Leipzig Lectures on Language Combinatorics 2021

End-of-Year Symposium

October, 20th-21st

Program & Booklet

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Index

Program at glance

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Website: https://www.cbs.mpg.de/leipzig-lectures-on-language

All times in the program are given in UTC as well as CEST (i.e. “Leipzig time”).

You can find all previous talks on “combinatorics in language” as part of the Leipzig Lectures on Language 2021 here: https://www.youtube.com/c/LeipzigLecturesonLanguage/featured

Keynote speakers

Simona Mancini

William Matchin

YouTube

William Matchin: https://youtu.be/CVDsSEWTNIA

Simona Mancini: https://youtu.be/GtmsmHA8wKo

Participation guidelines

- Please keep your microphone muted.
- Post your questions into the YouTube or Zoom chat prefaced by “Q:”.
- Junior researchers have priority. Please preface your questions with “QJ:”.

K1 - William Matchin

Grammatical parallelism in aphasia revisited

The study of aphasia has driven our understanding of the neurological organization of language since the 1800s, leading to the development of the classical model of Wernicke, Lichtheim, and Geschwind, in which Broca's area primarily supports language production. In the 1970s, novel experimental paradigms revealed apparent syntactic comprehension deficits in people with fluent Broca's aphasia and expressive agrammatism. This lead to a widespread movement away from the classical model and towards models of language organization in the brain positing a central syntactic function to Broca's area. I will present data from several studies of syntactic ability, both in comprehension and production, in people with post-stroke aphasia, showing that damage to the frontal lobe and expressive agrammatism are not associated with syntactic comprehension deficits, contrary to the contemporary received view regarding grammatical parallelism. By contrast, damage to the posterior temporal lobe is associated with both syntactic comprehension and production deficits, a grammatical parallelism consistent with Wernicke's original ideas and the theoretical model developed by Matchin & Hickok (2020).

K2 - Simona Mancini

Feature combinatorics

In spite of their structural diversity, human languages share the basic goal to convey fundamental coordinates about the world, such as the time and the temporal organization of an event, the gender, the role and the relation between the individuals involved in an event, to name a few. During comprehension, these properties, or *features*, are effortlessly extracted from the linguistic input by readers/listeners, who use them to build relations among words and eventually establish the overarching meaning of a sentence. How are these features handled by the comprehension system? Are they differentiated? And if so, when and how? In this talk I will show how distinct types of features and the relations they are involved in are processed, providing eye-tracking, electrophysiological and neuro-anatomical evidence for common and feature-specific mechanisms at work at distinct interface levels.

Workshops

W1 - Jixing Li (Day 1)

Grammatical predictors for fMRI time-courses during naturalistic listening

This workshop demonstrates how to model fMRI time-courses using structure-building computations under different parsing strategies. Different parsing strategies lead to different predictions about processing effort on a particular word. A top-down parser starts from a mother node and makes decisions about phrase structure before checking them against the input string. A bottom-up parser starts with the first terminal word and has to check all the evidence before applying a phrase structure rule. A left-corner parser combines both top-down and bottom-up directions, and it applies a grammatical rule after seeing the very first symbol on the right-hand side of the rule. We will examine neural evidence for these parser actions using blood-oxygen-level-dependent (BOLD) signals that came from participants listening to a story while in the scanner.

W2 - Stephan Meylan (Day 1)

Measuring Grammatical Productivity with Bayesian Inferential Methods

In this workshop, participants will conduct a replication and extension of key analyses in "The emergence of an abstract grammatical category in children's early speech" (Meylan, Roy, Frank and Levy 2017, Psychological Science). I'll present the theoretical motivation for the approach of treating linguistic productivity as a type of prior knowledge, and lead a discussion of its potential applications. Participants will work on hands-on examples of model specification and MCMC sampling using JAGS (including the rjags and coda packages). The workshop will also showcase how researchers can efficiently retrieve data from child language corpora within R using childes-db / the childesr package (Sanchez, Meylan, et al., 2019 Behavior Research Methods). The workshop will presume basic competence with the R language, as well as a familiarity with basic linguistic concepts (e.g., syntax, utterances, noun phrases), but will provide a maximally gentle introduction to the Bayesian approach.

W3 - Cristiano Chesi & Paolo Canal (Day 2)

Tracking processing: computational complexity and eyetracking with Minimalist Grammars

In this workshop we will present a set of explicit grammatical intuitions framed within the Minimalist perspective (Chomsky 1995, 2001, Stabler 1997, 2011, 2013, Chesi 2015, 2021) dealing with basic structure building operations (essentially Merge, Move and Agree). Here we will present a linking theory suggesting some non-trivial predictions during on-line sentence processing: We will mainly focus on eyetracking measures and their putative indication of processing efforts. Python scripts (to generate predictions given a lexicon and a specific grammatical parameterization) as well as R scripts (to interpret some relevant eyetracking results) will be provided and discussed during the workshop.

W4 - Simon W. Townsend, Mael Leroux, Alexandra Bosshard & Melissa Berthet (Day 2)

Unpacking animal call combinations: an introduction

In the last two decades there has been an upsurge in research into the propensity for animals to combine calls together into larger meaningful structures, not least given the striking parallels some of these examples have with human linguistic combinations. Despite growing interest, the study of animal call combinations is complicated by a lack of systematic methods. In this workshop we will highlight recent methodological developments and provide a step-by-step guide to the objective investigation of animal call combinations from collecting data in the field to quantifying non-random call associations, capturing acoustic variation and finally assessing meaning attribution.

