and was quantified using growth curve analysis (Mirman et al., 2008, Journal of Memory and Language, 59(4):475-494). Control participants exhibited robust semantic competition in both taxonomic and thematic conditions in both experiments. Both groups of participants with aphasia exhibited taxonomic competition effects that were approximately equal in magnitude to the control participants' effect. The participants with aphasia and anterior lesions also exhibited control-like thematic competition effects. In contrast, the posterior lesion group did not exhibit an overall thematic competition effect in either experiment. That is, unlike control participants and aphasic participants with left ATL lesions, aphasic participants with left TPJ lesions did not show evidence of automatic activation of thematic relations during spoken word recognition. These results are consistent with the proposal that the TPJ region is particularly important for processing of thematic (event-based) semantic relations and that taxonomic processing is particularly important for single-object tasks such as word-to-picture matching.

E35 The implicit transfer of motor strategy in language processing: an fMRI study ***Papeo, L.*** *(1,2),* ***Cecchetto, C****. (1),* ***Rumiati, R. I****. (1),* ***Tomasino, B****. (3); 1. International School for Advanced Studies, SISSA, Trieste, Italy; 2. Harvard University, Cambridge MA; 3. I.R.C.C.S. "Medea", Polo Friuli Venezia Giulia, Italy* – Neuroimaging measurements showed that the primary motor and premotor areas, especially in the left-hemisphere, are recruited during the processing of action-related verbs. It is unknown whether the information carried by motor regions is part of the semantic representation of these words, or reflects one motor-based strategy of processing meanings, e.g. via simulation. In this fMRI study, we exploited the phenomenon of the implicit transfer of strategies to vary the cognitive context in which a verb occurred: participants read action and nonaction related verbs (and letter strings), after performing either a task engaging motor imagery (motor context), or a task engaging visuo-spatial imagery (nonmotor context). To perform the two imagery tasks, participants learned the corresponding strategy through specific instructions and training. We tested whether motor/premotor activity was elicited only when reading in a motor context, thus reflecting the transfer of a motor strategy from one task to another; or whether it was triggered bottom-up, whenever an action-verb was met. We found that the cognitive context modulated neural activations associated with verb processing: reading both action and nonaction verbs (versus strings) in the motor (but not in the nonmotor) context activated the left primary motor cortex. Also activity in the left premotor was equal for action and nonaction verbs (versus strings) in the motor context, while it was greater for action than for nonaction verbs in the nonmotor cortex. This study provides evidence for a dissociable role of different motor regions in verb processing. The activity in early motor regions seems to serve one strategy or procedure, whose recruitment is not stimulus-driven. It is rather defined by the reliance on higher-level factors, such as the cognitive context, to the extent that it can be applied for processing action verbs in a given (motor) context but not in another, and can be "learnt" and readily extended to processing nonaction verbs. The activation of the premotor cortex in response to action-verbs, irrespective of the context (i.e., moor and nonmotor), is consistent with the view that higher-order motor regions may mediate the explicit retrieval of the sensorimotor aspects associated with action knowledge. However, this information carried by premotor regions appears as optional of a word meaning. Comparable premotor activity for action and nonaction verbs during reading in the motor context, suggests that, while sensorimotor attributes can be normally elicited for stimuli with salient sensorimotor components, the same attributes can be applied to words with no immediate action meaning, as depending on a given task context.

E36 Hemispheric asymmetries in processing expected and incongruous semantic information during sentence comprehension: a magnetoencephalography study. ***Pendl, S.*** *(1),* ***Binder, J.R.*** *(1),* ***Frishkoff, G.*** *(2),* ***Humphries, C.J.*** *(1),* ***Gross, W.L.*** *(1),* ***Desai, R.*** *(1),* ***Baillet, S.*** *(1); 1. Medical College of Wisconsin; 2. Georgia State University* – The timing of semantic integration processes during sentence comprehension and the roles played by the left and right hemisphere in these processes are imperfectly understood. The coarse coding hypothesis proposes that right hemisphere semantic networks are broader and less constrained than the left hemisphere by preceding context and prior probability. Whereas the left hemisphere is adept at rapid access to literal, dominant word meanings, the right hemisphere is more adept at sustaining conceptual flexibility, lexical ambiguity, and figurative meaning. We investigated semantic integration processes using magnetoencephalography (MEG) during a sentence comprehension task. Participants (N=18) were presented written sentence stems of the form [subject noun phrase] + [transitive action verb] + [noun phrase stem] (e.g., The runner finished the long…), followed by a noun that was either highly expected (e.g., race) or incongruous (e.g., mouth). Participants indicated whether or not the sentence made sense. Neural responses to the final noun were localized using distributed source modeling based on weighted minimum norm estimation and averaged over 50-ms time windows at 25-ms increments. Statistical parametric maps were constructed at each time step using paired t-tests between the Expected and Incongruous conditions and thresholded using magnitude, spatial extent, and duration criteria. The results revealed two prominent condition effects. The first of these was greater activity for the Incongruous

condition in the right inferior temporal gyrus from ~575 ms to ~675 ms. We propose that this difference represents greater activation of a broad semantic field in the Incongruous condition, resulting from a failure to integrate the final word semantically with the preceding sentence stem. The second prominent effect occurred at around the same time (~575 ms to ~625 ms) and consisted of greater activity for the Expected condition in the left inferior supramarginal gyrus. This region has been strongly associated with processing action concepts. We propose that successful integration of the final word in the Expected condition elicits a representation of the action depicted by the sentence, which is not possible in the Incongruous condition. The results clarify the timing of semantic integration processes during sentence comprehension, which occur late relative to initial lexical-semantic recognition. The dissociation between left and right hemisphere effects is broadly consistent with coarse coding theory and extends this hypothesis to the domain of semantic integration during sentence comprehension.