Posters

AB1 - Mohsen Dolatabadi

Predicting concreteness of English words by their perceptual and action strength norms

Introduction: Many datasets resulted by participant ratings for word norms also concreteness ratios are available. However the concreteness information of infrequent word and none words, is rare. Our aim in this work is proposing a model for estimating concreteness of infrequent and new lexicons.

Methods: Here we used Lancaster sensory-motor word norms, to predict word concreteness ratios of an English words dataset. After removing missing values, we employed a stepwise-multiple linear regression (SW-MLR) procedure for choosing an optimum number of norms to make a predictive multiple regression model. Finally, we validate our model using 10-fold cross-validation.

Results: The final model could predict concreteness by Residual Mean Standard error equal to 0.723 and R-Square 0.515.

Conclusion: Concreteness and abstractness of words and none words are fuzzy as well as graded property. Here we applied step- wised linear regression method to select the best model for predicting concreteness value in the Brysbaer dataset by using Lancaster English frequent word norms. Our results showed that all 11 variables of this dataset except the Head-mouth parameter are useful predictors. Furthermore, the chemosensory variables in our interested dataset, namely, gustatory and olfactory perception of a concept are positively correlated to the concreteness estimates.

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AB2 - Laura Giglio

The neural correlates of spontaneous sentence production

In the last decade there has been an increase in studies of naturalistic language processing. The benefit of studying linguistic processing with naturalistic stimuli is to increase ecological validity and reduce confounds due to the absence of context that is typical in controlled stimulus sets. Naturalistic studies so far have focused on comprehension, but studying naturalistic production may be even more critical, since most production studies use artificial tasks to ensure the production of varied speech output. These tasks give speakers no control over what is to be said, although deciding what to say and how is a critical characteristic of production, while lack of control over the linguistic input is typical in comprehension. As a consequence, the current understanding of the neural infrastructure for sentence production is confounded by task requirements. In this study, we aim to gain a better understanding of syntactic processing in naturalistic production, by analyzing an existing fMRI dataset where participants freely speak for several minutes recalling an episode of the TV series Sherlock [1]. The speech output includes 2000-5000 words per participant and is characterized by numerous hesitations, mid-sentence corrections and a variety of grammatical structures. Preliminary fMRI analyses into the hemodynamic response to syntactic complexity, quantified as node count per sentence, did not reach significance at the group level. We speculate that the low number of participants together with the high variability in the constructions used across participants, as well as variability in hesitations and corrections, resulted in low signal-to-noise ratio relative to more controlled studies. We have planned further analyses with encoding models to predict the BOLD signal with less coarse measures, such as word-by-word predictors, that may be less sensitive to the variability in structures used between participants and thus more appropriate in this context. The results will allow us to reflect on the characteristics of sentence production in unconstrained settings.

AB3 - Ariane Hohl

Verbal repetition in aphasia and its relationship with the structural and functional properties of the dorsal and ventral streams in the right hemisphere

The perisylvian area of the left hemisphere has been identified as the dominant area for language function, while the role of the right hemisphere in language is still unclear. Recent studies are pointing towards an important impact of this hemisphere in language recovery in post-stroke aphasia (loss or impairment of language due to brain damage after stroke, [PSA]). One language function that is often affected in acquired and degenerative language disorders is verbal repetition. In consequence, rehabilitation strategies may profit from its functional and structural characterization. The arcuate fasciculus with its direct and indirect segments as the main dorsal pathway has been linked to repetition of unknown words and pseudowords, whereas activity in the ventral pathway seems to be responsible for repetition of known words and sentences. As for all language functions, studies regarding verbal repetition and its brain correlates have been heavily focused on the left hemisphere. Even though after brain damage in the language-dominant hemisphere, there is high interindividual variability in verbal repetition abilities which can be related to the function and structure of the right dorsal and ventral systems. Moreover, investigations regarding verbal repetition in aphasia should explore the underlying mechanisms in a more comprehensive way by using different stimuli for the evaluation of repetition performance. This study aims to characterize the brain correlates of verbal repetition in the right hemisphere of 20 patients with chronic PSA. Importantly, different repetition stimuli will be evaluated (words, pseudowords and sentences). Functional and structural connectivity analyses of the dorsal and ventral streams will be performed based on MRI, DTI and rs-fMRI. Further, tractography analyses based on DTI of the direct and indirect pathways of the arcuate fasciculus, and the ventral pathways (inferior fronto-occipital fasciculus, inferior longitudinal fasciculus, uncinate fasciculus) will be performed. The functional connectivity strength between the areas connected by pathways will be investigated by rs-fMRI. All analyses will be performed bilaterally. Currently, data acquisition is ongoing. The resulting analyses will provide important insights on the role of the understudied right hemisphere in verbal repetition.

These results could lead to new information about language recovery in people with PSA and could guide future therapeutic interventions.

AB4 - Nafiseh Sadat Hosseini Esfidvajani

Slowing down or speeding up? The role of phrasal verbs in reading speed among Persian learners of English: An eye movement study

Phrasal verbs have been the area of difficulty that many English learners would rather to skip. Moreover, in some related literature it is mentioned that speakers of languages which include phrasal verbs (e.g., Germany) can read and learn English phrasal verbs easier in comparison with native speakers of other languages (e.g., Hebrew) that lack such phrases. Interestingly, although Persian language contains phrasal verbs and multi-word verbs, some behavioral studies have shown the avoidance of English phrasal verbs among English learners whose L1 is Persian. It is thought-provoking to know how their reading behavior is since in Persian reading is performed from right to left and in English from left to right. In this study we investigate the reading speed of Persian learners of English in the text containing phrasal verbs and also in the same text substituting one-word equivalent of the phrasal verbs. Our objective is to identify if reading speed varies when the participants read English texts containing phrasal verbs. Thus, in a pilot study, 10 advanced English learners whose first language is Persian are going to read three 1-page texts. One including non-compositional phrasal verbs which are opaque, another one with the one-word equivalent of the same phrasal verbs, and the third text that acts as a control text. The participants should answer three comprehension questions after each passage. Their eye movements through reading the task will be recorded by SensoMotoric Instruments (SMI) eye-tracker. Fixation points, first pass reading time and total reading time will be focused on for data analysis. Area of interest (AOI) are defined to be phrasal verbs, their equivalents, and the whole passage, as well. The materials included in the pilot study are a consent form, language background questionnaire, a proficiency test, reading tasks, and summary production task. In later phases of the project, we ask the participants to summarize the texts which they have read to explore if they use phrasal verbs in the summary and whether the results can be related to their reading speed or their proficiency level.

Key words: phrasal verbs, reading speed, eye-tracking

AB5 - Veronika Prigorkina

Temporal reference in Russian perfective converbs: effect of clause order and event coherence.

There is much debate in the literature, whether Russian perfective converbs can express posteriority (event of the dependent clause following the event of the main clause). If this (followance) interpretation is possible, the question arises which factors affect interpretation acceptability and reaction to it. Presumably, two such factors are 1) linear position of the embedded clause with respect to a linear position of the main clause, associated with specific functions (“guideposts” and “afterthoughts” of Chafe, 1984) and allowing for iconic presentation of the events, and 2) event coherence (presence of a contextually preffered temporal interpretation for the two events), as predicted by Narrative event chronology account (Lehmann, 1998).

245 Russian native speakers were instructed to read sentences with converbial clauses presented in the screen and to accept/deny precedence/followance interpretations choosing either "yes" or "no" on the keyboard. Their reaction to an interpretation was measured. The study had a 2 x 2 factorial design: Clause order (Main-Sub vs. Sub-Main) and Coherence (coherent vs. non-coherent events in the embedded and main clauses). Each condition included 16 critical items distributed among 8 experimental lists. Filler items comprised 24 coordinate sentences and did not differ across the lists. Generalized and Linear Mixed-effects models were used for binary answers and reaction times respectively.

Although anteriority was generally accepted significantly more often ($p < 0.001$) and faster ($p < 0.001$) than posteriority, they were equally acceptable in a neutral context in postposition ($p > 0.05$). Order iconicity significantly affected both interpretation acceptability and latency: anteriority is facilitated in preposition ($p < 0.001$), while posteriority – in postposition ($p < 0.05$). Coherent contexts increased acceptability for anteriority and decreased for posteriority ($p < 0.001$).

The study demonstrates that both interpretations of Russian converbial clauses are influenced by the clause order and the event coherence. Clause order, but not contextual

prompt is crusial for posterioirity interpretation, contrary to previous views (Weiss, 1995; Birzer, 2010), showing that Order Iconicity principle plays a major role in converbial constructions processing. Results do not support findings of coherent contexts facilitate temporal interpretation (e.g., Natsopoulos & Xeromeritou, 1988).

AB6 - László Drienkó

Structural priming from an Agreement Groups perspective

We demonstrate how various structural priming phenomena can be interpreted in the Agreement Groups model (AGM) of linguistic processing (e.g. Drienkó 2020, in Haselow & Kaltenböck (eds.) Grammar and Cognition: Dualistic models of language structure and language processing. 310-354. John Benjamins P.C.)

AGM is a usage-based distributional cognitive framework operating with memorised groups (AGs) of similar utterances as basic processing units and a combinatorial mapping mechanism defined over them. Similarity means that utterances within an AG differ from a base utterance in exactly one word. AGs consist of 2-5-word-long utterances. For the processing of longer utterances the model applies a coverage apparatus.

We assume two major levels: i). direct mappings onto AGs for processing holophrases, shorter utterances, or “formulaic” expressions; ii) coverage, i.e. the selection of optimal combinations of AG-compatible fragments to “grammatically” cover more complex utterances. This duality is reflected in the coverage structure of a given utterance.

AGM is compatible with findings in cognitive linguistic processing including (over)generalisation, categorisation, a semantic/syntactic categorical less-is-more principle (Newport 1990) and its relationship to U-shaped learning (Strauss 1982), parallelisms with the dual-process model of Van Lancker Sidtis (2009), neurolinguistic processing (Bahlmann et al. 2006), and the processing of complex linguistic structures such as long-distance dependencies, crossing dependencies, or embeddings. Beyond syntax, the approach might be applicable to morphological, historical/evolutional, semantic/conceptual and analogical aspects of language.