E37 Event-related potential investigation of scalar implicature processing using picture-sentence verification ***Politzer-Ahles, S.*** *(1),* ***Fiorentino, R.*** *(1),* ***Jiang, X.*** *(2),* ***Zhou, X.*** *(2); 1. University of Kansas, Lawrence, KS; 2. Peking University, Beijing, China* – During communication, comprehenders must derive meaning not only from language-internal sources (syntax and semantics), but also from context and interpersonal expectations, i.e., pragmatics. Whereas the event-related potential (ERP) correlates of syntactic and semantic processes have long been a focus of research on the electrophysiology of language processing, the ERP correlates of pragmatic processing have not received substantial attention until recently (e.g. Van Berkum, 2009). The present study investigates scalar implicatures, which occur in statements like some of the students are hardworking; such sentences have both a logical meaning (at least one is hardworking) and a pragmatic meaning (not all of them are hardworking). The psychological mechanisms by which the pragmatic meaning is realized have been the subject of extensive debate (Katsos & Cummins, 2010). Previous experiments (Nieuwland et al., 2010; Noveck & Posada, 2003) have investigated the ERP correlates of scalar implicature processing using underinformative sentences, in which the logical meaning is true but the pragmatic meaning is false (e.g., Some turtles have shells). Such studies investigated critical words downstream of the quantifier (e.g. shells) and thus could not address the possibility of immediate construction of pragmatic interpretations the moment the quantifier is encountered. Furthermore, in such studies the effects of pragmatic processing may be obscured by simultaneous effects of the lexico-semantic processing of content words. The present study, which was conducted in Mandarin Chinese, adopted a picture-sentence verification design (Wu & Tan, 2009; Tavano, 2010) to make the violation immediately detectable when the quantifier is read. Participants (N=19) saw 160 pictures in which several characters were either performing the same activity (all-type pictures) or different activities (some-type pictures), followed by sentences describing the pictures using some or all, creating a 2x2 design with both pragmatic violations and pure logic violations. The pragmatically underinformative condition consisted of some-type sentences (e.g., 图片里，有的女孩坐在毯子上, Some of the girls are sitting on blankets) appearing after a picture in which all of the girls are doing the same activity; control sentences were identical but appeared in a different context (after some-type pictures). The logically incorrect condition consisted of sentences using the quantifier 所有的, all, after some-type pictures, and controls for this condition were lexically identical but appeared after all-type pictures. The critical word in all conditions was the quantifier itself and sentences were identical across violation and control conditions, allowing us to test for the immediate emergence of implicature-related effects independently of lexico-semantic effects. The critical pragmatic violation yielded a late, right-lateralized centro-parietal negativity (500-1000 ms); no such effect was observed in the sentences that were logically incorrect. This effect contrasts with the N400 effect found in previous studies, suggesting that the recognition of this type of pragmatic error elicits a qualitatively different ERP signature than the recognition of lexico-semantic errors. The present results constitute the first ERP study to directly show pragmatic effects of scalar implicature at the quantifier itself, independently of lexico-semantic processes.

E38 When meaning becomes open-ended: An ERP study on processing literary metaphors ***Resta, D.*** *(1),* ***Bambini, V.*** *(2),* ***Grimaldi, M.*** *(1); 1. University of Salento, C.R.I.L., Lecce, Italy; 2. Scuola Normale Superiore, Pisa, Italy* – **Introduction:**Neuroscientific approaches to metaphor have focused on everyday expressions, either familiar (e.g., "Those fighters are lions") or newly-coined (e.g., "Those apprentices are lions") [1]. However, language users experience also metaphors that are more evocative, open-ended and 'poetic', e.g., "[She] had entombed her memory under a pyramid of silence" (Rushdie, "Shalimar the Clown"), and literature is a privileged source. Pragmatics and cognitive studies propose that the distinctive features of literary metaphor may result from the condensation of multiple meanings in a few words and from the vast array of non-manifest implications (the so-called weak implicatures) identifiable as "poetic effects" [2]. Nevertheless, it remains unexplored how the brain processes open-ended metaphors. This study aimed at identifying a possible distinctive ERP signature of literary metaphors. Based on previous studies on metaphor [3], we hypothesized a biphasic pattern: a lexical access stage (indexed by the N400) and a semantic/pragmatic enrichment stage (reflected in the late positive component, LPC). Poetic effects are expected to influence the meaning enrichment phase (thus the LPC) rather than lexical access per se. **Methods:** Stimuli consisted of 104 metaphorical phrases extracted from Italian poems and novels (e.g., "grass of velvet") compared to

literal ("throne of velvet") and anomalous ("marble of velvet") phrases. Target words were constant across conditions, while the other words were balanced for length and frequency. In a pretest literary metaphors were rated as meaningful (N=15, median=3 on a 5-point scale), as opposed to anomalies (N=15, median=2); cloze probability was equally low across conditions (0-7%) . In the ERP experiment, 27 subjects (9F; 23±3years) were presented with the phrases (word duration=400ms; ISI=200ms) and performed a semantic matching task (selecting the best match out of two words presented after the target expression, e.g., "balance" and "flower" presented after "grass of velvet"). **Results:** Behavioral results showed that subjects were more accurate and faster in performing the task after literal phrases than in the other two conditions (ps<.001), indicating that literal expressions were easier in terms of meaning construction. The ERP results showed that the N400 amplitude (360-560ms) for literary metaphors did not differ from the N400 recorded for literal phrases (p=.156), but was significantly smaller than for anomalies (p<.05). In the LPC time window (600-1000ms) literary metaphors elicited a more positive amplitude than literal phrases (p<.001), but did not differ from anomalies (p=.132) [Fig.1]. **Conclustions:** Lexical access did not result more demanding for literary metaphors than for literal phrases. However, the LPC modulation suggested extra cognitive costs for literary metaphor and anomalies in the semantic/pragmatic enrichment process. While for anomalies this positivity is likely to index a failure in the meaning construction process, for open-ended literary metaphors it may suggest the activation of multiple meanings underlying poetic effects. Overall, this study points to the role of late time components in processing open-ended metaphors, and paves the way to a fruitful combination of cognitive poetics and (neuro)pragmatics. [1] Pynte et al. (1996), BrainLang, 55:293-316. [2] Sperber & Wilson (2008), in Gibbs (ed.), CUP:171-203. [3] Arzouan et al. (2007), BrainRes, 1160:69-81.

E39 Body movement and action word memory: Facilitation and inhibition effects ***Shebani, Z.*** *(1),* ***Pulvermuller, F.*** *(1); 1. MRC Cognition and Brain Sciences Unit* – Language and motor systems of the human brain are functionally interconnected. Perceiving and understanding action related language activates the motor system of the brain and, conversely, motor system activation has an effect on the comprehension of action related words and sentences. Although previous research has shown that motor systems become active when we understand action-related language, the question of whether these motor system activations are necessary for processing action words remains unresolved. We here report that movements of either the hands or the feet can inhibit or facilitate working memory for action related words depending on the complexity of the motor task used. With complex, rhythmic movements of either the hands or the feet, a differential impairment of working memory for concordant arm- and leg-related action words was found, with hand/arm movements predominantly impairing working memory for words used to speak about arm actions and foot/leg movements primarily impairing leg-related action word memory. However, when the motor task was changed to one with a simple motor sequence, the sign of the effect changed from inhibition to facilitation, leading to enhanced working memory for action-related words. These facilitation and inhibition effects of motor movement on action word memory demonstrate that body-part specific and meaning-related processing resources in specific cortical motor systems are shared between overt movements and working memory for action-related words, thus providing evidence of the necessity of motor systems for action word memory and documenting a genuine motor locus of semantic memory.

E40 Hierarchical agreement processing in pronoun resolution: ERP evidence ***Xu, X.*** *(1,2),* ***Jiang, X.*** *(3),* ***Zhou, X.*** *(3); 1. Nanjing Normal University, Nanjing, China; 2. (Ministry of Education), Southeast University, Nanjing, China; 3. Peking University, Beijing, China* – **Introduction:** Agreement between sentence constituents is a widespread phenomenon that appears in about three-quarter of world's languages. To comprehend a sentence or utterance properly, readers or listeners must compute dependencies between words at multiple levels of language processing, including morphosyntactic and semantic levels. The agreement relationship is assumed to be processed at any of these levels in terms of number, gender, person, or case features. Previous psycholinguistic and neurocognitive studies concentrate mostly on agreement processing at the morphosyntactic level, which indicated that morphosyntactic features for agreement between sentence constituents are organized hierarchically, with some features grammatically more salient than other features(e.g., Person > Number > Gender,). However, it remains unclear how agreement based on semantic properties is processed during sentence comprehension and, in particular, how different types of agreement would function together when they appear simultaneously to establish referential constraints. Methods: twenty-four native Chinese speakers' brain potentials were recorded while they read sentences in a word-by word paradigm in each experiment. The following presents exemplar sentences from Experiment 1 in which number agreement and gender agreement were crossed factorially, forming 4 experimental conditions. While the first clause presents the antecedent noun in either the singular or the plural form (through the determiner preceding the noun), the singular pronoun in the second clause, at the object position, agrees or disagrees with the antecedent in number and/or gender. Experiment 2 used a similar design but with a plural pronoun in the second clause. Results: This ERP study demonstrates that both gender and number mismatches elicit more positive responses on the pronoun (P600 effect), relative to the control condition. This P600 effect, however, appears earlier and has a larger magnitude for gender mismatch than for number mismatch. While a number mismatch elicited a P600 effect starting from 550 ms (for singular pronouns in Experiment 1) or 400 ms (for plural pronouns in Experiment 2) post-onset of the pronoun, a biological gender mismatch

elicited an earlier (for singular) and larger (for both singular and plural) P600 effect. Moreover, when a pronoun simultaneously mismatches its antecedent in both gender and number, it is the gender mismatch that determines the magnitude and latency of the P600 effect. Conclusions. The results provide evidence suggesting that biological gender agreement and notional number agreement in pronoun resolution during Chinese sentence comprehension have different functional precedence, with the processing of gender information dominating over the processing of number agreement. However, the hierarchical agreement relations obtained at conceptually-based level is inconsistent with that built at grammatically-based level, since the latter showed that number is cognitively more salient than grammatical gender. Examples in Exp. 1 (The materials used in Exp. 2 was same with Exp.1 with the exception that critical pronouns were in plural ('他们/她们') instead of singular forms ('他/她'): 这位女患者情绪低落，医生/鼓励/她/振作/起来。 This woman patient was in low spirits, doctors encouraged her to cheer up. 这些女患者情绪低落，医生/鼓励/她/振作/起来。 These women patients were in low spirits, doctors encouraged her to cheer up. 这位女患者情绪低落，医生/鼓励/他/振作/起来。 This woman patient was in low spirits, doctors encouraged him to cheer up. 这些女患者情绪低落，医生/鼓励/他/振作/起来。 These women patients were in low spirits, doctors encouraged him to cheer up.

E41 "Even a rich person can afford that luxury house": Processing construction-based pragmatic violation during sentence comprehension ***Xiaoming Jiang*** *(1),* ***Yi Li*** *(1),* ***Xiaolin Zhou*** *(1, 2); 1. Peking University, Beijing, China; 2. (Ministry of Education), Peking University, Beijing, China* convey semantic/pragmatic meanings that are independent of the meanings of lexical items embedded in the structure (Goldberg, 1995; Ye et al., 2007). In event-related potentials (ERPs), it has been shown that an increased N400 can be observed on words violating the constructional-based semantic constraints (e.g. disposal/caUStion in ba construction in Mandarin Chinese), as compared with words congruent with the constraints (Ye et al., 2007). This study goes further to investigate how the brain responds to construction-based pragmatic constraints (e.g., scalar implicatures). The Chinese construction "Lian…dou… (even)" introduces a pragmatic scale of the event likelihood, such that a verb phrase describing an event/action with the least likelihood (e.g. a poor person buys a luxury house) can be embedded into the construction (Shyu, 2004; Xiang, 2006)). The unexpectedness of the event is implied and conveyed with this construction. An event with a high likelihood (a rich person buys a luxury house), if describe with this construction, would cause pragmatic violation and an event with higher or un-specified likelihood (a person buys a luxury house) may incur greater effort during comprehension. Moreover, the affirmative USge or negative USge of the "Lian… dou…" construction also modulates the inferred unexpectedness of the event described with the construction (Chen, 2004). Method. Two ERP experiments were conducted in which participants were asked to make comprehensibility judgments to sentences. In Experiment 1, three types of sentences were created, with sentences describing less-likely events (baseline; lian namo gui de fangzhi ta dou neng mai de qi / even such an expensive house he can afford / he can afford even such an expensive house), un-specified events (pragmatic inference; lian nayang de fangzhi ta dou neng mai de qi / even such a house he can afford / he can afford such a house), highly-likely events (pragmatic violation; lian namo pianyi de fangzhi ta dou neng mai de qi / even such a cheap house he can afford / he can afford even such a cheap house). In Experiment 2, two factors (affirmation/ negation vs. event likelihood) were manipulated, creating four types of sentences: correct affirmative sentences, correct negative sentences, affirmative sentences with pragmatic violation, and negative sentences with pragmatic violation. Results. Experiment 1 showed that critical words (verbs) in sentences with pragmatic violation elicited a larger N400 and a late negativity as compared with the correct sentences. Moreover, critical words in sentences with pragmatic inference did not elicit an N400 effect but elicited a late negativity effect, which was the same as the effect elicited by sentences with pragmatic violation. Experiment 2 showed that both affirmative and negative sentences with pragmatic violation elicited a larger N400 and a late negativity as compared with the correct sentences. Moreover, both correct and incorrect negative sentences elicited a larger N400 as compared with affirmative sentences. Furthermore, incorrect negative sentences elicited a broadly distributed late negativity as compared with incorrect affirmative sentences; correct negative sentences elicited only a smaller, posteriorly distributed late negativity as compared with correct affirmative sentences. Discussion. These findings suggest that processing construction-based pragmatic implicature can be differentiated into two stages. In the first stage, the event likelihood described by the verb phrases is checked against the construction-based pragmatic constraints; the incongruency here would cause difficulties in integrating critical words into the prior sentence representation, leading to the N400 effect. In the late stage, an inference process is executed in which events violating pragmatic constraints of the "Lian…dou…" construction are re-interpreted or events unspecified with likelihood are endowed with values congruent with pragmatic constraints.