Structural priming in AGM can arise from the repetitive usage of previously activated AGs, or AG configurations (coverage structures, schemas). Here we propose possible analyses for a selection of priming phenomena involving thematic role assignment with prepositions and word order (prepositional/double-object dative, passive, etc.) – Hare & Goldberg (1999), Chang et al. (2003), Rowland et al. (2012), Bidgood et al. (2020); locative vs. agentive

by-phrases – Bock & Loebell (1990); closed-class variation – Pickering & Branigan (1998); subordinate vs. main clauses – Branigan et al. (2006); relative clause attachment (high vs. low) – Scheepers (2003); object-raising/object-control – Griffin & Weinstein-Tull (2003); coerced sentences – Raffray et al. (2014).

AB7 - Jessica Aloisi

Changes in attentional networks induced by combined therapy of donepezil, intensive language-action therapy and transcranial direct current stimulation in chronic post-stroke aphasia

Language impairments in aphasia are frequently associated to attentional deficits, which may influence therapy outcomes. Attentional deficits may be improved by enhancing the cholinergic system. Yet, just a few studies have used well-validated experimental tasks to explore treatment effect on attention in people with post-stroke aphasia (PWA). The aim of the current study is to explore the effect of a cholinergic modulator (donepezil) alone and combined with intensive language-action therapy (ILAT) and transcranial direct current stimulation (tDCS) over attentional networks (executive control, orienting and alerting) assessed by a modified version of the Attentional Network Test (ANT) in PWA. Twenty PWA participated in the study. The study design consisted of a 10-week open-label intervention trial using a combined treatment approach. First, the pharmacological treatment with donepezil (5 and 10 mg/day) (weeks 0 to 8) was administered, then ILAT and anodal tDCS vs sham were added to an ongoing treatment with donepezil (weeks 8 to 10). The stimulation was administered over the right perisylvian cortex using a montage of seven electrodes, 2 mAh per 25 minutes/day. The executive control, orienting and alerting attentional networks were tested with the modified ANT at four different time points: at baseline (T1), following 8 weeks of pharmacological therapy with donepezil (T2), following two weeks of combined therapy including donepezil + ILAT + anodal tDCS/sham (T3) and three months after washout of all interventions (T4). The scores of the three attentional networks were calculated based on the reaction times for correct trials. Analysis of variance test highlighted a significant main effect of congruency, visual cue and warning tone at all time points. Further, a Friedman test revealed that executive control network scores changed significantly over time (main effect of treatment). Post-hoc test showed that combined therapy induced significant improvements in executive control (T3 vs T1) with no significant changes between the combined therapy (T3) and the follow-up (T4), suggesting that the benefits were maintained 3 months after treatment interruption. Alerting and orienting networks showed no significant changes over times. Preliminary analyses showed no main effect of tDCS or interaction with other treatment. Our findings suggest that executive control

may be boosted with donepezil combined with ILAT, and that these benefits are maintained over time.

AB8 - África Yolanda Gómez-Pérez

Differences between the logopenic variant of primary progressive aphasia and of Alzheimer's Disease. A systematic Review.

Introduction. Primary progressive aphasia (PPA) consists of a language impairment present for at least two years without impairment of other cognitive domains. This syndrome is classified on three variants: non-fluent/agrammatic, semantic and logopenic. PPA is usually associated with frontotemporal lobar degeneration (FTLD). However, the logopenic variant is mainly associated with Alzheimer's disease (AD), although there is evidence of cases in which the underlying pathology was FTLD.

Development. A systematic review of the latest literature was implemented to determine whether clinical, neuropsychological, or neuroanatomical differences have been found between the logopenic variant with PPA as underlying pathology (lvPPA) and the one with AD as underlying pathology (lvAD). Inclusion criteria were a) study includes a lvPPA experimental group; b) comparison between lvPPA and lvAD subgroups; c) underlying pathology confirmed via autopsy or biomarkers; c) methodologic and statistical analysis quality. From the initial 736 papers found, 22 were revised. From these 22 revised studies, only 13 made a direct comparison between lvPPA and lvAD. Four studies found neuropsychological/linguistic differences, one found neuroanatomical differences, and seven studies found both neuropsychological/linguistic and neuroanatomical differences. One study didn't find any differences between subgroups.

Conclusions. The most consistent differences between the groups were the ones found at the neuroanatomical level, as lvAD shows more extended patterns of atrophy, as well as greater involvement of the right hemisphere. The linguistic and neuropsychological differences found were mild, distinguishing greater impairment of naming and global cognitive measures in the lvAD group, and greater impairment of phonological fluency and syntax in the lvPPA group. Despite the observed differences, there are very few studies on this subject, and more investigation on this syndrome is needed to fully understand it, to improve the diagnosis and to better adapt the treatment for each patient.

Key words. Alzheimer, Dementia, Frontotemporal lobar degeneration, Logopenic progressive aphasia, Logopenic variant, Primary progressive aphasia.

AB9 - Dora Uštulica

Humans vs. Machines - The Question of Compositionality

This is a project in its early stages. Some results may be obtained by the time of the workshops.