E42 Electrophysiological investigation of biological and stereotypical gender violations in a gender-marked language ***Siyanova-Chanturia, A.*** *(1),* ***Pesciarelli, F.*** *(1),*

and ***Cacciari, C.*** *(1); 1. University of Modena and Reggio Emilia, Modena, Italy* – There is evidence showing that stereo-typical gender associated with certain occupations and characteristics is incorporated into speakers' representations, and that such information is difficult to suppress during on-line language processing (Cacciari & Padovani, 2007; Oakhill, Garnham, & Reynolds, 2005). However, relatively little is known about the neural correlates involved in, and the time course of, the processing of such information. Existing studies have shown that different neural processes may engage in the processing of gender stereotypes (Irmen, Holt, & Weisbrod, 2010; Osterhout, Bersick, & McLaughlin, 1997; White, et al., 2009). The aim of the present ERP study was to investigate the activation of gender stereotypes in Italian using a paradigm adapted from Banaji and Hardin (1996). Specifically, our goal was to establish how early such information becomes available to the reader. Participants were presented with a prime, such as: (1) masculine stereotypical gender nouns (conducente "driver"); (2) feminine stereotypical gender nouns (insegnante "teacher"); (3) masculine biological gender nouns without associated stereotypes (pensionato "pensioner"); (4) feminine biological gender nouns without associated stereotypes (passeggera "passenger"); or (5) bi-genders without associated stereotypes (conoscente "acquaintance"). Each prime was followed by either a masculine or a feminine personal pronoun (Lui "he" vs. Lei "she"). Participants decided whether the pronoun was masculine or feminine, while their RTs and ERPs were recorded. Participants were faster to judge the gender of the pronoun (as masculine or feminine) when it was preceded by a gender-congruent prime, compared to a gender-incongruent one. This was found in biological and stereotypical conditions. The ERP results suggest two different effects. First, a larger negativity between 200 and 380 ms peaking around 300 ms (most prominent across frontal/central sites) was observed when masculine and feminine pronouns were preceded by biological gender-incongruent vs. biological gender-congruent primes. When primes had a stereotypical connotation, this negativity was found only for masculine pronouns preceded by stereotypical gender-incongruent primes compared to stereotypical gender-congruent ones. Second, an increased positivity between 380 and 500 ms peaking around 420 ms (most prominent across frontal/central sites) was observed when pronouns followed biological, but not stereotypical, gender-incongruent primes. Our results for biological gender violations appear to be comparable to those reported by Barber and Carreiras (2003), who observed negativity around 400 ms for gender-incongruent conditions in word pairs. Our seemingly early and more frontal effect could be due to the use of function words (pronouns) rather than content ones used by Barber and Carreiras (2003). The positivity around 420 ms for biological gender violations appears to be in line with the P300 effect, observed in Barber and Carreiras (2003) together with N400 which preceded it. Crucially, our findings provide further support for online effects of stereotypical gender in language comprehension. The presence of a large negativity for the masculine but not feminine pronoun suggests that when the gender stereotype conveyed by the prime was feminine, the brain registered a mismatch in response to a stereotype-violating pronoun (insegnante "teacher" – lui "he"). In sum, male and female gender-stereotypes affected the processing of pronouns differently.

E43 Language lateralization and verbal creativity: A developmental perspective ***Patael, S.*** *(1),* ***Borodkin, K.*** *(1),* ***Faust, M.*** *(1); Bar-Ilan University, Ramat-Gan, Israel* – Linguistic creativity is a unique human capability which is essential for cognitive processes and for communication. However, the neural mechanisms underlying the development of higher level, creative, semantic abilities such as the comprehension of metaphors, ambiguity, humor and insight problem solving are poorly understood. Several neurolinguistic models emphasize that the right cerebral hemisphere (RH) plays a major role in processing the creative aspects of language while other findings suggest that the two hemispheres are equally involved in such processing. However, these models are based mainly on studies with adults whereas the developmental aspects of linguistic creativity have generally been overlooked. Recent brain imaging studies have shown that during the second decade of life, there is an increase in language related lateralization towards left hemisphere (LH) dominance. However, these findings are relevant to core linguistic processes. Currently, little is known about the links between brain maturation and the development of higher level semantic creative abilities.

The aim of the present research was to investigate the neural basis underlying the development of linguistic creativity. Specifically, we focused on the relations between the development of higher level language processing. i.e., comprehension of ambiguity, and the pattern of hemispheric involvement in adolescence versus adulthood. Forty eight normally developed adolescents and 44 adults performed two language tasks. The first task measured verbal creativity level using the Hebrew version of Remote Associative Test (Mednick, 1967; Levin, 1973). The participants were then asked to perform a priming task combined with a split visual field paradigm. Since the comprehension of lexical ambiguity requires linguistic creativity (e.g., Faust & Lavidor, 2003), we used ambiguous target words primed by either dominant or subordinate meanings. Results showed that in adults, both hemispheres contribute to the maintenance of multiple word meanings, while adolescents show subordinate priming only in the LH. These findings suggest that during adolescence, there is a developmental shift in the pattern of brain lateralization associated with processing of subordinate, more distantly related semantic meaning. However, it is not clear how this hemispheric shift relates to development of mature language abilities, particularly to linguistic creativity. A regression equation was used to address this question and the findings show that for the adult group, when reaction time (RT) for subordinate meanings presented to the two visual fields/hemispheres were similar, namely, either both hemispheres were fast or both slow, the

performance on the verbal creativity test was better. However, in the developing brain, slower RT for subordinate meanings presented to the RH was associated with better performance on a verbal creativity task (Fig. 1). These findings suggest that in the mature brain, a high level of synchrony between the two hemispheres contributes to verbal creativity. However, different neural mechanisms underlie verbal creativity in the developing brain. It thus seems that during adolescence, the RH plays a significant role in processing the creative aspects of language. The findings have important implications for understanding the developmental changes in higher level semantic abilities and the neural basis of these changes.