The principle of compositionality is understood to entail that the meaning of every expression in a language must be a function of the meaning of its immediate constituents and the syntactic rules used to combine them. The compositional skills of people (appx.50) are tested through language-like instruction learning tasks. Groups of subjects are tested on the examples created to test their accuracy in the compositional way of thinking. The assumptions that people make when solving those tasks are taken into account, e.g. biases such as mutual exclusivity and iconic concatenation. Also, some challenges for the concept of compositionality as such are considered, e.g.quantifiers, argument structure construction. Such experiments allow us to further explore the cognitive underpinnings of the natural language. The results are analyzed by means of descriptive statistics in R.

In contrast to humans, who are able to make generalizations about new concepts with only a few examples, neural networks need vast amounts of data to do the same. Do deep neural networks exhibit the capability of generalization based on the compositional rules? Emergent, a neural simulation software, is used to train a neural network with the examples such as the ones mentioned below, and then to test the network with newly formed examples based on the ones it was trained on. Examples are based on the principle of compositionality. They consist of a verb such as jump, run etc. and a modifier or a conjunction such as once, twice, before, and etc. If neural networks do make some generalizations, but not based on the principle of compositionality, that raises questions about the nature of that principle, which is crucial for the functioning of a language as a system.

Combining two types of tests, the one on human subjects and the other one on neural networks, allows us to further explore a topic crucial for the understanding of language. Two tests can mutually inform each other. Neural networks can spark new ideas about the

possible ways thanks to which people are able to make generalizations, and human subject tests further explore the principle, taking into account biases and constraints that appear, which in turn may be useful for creating more efficient neural networks.

AB10 - Shailee Jain

Discovering distinct patterns of semantic integration across cortex using natural language encoding models for fMRI

Encoding models (EM) are a powerful tool for modeling language processing in the brain. While previous research has used word-level EMs to discover how semantic concepts are organized across cortex, we are yet to understand how the brain processes compositional meaning. Recent work has shown that language model (LM) based EMs can be used to study phrase-level processing. LMs are artificial neural networks that learn to predict the next word by developing a representation of the preceding phrase. This phrase-level representation can be extracted for each stimulus word to build encoding models. Here we built EMs using a 12-layer transformer LM (GPT) and data from an fMRI experiment with 5 subjects (3 female) listening to 5 hours of naturally spoken narrative English language stimuli. EMs were learned using ridge regression and performance was measured by testing predictions on held-out datat. The phrase-level model performed well broadly throughout the cortex, highlighting the importance of context in the brain. The learned weights were then used to find phrases that were predicted to maximally activate each voxel, revealing its phrase-level semantic properties. This model predicts voxel response as a function of words constituting a phrase. However, different brain areas integrate over different amounts of information. To investigate these differences, we next assessed how sensitive each voxel was to constituent words in a phrase. We found that most voxels were much more sensitive to changes in recent words but we also found substantial differences across brain areas. Overall, voxels in the right hemisphere integrate over more words, but voxels in prefrontal cortex showed substantial heterogeneity in both hemispheres. Finally, we compared integration across areas that are selective for the same semantic category, such as "places". This revealed significant differences between areas; for example, voxels near parahippocampal place area had small integration windows, while voxels in retrosplenial cortex had longer windows and were particularly sensitive to prepositional phrases involving places. These results paint a more nuanced, and accurate picture of language selectivity across cortex than previous computational models. Further, examining phrase-level selectivity reveals differences among brain areas in the same semantic network, leading to a

better understanding of how these areas work together to extract compositional meaning from natural language.

AB11 - Cas Coopmans

Effects of structure and meaning on cortical tracking of linguistic units in continuous speech

Recent studies have shown that the brain 'tracks' the syntactic structure of phrases [1], and that such phrase structure tracking is modulated by the compositional content of these phrases [2]. Following up on this literature, the current EEG study examines to what extent cortical tracking of linguistic structure is modulated by the compositionality of that structure.
We measured EEG of 38 participants who listened to naturally produced stimuli in five different conditions, which systematically modulated the amount of linguistic information. We compared sentences (+syntax, +lexical meaning, +composition) to idioms (+syntax, +lexical meaning, ~composition), syntactic prose (+syntax, +lexical meaning, ~composition), jabberwocky (+syntax, –lexical meaning), and word lists (–syntax, +lexical meaning), and included backward versions of sentences and word lists as acoustic controls. Based on manual annotations of all speech recordings, we derived the frequency band corresponding to the presentation rate of phrases (1.1-2.1 Hz). Tracking was quantified through Mutual Information (MI), both between the EEG data and the speech envelope in this frequency band, and between the EEG data and abstract annotations of syntactic structure (i.e., bracket count).

We consistently found that MI between speech and EEG was higher for sentences than for jabberwocky, but not higher than for idioms or syntactic prose. This result was also found when MI was computed between the EEG signal and the abstract syntax annotations. Phrase structure tracking was also higher for sentences than for word lists, but as this difference was found for the backward versions of these stimuli as well, it could reflect the difference in their acoustics.