E44 A dual lexicon model of cortical spoken language processing ***Gow, D.*** *(1,2,3); 1. Massachusetts General Hospital, Boston, MA; 2. Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA; 3.Salem State University, Salem, MA* – Lexical representations and processes play a critical role in nearly every aspect of language perception, production and acquisition. Given the theoretical importance of spoken wordform representations, it is somewhat surprising that after over 140 years of aphasia research and the growth of cognitive neuroscience as field, that there is still no consensus about where these representations are stored in the human brain. In this work I will present a dual lexicon model which posits the existence of a dorsal lexicon located in the supramarginal gyrus and adjacent inferior parietal cortex that supports the mapping between sound and articulation, and a ventral lexicon located in the posterior middle temporal gyrus and adjacent cortex that supports the mapping between sound and meaning. This model is an extension of current neuroanatomical dual stream models of speech processing. This model is driven by converging evidence from behavioral psycholinguistics, neuroimaging, aphasiology, neuroanatomy and aphasiology. The hypothesized role and function of the ventral lexicon is supported by results including: (1) the pattern of semantic paraphasia coupled with preserved phonological processing and semantic representation seen in transcortical sensory aphasia, (2) BOLD sensitivity to word frequency, polysemy and word relatedness in simple lexical tasks, and (3) evidence for MTG involvement in morphological representation. The role of the supramarginal gyrus as a lexical interface between sound and articulation is supported by results including: (1) sensitivity to word frequency in repetition conduction aphasia, (2) BOLD sensitive to manipulations of wordform similarity and competition, (3) changes in BOLD activation associated with wordform acquisition, (4) evidence from acoustic-phonetic analyses for lexical influences on articulation, and (5) correlations between localized gray matter density and vocabulary size in monolingual and bilingual subjects. This two-way distinction is consistent with behavioral evidence for differences in sensitivity to phonological competitor environments seen in wordform versus associative semantic cross-modal lexical priming of meaning and articulation in unimpaired subjects. Evidence from studies of effective connectivity suggest that both lexica show bidirectional connectivity with the posterior superior temporal gyrus.I hypothesize that this pattern of connectivity provides redundancy in that contributes to the robustness of spoken language perception. This synthesis provides an integrated framework for interpreting current data from a range of disciplines. More importantly, it provides a framework for future neurobiological explorations of the role of lexical processes in diverse spoken language functions.

E45 Neural Separation of Acoustophonemic from Lexicosemantic Word Encoding ***Leonard, M. K.*** *(1),* ***Travis, K.E.*** *(1),* ***Torres, C.*** *(1),* ***Sizemore, M.L.*** *(2),* ***Qu, Z.*** *(1,3),* ***Hagler, D.J.*** *(1),* ***Dale, A.M****. (1),* ***Elman, J.L.*** *(1,4), and* ***Halgren, E.*** *(1,4); 1. UCSD; 2. Joint Doctoral Program, SDSU/UCSD; 3. Sun Yat-sen University; 4. Kavli Institute for Brain and Mind, UCSD* – **Summary:** Distinguishing between models of speech perception has been difficult to test neurobiologically because hemodynamic measures (PET, fMRI) find that acoustophonemic versus lexicosemantic processing activate overlapping cortical locations and do not have the resolution to separate them temporally. Such spatiotemporal resolution is possible by combining MEG with MRI. Using these methods, we identify a neural process generated within superior temporal regions that distinguishes words from control stimuli individually-matched on acoustic properties, beginning ~60ms after stimulus onset. Within the same task, we show that semantic priming of the same words by a related picture modulates brain processing in a broader cortical network, beginning at ~180ms. The present findings provide the first direct evidence for an acoustophonemic neural process, termed M100w (word-selective), that can be isolated in time and space from lexicosemantic encoding stages, indexed as the N400m. Methods: During a MEG scan, 8 healthy right-handed, monolingual adults were presented with an object picture that appeared for the entire 1300ms trial duration. 500ms after picture onset, either a congruously or incongruously paired word or acoustically-matched noise control was presented binaurally. MRI scans were obtained to constrain source estimations of brain activity detected with MEG. Results: Word>noise differences occurred significantly earlier (average onset 61±22ms) than incongruous>congruous semantic priming effects (average onset 183±93ms; $t(6)=-3.69$ $p<0.02$). Nonparametric randomization testing confirmed significant early word>noise differences for all subjects in the same left temporal MEG sensor. Source estimations of group average activity to words versus matched noise concentrated mainly to left superior temporal regions. No significant differences to incongruous versus congruous word were observed during word>noise effects (90-110ms), but were present at later time windows (200-400ms) in more broadly distributed left superolateral temporal and inferior frontal regions. Right hemispheric activity was concentrated mainly within insular and superior temporal regions. Random effects tests of source estimation values in cortical regions of interest confirmed these maps for both the early acoustophonemic response in superior temporal regions and the lexicosemantic effect in more

widespread areas. Conclusions: The ability to measure these components non-invasively invites research into their respective roles in speech perception, their normal development, as well as their integrity in common language impairments.

E46 Does the N400 reflect lexical access, integration, or both? ***Huang, Y.** (1), **Hopfinger, J.** (1), and **Gordon, P.** (1); 1. University of North Carolina at Chapel Hill, Chapel Hill, NC* – The N400 is an important index of language comprehension, sensitive to diverse factors ranging from frequency, semantic similarity, and pragmatic anomaly (Kutas & Hillyard, 1980; van Petten & Kutas, 1990; van Berkum et al., 2003).Nevertheless, the exact nature of this component has been debated.Some argue that the N400 corresponds to the access of lexical information from long-term memory (Kutas & Federmeier, 2000; Lau et al., 2008) while others claim that it reflects later integration with other linguistic representations (Brown & Hagoort, 1993; Hauk et al., 2006). Critically, both accounts suggest that the N400 indicates a single neural process.Yet recent studies find that responses are elicited by events that are unlikely to reflect the same procedure (Swaab et al., 2004; Ledoux et al., 2007).In particular, repeated names in (1) generate reduced N400 effects (relative to new names) when they co-reference nonprominent antecedents.This suggests that the N400 reflects facilitation of lexical access.However, repeated names generate greater N400 effects when they co-reference prominent antecedents (relative to nonprominent antecedents). This suggests that the N400 reflects effortful integration of overinformative expressions. Moreover both patterns are triggered by the same expression so there are no apparent lags in the time-course of lexical access and integration. -1 PROMINENT (REPEATED/NEW): John left work after John/Bill completed the project NONPROMINENT (REPEATED/NEW):John and Karl left work after John/Bill completed the project .The current experiment distinguishes between the neural processes associated with the N400 by examining possible interactions with lexical frequency.Critical sentences were based on (1) and varied the prominence of antecedents and the repetition and frequency of referring expressions (high-John/Bill; low-Micah/Weston).Previous research has found that lexical access and integration interact with frequency along different time-courses (Tilly et al., 2010; Johnson et al., in press).Thus if the N400 reflects a single neural process, then evidence of both access and integration should again be evident simultaneously after the critical name.If however it reflects multiple processes, then evidence of access may emerge earlier than integration. Figure 1a illustrates that consistent with prior research (Swaab et al., 2004; Ledoux et al., 2007), repeated names elicited smaller N400 responses compared to new names ($p<.01$).Critically, repetition priming was greater among low frequency names compared to high frequency names, leading to a frequency by repetition interaction ($p<.05$). This signature of lexical access suggests that the N400 is sensitive to both inherent and relational statistics of words (Young & Rugg, 1992).In contrast, evidence of lexical integration was not apparent after critical expressions ($p>.30$) but was delayed until the word following.Figure 1b illustrates that one word after the repetition of low frequency names, larger N400 responses emerged when expressions co-referenced prominent antecedents compared to nonprominent antecedents ($p<.01$).However, effects of overinformativity did not appear among high frequency names ($p>.30$), suggesting that integration with discourse representations was modulated by the familiarity of expressions.The presence of divergent time-courses suggests that the N400 is produced by multiple neural processes which reflect both lexical access and integration.

E47 Word frequency and contextual predictability effects in an eye movement reading study: Evidence for early interactive processing ***Shahid, A.** (1), **Hand, C.J.** (1), **O'Donnell, P.J.** (1), **Sereno, S.C.** (1); 1. Institute of Neuroscience and Psychology, University of Glasgow* – Two main factors that influence the speed of word recognition are how often a word occurs in a language and the degree of bias associated with its preceding context.Word frequency and contextual predictability effects have been reliably demonstrated across a variety of measures – lexical decision RTs, eye fixation durations, and event-related potentials (ERPs).Previous research has been inconsistent as to whether these factors, when examined simultaneously, are additive or interactive.Behavioural RT studies have typically demonstrated interactive effects (e.g., Stanovich & West, 1983), with a greater predictability difference for low frequency (LF) than for high frequency (HF) words.Sereno, Brewer, and O'Donnell (2003) obtained a similar pattern of effects in their ERP voltage amplitude data.In contrast, eye movement reading studies have shown additive effects of frequency and predictability (e.g., Miellet, Sparrow, & Sereno, 2007; Rayner, Ashby, Pollatsek, & Reichle, 2004).More recently, Hand, Miellet, O'Donnell, and Sereno (2010) also found additive fixation time effects.However, when launch distance to the target (used as a metric of parafoveal preview) was additionally considered as a factor, an interactive frequency-predictability effect emerged.Whether frequency-predictability effects are additive or interactive has implications for models of word recognition as well as for models of eye movement control. One factor of interest regarding prior eye movement frequency-predictability studies is that of the level of predictability, with predictability operationally defined as Cloze probability (the proportion of subjects who guess the target word when presented with the text up to but not including the target).In such studies, "high" and "low" predictable labels imply Cloze values of around 0.50–0.80 and 0.00–0.30, respectively.It is possible that an additive pattern of results may be the result of under-sampling the extremes, and that an interactive pattern may emerge given a larger discrepancy in Cloze probabilities between conditions.Although Rayner and Well (1996) employed 3 levels of predictability, they did not manipulate word frequency.In their study, the mean Cloze values and ranges for their predictability conditions were as follows:high predictable (HP) = 0.86 (0.73-1.00); medium predictable (MP) = 0.41 (0.13-0.68); and low predictable (LP) = 0.04 (0.03-0.08).They found that fixation

times on LP targets were longer than those on HP or MP targets which did not differ from each other. The present study used a 2 (Frequency: LF, HF) × 3 (Predictability: LP, MP, HP) design. In particular, the Cloze probability values for our "high" and "low" predictability conditions were more extreme than what has typically been used in prior research:HP = 0.96 (0.85-1.00); MP = 0.54 (0.20-0.75); and LP = 0.01 (0.00-0.05).Target words were embedded in the second of two-sentence text passages.Our results showed an interactive pattern of effects in fixation time measures.As fixation times were relatively fast compared to those in prior studies using more pixilated displays (e.g., Hand et al., 2010; Rayner et al., 2004), it is possible that our findings are due in part to floor effects masking an underlying additive pattern.

E48 The N400 in sentence frames or in prime word pairs:a unique electrophysiological effect? ***Franca, A. I.*** *(1);* ***Gomes, J. N.*** *(1);* ***Soto, M.*** *(1);* ***Lage, A. C.*** *(1);* ***Gesualdi, A. R.*** *(2); 1. The Federal University of Rio de Janeiro, Brazil – UFRJ; 2. Federal Center for Technological Education - CEFET-Rio, Brazil* – **Introduction:** In the past 30 years, language-related ERP studies took the relevant role of testing precise theoretical hypotheses, which have been revealing a detailed chronology of computations involved in lexical access and in sentence processing. For instance, lexical access studies relate N400 modulations to three main factors: (i) lexical frequency, (ii) phonological similarity versus morphological identity: spin-spinach versus spin-spinning or (iii) semantic relatedness: pork-beef. In contrast, many sentence processing studies propose that the N400 is a measure of syntactic integration, which on its turn is modulated by one more factor:(iv) the level of semantic predictability of verb selection of its complement. Objective: Granted these very different factors cited in the literature as N400 promoters, the field still lacks a unified reasoning: is the N400 related to the context available for the access of lexical information in the memory or does it relate with syntactic integration efforts?This study established the main objective of shedding some light onto these questions by testing a set of stimuli distributed into three lexical access and three sentence processing conditions, all of them using the same word as target. The idea was to build six stimulus series in which the target will be rejected, accepted or strongly anticipated both for the lexical and for the sentential conditions. Electrophysiological reactions to the target word were measured in all conditions. Methods: While being monitored by a 32 channel EEG, 31 volunteers (mean age of 23)participated in an EEG testcomposed of two separate sessions ofvisual kinetic stimulation:one with word pairs and the other with sentences, each one containing three conditions: Series 1, 2 and 3 for the lexical access word pairs and Series 4, 5 and 6 for sentence processing.A Table with examples of the Latin Square distribution of the stimuli was annexed. Results: In the lexical access conditions, the shorter N400 latencies were those in Series 1 whose words formedhierarchically arranged pairs, that is: prime and target could have a syntactic connection. Series 1 targets had related N400 latencies 50 ms shorter than those of the unrelated words in Series 3. Targets in semantically related pairs in Series 2 were not statistically different from thosein the unrelated word pairs (Series 3). In the sentence processing conditions (Series 4 through 6) the shorter latencies of most derivations were those inSeries 4 and 5, whose related target latenciescould not be statistically discriminated, regardless of the most propitious context in Series 4. Discussion: The N400 waves in both sessions seem to be modulated by the presence or virtual possibility of syntactic structure, and not by semantic field or by contextual cues in the adjunct phrase. Maybe these sorts of information might facilitate later computational phases, but did not seem to produce an effect within the N400 time-frame. Conclusion and significance of results:These N400 findings seemed to point to the unification of lexical and syntactic processes around the syntactic hypotheses. Both for sentence frames or forprime-targetpairs shorter target latencies seem to be connected with syntactic computations thatnarrow down the linguistic expectations. Thus, rather than the extended context, it is the narrow syntax context that rushes the course of computations.