Overall, phrase structure tracking was stronger for sentences than for stimuli that lacked either lexical meaning or syntactic structure, but it was not consistently different from stimuli which had lexical meaning and syntactic structure. These findings suggest that cortical tracking of linguistic structure reflects the generation of lexicalized structure [3,4], whether this structure straightforwardly maps onto semantic meaning or not. This conclusion is in line

with neurobiological models of language comprehension which make a functional distinction between syntactic structure building and semantic composition.

[1] Ding et al., 2016 Nat. Neurosci.; [2] Kaufeld et al., 2020 J. Neurosci.;
[3] Martin, 2020 JoCN; [4] Meyer et al., 2019 LCN

AB12 - Julia Cataldo

Friend of foe: the morphological kinship between words

Lexical access allows the immediate understanding and production of words online. Despite being a basic linguistic computation, there is a lot of heated theoretical dispute in this area. This study will present an empirical research whose results shed light on the way we access transparent and semantically opaque words (as whole words vs. by affix stripping - Taft, Forster, 1970) and on the method of storing them in the mind (morphologic vs. semantic routes).

The Distributed Morphology (MD - Halle, Marantz, 1993) theory suggests there are different lexical approaches, originated from psychologically different processes. However, we are interested in the access of words that bear a morphological relationship between them and that once also shared a semantic relation, but that under the synchronous perspective have lost it. For instance, liquidação (Brazilian Portuguese for the word sale) derives diachronically from líquido (liquid), but nowadays Brazilian speakers seem to ignore this semantic relationship. This very specific type of morphologic and semantic relationship between words has never been tested before in this language.

In order to evaluate MD predictions, we ran a priming test with a lexical decision judgment (word/non-word). We compared pairs of synchronically semantically unrelated (but morphologically linked) words -like líquido/liquidação (liquid/sale)- with pairs that maintain a transparent compositional relationship -like líquido/liquidificar (liquid/liquefy)- and with pairs that maintain only a semantic relationship -like líquido/aquoso (liquid/aqueous).

The results of a first behavioral pilot test confirmed the MD hypothesis, evidencing i) a decompositional course during processing, regardless of semantic opacity; ii) new entries for words as liquidação (sale) in the mental lexicon; and iii) different psychological processes for the morphologic and semantic routes: linguistic composition for the former and joint memory for the latter.

Our next step will be to run an EGG test with the same design (Bozic et al., 2007; Moris et al., 2007). We expect to find wider ERP amplitudes for the semantically opaque conditions

and different latencies between two-different-size stimuli (2 and 3 morphologic layers) for both the transparent and opaque morphological conditions, but not for the semantic-only one. These findings would confirm our previous conclusions for the pilot test.

AB13 - Jordi Martorell

Tracking hierarchical processing during meaning composition

Does meaning composition during language comprehension rely on hierarchical or linear computations? Recent experiments using the frequency-tagging paradigm have suggested that neural activity tracks the incremental combination of words into phrases, and phrases into sentences – that is, the unfolding of hierarchical linguistic structures. Yet, non-hierarchical computational models purely based on word-level lexical features also seem able to explain such findings, suggesting that linear computations may instead underlie meaning composition. Here we present the experimental design for a magnetoencephalography (MEG) study aimed at testing for the presence of hierarchical processing during minimal phrase composition. We will implement the frequency-tagging paradigm in the visual modality (written words) by presenting sequences of 3-word Noun Phrases (NPs) in Spanish with either linear or hierarchical structures. In both conditions, the first two words are identical (Noun and Colour Adjective; árbol rojo, tree red). The critical manipulation resides on the third word: in the linear condition, a Size Adjective (grande, big) modifies the Noun – thereby resulting in a 3-word NP without hierarchical relationships; in the hierarchical condition, a Degree Adjective (oscuro, dark) modifies the Colour Adjective – giving rise to a 2-word Adjective Phrase (AP) embedded within the 3-word NP, thus forming a hierarchical structure. Spanish speakers (n = 30) will be presented with trials composed by sequences of 3-word NPs (each word for 0.666 s) in either the linear or hierarchical condition. Trials will contain between 2 and 9 consecutive NPs. After the last NP of each trial, a picture will appear and participants will have to indicate whether or not it matches the lastly presented NP. MEG data will be analyzed in the frequency domain. Based on word/phrase durations, our frequencies of interest will be 1.5 Hz for words, 1 Hz for APs, and 0.5 Hz for NPs. We expect to observe neural activity peaks at the word and NP frequencies in both linear and hierarchical conditions. Critically, if participants deploy hierarchical processing, we should find an additional peak at the AP frequency only in the hierarchical condition. This peak would reflect an extra computation required to access the overall compositional meaning of hierarchical NPs. We will present the experimental design of our study and simulated data providing support to the feasibility of our manipulation.

AB14 - Astrid Graessner

Electrophysiological responses to basic semantic composition in people with aphasia

The ability to combine single words to meaningful phrases is essential for successful communication. People with post-stroke aphasia show impaired semantic composition, leading to comprehension deficits. Previous studies using classical sentence anomaly or picture-word matching paradigms have found a diminished and delayed N400 effect in aphasic patients that is modulated by the degree of their semantic deficits. What remains unclear, however, is whether these effects are due to lexical access or due to specific compositional difficulties. Here, we address this question using a minimal semantic composition paradigm that varies both phrasal plausibility and lexicality while measuring event-related potentials (ERPs) from 64 electrodes.

We included 20 post-stroke aphasic patients, 20 young healthy controls and are currently collecting data from 20 age-matched healthy controls. Participants listened to adjective-noun phrases that were either meaningful (“fresh apple”), anomalous (“awake apple”) or had the noun replaced by a pseudoword (“awake gufel”), as well as a single-word control condition (“apple”). After a short delay, participants made a plausibility judgement to each stimulus via button press.

To test for significant within-group differences between conditions, cluster-based permutation tests were conducted for a pre-defined time-window of 300-500 ms for: anomalous – meaningful, pseudoword – meaningful and pseudoword – anomalous phrases.

Preliminary results for the young control group show a significant N400 effect for both anomalous - meaningful and for pseudoword - meaningful phrases, but not for pseudoword – anomalous phrases. In the aphasic group, however, only the difference between anomalous and pseudoword phrases becomes significant. Additionally, the latency of both meaningful and anomalous phrases is significantly delayed in aphasic patients as compared to the young controls. Interestingly, exploratory analyses of the P600 time-window reveal a significantly increased and sustained frontal positivity for pseudoword phrases versus

meaningful and anomalous phrases in the aphasic group, while young controls show a parietal positivity for meaningful phrases.

These results suggest a processing difference both at the lexical and at the compositional level in aphasic patients as compared to healthy young controls. Whether these differences are due to age or due to lesion will be investigated by including the age-matched control group.

AB15 - Piermatteo Morucci

Building syntax in space: can processing syntactic movement induce shifts in spatial attention?

Several cognitive processes (e.g., serial-order working memory, number processing) can induce covert shifts of spatial attention, suggesting that some aspects of cognition are grounded in the spatial system. Similar effects have been reported even when performing more complex operations like arithmetic – indicating that similar spatio-attentional resources may support even higher-level cognitive functions. Inspired by this literature, we hypothesize that spatio-attentional resources may support some aspects of language processing. In particular, this mechanism may be suited to support those syntactic operations requiring conceptual movement of constituents within a mental working memory space – such as derivations of non-adjacent dependencies (e.g., syntactic movement). To test this hypothesis, we presented Spanish speakers (N = 30) with syntactically dislocated sentences flashed one word per time in the centre of a screen. In syntax, dislocation refers to constructions in which a referential constituent occurs outside its canonical position, either to the left (left-dislocation; e.g., “the bicycle thief, the police arrested him”) or right periphery (right-dislocation; e.g., “they swam all day, my kids”) of the sentence. After reading each sentence, participants were asked to vocally reproduce the sentence in its canonical word order. The verbal answer was followed by a target detection task, in which participants had to detect a dot that appeared on the left or the right side of the screen. Preliminary analysis showed that participants were consistently faster in detecting a dot when presented on the left side of the screen. This finding suggests that processing syntactic dislocated sentences induce some spatial shifts of attention. The directionality of the effect suggests that, when presented with syntactically dislocated structures, participants mentally move the beginning of the sentence towards the left-side to derive its canonical word order, independently of the position of the dislocated constituent. This result provides a novel link between syntactic processing and spatial attention.

AB16 - Aicha Rahal

The Role of PRAAT in Identifying Fossilized Phonological Errors in the Spoken Output of Tunisian Tertiary English Students

Fossilization refers to the presence of incorrect linguistic features as a permanent way and the cessation of learner's acquirement of L2. It is one of the ways in which this partial acquisition of a native-like competence is evidenced. Fossilization, therefore, has become a major area of interest in the field of psycholinguistics. The literature available on Interlanguage (IL) fossilization (Yahya, 1980; Rahal, 2014; Smaoui and Rahal 2015; Rahal, 2016), especially in the Tunisian context, shows that this linguistic phenomenon still remains to be extensively researched. This poster addresses this main research question: (1) what are the fossilized pronunciation errors in the speech of Tunisian English students? This study is a combination between psycholinguistics and computational linguistics. It is an attempt to show the existence of a psycholinguistic phenomenon through the use of the software PRAAT and perform an acoustic analysis. Methodologically, the present study uses the longitudinal approach to investigate IL fossilization and describe the developmental processes or language change overtime. The researcher collected data two times from the same informants for the purpose of identifying the fossilized phonological errors. To answer the research question, data will be taken from the Tunisian corpus. The token consists of two lists of words and a text, and a list of sentences. PRAAT is used to identify formant measures and duration. Then, data will be statistically processed using EXCEL. Preliminary results demonstrate that there are a number of phonological errors that remained persistent in the participants' IL, including consonant and vowel sounds and diphthongs which are evidence of the existence of fossilization. To conclude, it is worth noting that the study may contribute to raise teachers' awareness of this linguistic phenomenon to find pedagogical ways that should be used to avoid stabilized errors in learners' IL.

Keywords: fossilization, Tunisian learners, phonology.