E49 The influence of discourse context on verb integration and argument prediction: Evidence from Event-Related Potentials ***Crocker, M.*** *(1),* ***Niefind, F.*** *(1),* ***Drenhaus, H.*** *(1); Saaaland University, Saarbruecken, Germany* – The role the discourse context plays in modulating the predictions of verbal complements during incremental sentence comprehension remains poorly understood. One recent study by MetUSlem et al. (2010) suggests that verbal expectations for its arguments are largely unaffected by discourse context. However, their study did not contrast the influence of discourse context with that of verb information on the integration of verbal arguments. We investigated both the integration of the verb and its subsequent argument with the discourse context as a function of semantic fit between the verb and the context. We presented a context sentence followed by a sentence containing either a fitting or non-fitting verb followed by a noun, which either fit with the context or not, but always fit with the verb (A-D) independent of context. This yields a 2x2 design with the factors 'Verb-congruency' and 'Noun-congruency'. The experiment was conducted in German. We found a centro-parietal negativity (400-600ms) on the incongruent compared to the congruent verb (A&B: opened versus C&D: closed), suggesting an integration effect (Kutas and Hillyard, 1984). The analysis on the noun revealed a main effect of the factor verb congruency and noun congruency as well as a significant interaction. Single comparisons between the context-congruent (A: bottle) versus the context-incongruent (B: window) noun after the semantically fitting verb showed an increase in the N400 amplitude. The noun comparison after the non-fitting verb (C vs. D) showed a similar, yet reduced, effect: Context-incongruent (D) nouns elicited larger N400 amplitudes than the context-congruent (C) nouns. The N400 amplitude for the context-congruent noun was larger after the non-fitting verb (C) than after the fitting verb (A). For the context-incongruent noun this effect was reversed: The amplitude after the non-fitting verb (D) was smaller than after the fitting verb (B). Our findings suggest that integration of both verb and noun is determined by

the context. Further, while integration of the noun is modulated by the verb, this does not override contextual expectations, contra the findings of MetUSlem et al (2010). If the verb was playing a predominant role in expectation generation, one would expect a much larger reduction or even extinction of the N400 effect after the incongruent context. It rather seems that the verb is treated like any other meaningful element in the context, which leads to more specific expectations in conditions A and B, resulting in a larger effect of expectation violations. These results challenge psycholinguistic accounts in which prediction is controlled by the verb, but are generally in line with recent studies on the influence of distinct cues (verbal information, discourse context) on semantic/pragmatic processing of meaningful elements (van Berkum 2004; Kuperberg 2007). Context: As Jan walks past a water box, he wants to drink something. Conditions (original stimuli were German): A. Therefore he opens the bottle carefully. [fitting verb, context-congruent noun] B. Therefore he opens the window … [fitting verb, context-incongruent noun] C. Therefore he closes the bottle … [non-fitting verb, context-congruent noun] D. Therefore he closes the window … [non-fitting verb, context-incongruent noun]

E50 Prominence features in discourse: an visual ERP study of prodrop constructions in Chinese ***He, Y.****(1) and* ***Schlesewsky, M****.(1); 1. Johannes-Gutenburg University Mainz, Department of General Linguistics, Mainz, RP, Germany* – It has been well-established that features that are related to sentence-level processing could be influenced by certain facilitative contexts. For example, although sentences such as "the peanut was in love" would typically elicit an animacy-related N400 effect, this effect is erased when its preceding discourse context was strongly predicative of a human-like "peanut" [1]. The modulation effect suggests an interactive nature between sentence-level features (e.g. animacy) and context-level features (e.g. world knowledge and discourse relations). Given the interactive nature of the two levels of processing features, it is worth looking at what would happen if sentence internal properties are forced to be realized at a context level. This scenario is not uncommon in so-called "prodrop" lanuages such as Vietnamese and Chinese: namely, if "the peanut" has to be enriched from its preceding context, will "in love" elicit an N400 effect as well? Will this effect be modulated because of the "constraint" from clause boundaries? To investigate this question, we ran a visual ERP experiment examining how animacy manipulation in context level was incrementally processed in target sentences with an empty subject. The sentence stimuli are exemplified in (1): the context sentences were one argument sentences with the sole argument varying in terms of animacy; all target sentences were Φ-coverb-NP-V sentences, in which the null pronoun has to be recovered as a noun phrase (NP) from its preceding context. In Chinese, coverb BA is usually used as an active marker, and BEI is used as a passive marker. In an experiment examining Chinese NP1-coverb-NP2-V sentences [2], immediately at the coverb BEI itself, the authors have found that inanimate vs. animate NP1 elicited an N400 effect. The effect comes from a construction-specific restriction: namely, although NP1 in a BEI construction is usually an undergoer, it should be capable of experiencing a psychological state, thus it is preferred to be animate. Besides, the inanimate vs. animate NPs after BEI, being an actor, not surprisingly elicited an N400 effect as well. This mirrors the findings of English and German, suggesting that there is a thematic dependency between thematic roles and animacy [3, 4]. The design of the present experiment was similar to that of [2], and the crucial difference lies in the fact that the NP1 in [2] has become a covert argument in the present experiment and has to be enriched from its context. As a result, if contextual animacy impacts thematic processing in a similar way to how it functions sententially, we expected that all effects from [2] to be replicated. If not, we may find no effect at the coverbs themselves, whereas inanimate vs. animate NP at the target sentence after BEI will still elicit an N400 effect. The results of this experiment have shown that animacy information behaves indeed differently at context level: contextual animacy manipulation did not result in any effects at coverbs as well as target NPs; additionally, as expected, inanimate vs. animate target NPs after BEI yielded an N400 effect. Interestingly, different from [2], at NPs after BA, the same inanimate vs. animate comparison resulted in a late positivity. We conclude that the absence of any contextual animacy effects at coverbs and target NPs may result from the inability of animacy (being a sentence internal feature) to impact thematic processing across sentence boundaries. Within a sentence, however, the animacy of an NP tends to generally correlates to its protorole (animate-actor), and that the violation of this preference generally leads to an N400 effect.

E51 Reading words, sentences and stories: Distinct oscillatory brain mechanisms for processing language meanings and constructing abstract mental representations ***Wang, C.*** *(1),* ***Xu, Y.*** *(1),* ***Chow, H.*** *(1),* ***McArdle, J.*** *(1),* ***Braun, A.*** *(1); 1.National Institute on Deafness and Other Communication Disorders/ National Institutes of Health, Bethesda, Maryland, US* – The processing of narrative involves not only understanding word and sentence meanings, but entails formulation of a coherent mental representation of the complete story, following a certain level of integration and abstraction. Changes in oscillatory brain activities have been reported to underlie the processing of words and sentences. However, little is known about the neurophysiology underlying the ways in which the brain constructs abstract mental representations from these meaningful language units at the level of discourse. Here we report distinct temporal dynamics of low-frequency (theta: 4-7 Hz; alpha: 8-12 Hz) and gamma (31-50 Hz) oscillations that appear to be related to these two fundamental processes: understanding language meanings and formulating mental representations. During a condition in which unrelated sentences were presented word by word (Sentence condition), low-frequency power showed a linear increase across words and a reset at each sentence onset, consistent with a role in decoding and maintaining sentence

meanings in working memory. However, this linear increase and reset diminished during a second condition, in which sentences were linked together in a coherent story (Narrative condition), suggesting a decreased working memory load. Moreover, gamma power was significantly higher during the Narrative condition, when readers are able to generate a mental representation of the story. Our results suggest that gamma oscillations may play a critical role in converting language meanings to abstract mental representations, reducing the demand on low-frequency oscillations that maintain the ongoing information in working memory during sentence-level language comprehension.

E52 Functional heterogeneity within Broca's area

Fedorenko, E. *(1)* ***Kanwisher, N.*** *(1); 1. Massachusetts Institute of Technology* – Broca's area, encompassing the triangular and opercular portions of the left inferior frontal gyrus (IFG), has been implicated in many linguistic processes, including phonological (Blumstein_et_al.,2005; Myers_et_al.,2009), lexical (Hagoort_et_al.,2004,2009; Rodd_et_al.,2005; Schnur_et_al.,2009), and syntactic (Ben-Shachar_et_al.,2003,2004; Friederici_et_al.,2006; Stromswold_et_al.,1996) processes.Furthermore, although originally argued to be language-specific (Broca,1861), this region has now been implicated in a wide range of non-linguistic functions, including general working memory(WM), cognitive control, arithmetic processing, goal-directed behavior, action representation, and music (e.g.,Awh_et_al.,1996; Badre_et_al.,2005; Braver_et_al.,1997; Bunge_et_al.,2000; Cohen_et_al.,1994; Fadiga_et_al.,2009; January_et_al.,2009; Koechlin_et_al.,2003; Koelsch_et_al.,2002; Levitin&Menon,2003; Novick_et_al.,2005; Piazza_et_al.,2006).Consequently, it has been challenging to determine the function(s) of Broca's area, and no clear consensus has emerged (e.g.,Rogalsky&Hickok,2010). However, it has also long been known that IFG is cytoarchitectonically heterogeneous, consisting of cortical patches with distinct cellular, myelination, and connectivity properties (Amunts_et_al.,1999,2010; Petrides&Pandya,1994). Given this structural heterogeneity, it may not be productive to conceive of "Broca's area" as a single region.In addition, the use of traditional group-based analyses may obscure functional differences among nearby but distinct sub-regions within Broca's area (Fedorenko_et_al.,2010). To shed light on the organization of Broca's area, we use individual-subject fMRI analyses across seven experiments (n=48 across experiments, with at least n=11 in each).In each experiment participants performed a language task and one or more non-language tasks, each of which has been previously argued/shown to activate "Broca's area".The results provide clear evidence of a functional dissociation within Broca's area between an anterior and a posterior sub-region.The anterior sub-region responds robustly to linguistic stimuli (sentences, presented visually/auditorily, with a weaker response to word/nonword lists) but shows little or no response to non-linguistic tasks, including arithmetic, spatial/verbal WM, three cognitive control tasks (Stroop and two versions of the multi-source interference task; Bush&Shin,2006), and music.In contrast, the posterior sub-region responds robustly to demanding cognitive tasks (arithmetic, spatial/verbal WM, and cognitive control tasks), but shows little response to linguistic stimuli, responding more strongly to nonword-lists than sentences.This posterior part of Broca's area, along with nearby anterior insula / frontal operculum regions, has been argued by some (e.g.,Duncan,2001,2010) to be a part of the larger network of domain-general regions that support goal-directed behavior ("fronto-parietal", or "multiple-demand" network). Because the precise locations of the anterior and posterior sub-regions vary widely across individuals (Amunts_et_al.,1999; Fedorenko_et_al.,2010; Tomaiuolo_et_al.,1999) – in spite of being highly stable within an individual– traditional group analyses are unlikely to yield a clear picture of the functional organization of this region.Consequently, individual-subject functional-localization analyses that take into account differences in brain anatomy (e.g.,Fedorenko_et_al.,2010; Hickok_et_al.,2009; Pinel_et_al.,2007) will be key for determining the computations conducted in different portions of Broca's area. To conclude, referring to a particular activation as originating within "Broca's area" is ambiguous given the clear functional dissociation between its anterior and posterior portions. In order to understand how human cognition is implemented in the brain, instead of using approximate anatomical locations in the stereotaxic space as reference points we should instead focus on providing careful functional characterization of key regions with the regions defined consistently across studies and across labs.

Author Index

Entries are indexed by abstract number, not page number. The S- entries indicate slide presentations. The P- entries indicate poster presentations.

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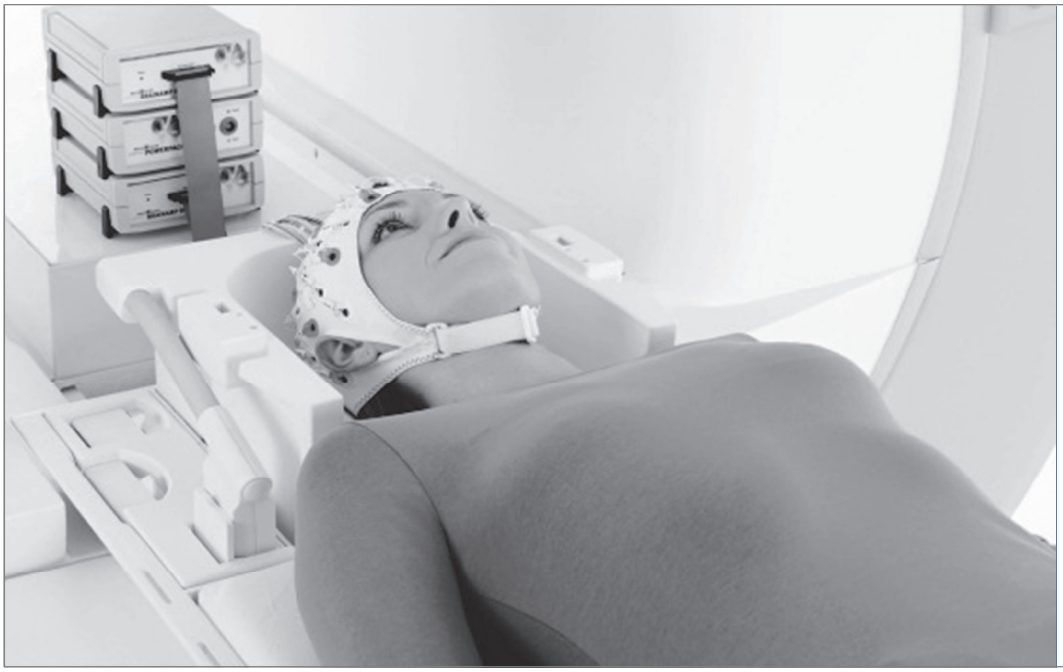

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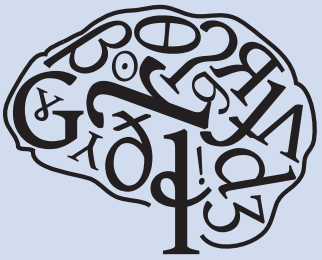

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