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AB17 - Seth Wiener

A combinatorics approach to spoken word recognition: Evidence from native and non-native Mandarin Chinese listeners

Mandarin Chinese has approximately 400 unmarked (consonant)-vowel-(consonant) syllables. These syllables can combine with one of four phonemic pitch patterns or tones to create a monosyllabic morpheme or word. Because many syllables do not co-occur with all four tones (i.e., there are nonword gaps analogous to English 'blick'), there are about 1,300 syllable-tone combinations used in modern spoken Mandarin. Of these 1,300 combinations, roughly 100 syllable-tone combinations make up nearly 50% of the tokens in modern spoken language corpora, resulting in a Zipfian distribution. In a series of behavioral and eye-tracking experiments, we explore four questions central to how this distribution of syllable-tone combinations affects spoken word recognition. First, using the visual world paradigm, we examine the time course of spoken word recognition in native Mandarin listeners. We show that at a very early stage of online word recognition listeners predict the most probable tone given the syllable. This syllable-tone co-occurrence or dimension-based statistical learning occurs rapidly and can lead to incorrect predictions, which are quickly revised upon hearing the full stimulus. Second, using the gating paradigm, we examine how much of the acoustic signal is necessary to trigger this probabilistic syllable-tone processing. We show that with the onset and as little as 40 milliseconds of the vowel, native listeners begin predicting likely syllable-tone combinations given their prior experience with the language. Third, we examine whether non-native listeners are able to track and process syllable-tone combinations in a native-like manner. We extend both the eye-tracking and gating findings to adult second language learners and demonstrate similar patterns of syllable-tone predictive processing despite their limited experience with the language. Fourth, we examine to what degree talker variability affects this predictive processing. We show that both native and non-native listeners increase their use of predictive syllable-tone processing given greater talker variability in the speech signal. Taken together, these studies support a usage-based or exemplar model of the mental lexicon involving phonological combinations at the syllable-tone level. Lexical access is mediated by the degree to which the acoustic signal matches the stored representation, with an innate statistical learning mechanism playing a role in these lexical processes.

AB18 - Genta Toya

Computational neurocognitive modelling of recursive combinatorial ability

Hierarchical structures underlying language, music, and action sequencing are produced by recursive application of operation combining two items, i.e., recursive combination (RC). A previous evolutionary simulation study suggests that RC is adaptive for the exploration of combinatorial space in generating diverse sequences (Toya & Hashimoto, 2018). In the current study, we propose an extension of this model to reflect neural processes underlying hierarchical control, which was suggested to be a shared neurocognitive mechanism for language, music, and action (Asano, 2021), by combining deep reinforcement learning (RL) model and RC. Language, music, and action sequencing can be defined as the exploration of the combinatorial space, i.e., the exploration of the reward by altering environmental states through actions. Model-based RL, in which multiple sequences are first planned and then evaluated, is used to efficiently explore the combinatorial space. If there are multiple possible rewards, there are various paths for state transitions to achieve the rewards. Because the paths may partially overlap with each other, their subparts can be reused to achieve other rewards. We hypothesize that humans efficiently explore combinatorial space by recursively combining those sub-paths and model RC of the sub-paths in terms of autoencoder. We argue that 1) the basal ganglia implement RL for reward exploration, 2) the fronto-parieto-temporal networks perform planning based on (hierarchical) internal models acquired by statistical learning (and the autoencoder for RC), and 3) the planned action sequences are evaluated via the cortico-basal ganglia-thalamocortical circuits. Our current model realizes the interplay between the cortico-basal ganglia-thalamocortical circuits and the fronto-parieto-temporal networks, which is suggested to have been elaborated in the course of the primate brain evolution and provides an important implication for research on the evolution of the combinatorial ability for language, music, and action (Asano, 2021).

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AB19 - Xuehu Wei

Longitudinal Structural Plasticity of the Language Network by Second Language Learning

Introduction: Languages of the world strongly differ from one another in all dimensions (sound, lexicon, syntax and orthography)(Evans & Levinson, 2009), and each language relies on a particular neural network adapted to its processing demands (Ge et al., 2015; Goucha, 2019; Paulesu et al., 2000). Similar to the specialization of the brain to the characteristics of the mother tongue, efficient processing of novel structures in adult foreign language learning was previously related to brain plasticity(Bialystok, Craik, & Luk, 2012; Li, Legault, & Litcofsky, 2014; Qi & Legault, 2020). Initial studies found structural changes in various gray matter and white matter regions(Kuhl et al., 2016; Mamiya, Richards, Coe, Eichler, & Kuhl, 2016; Pliatsikas, Moschopoulou, & Saddy, 2015; Schlegel, Rudelson, & Tse, 2012). Here we analyzed the longitudinal structural changes of the white matter language connectome during adult second language learning in a large and well controlled cohort.

Method: We recruited 60 young healthy right-handed Arabic native speakers (mean age, 25.9 years; range, 19-34) for an intensive German course (5h/day, 5days/week) over a 6-months period leading from beginners to the advanced B1 language level. We acquired high angular and spatial resolution diffusion MRI data from each participant at the beginning (time point 0: TP0), after 3 months (TP1) and after 6 months (TP2) of language learning. Using probabilistic tractography, we computed the structural connectivity network between all the language related areas in both hemispheres (Fig.1a) and used the normalized number of streamlines between each region as measure of the connection strength. On a global level, we first analyzed overall connectivity change (sum of all weighted connections in language network) by testing the brain lateralization at each time point in a paired t-test analysis. In a longitudinal analysis we then tested the learning induced connectivity change of the intra- and inter-hemispheric connectivity using a Linear Mixed Effects (LME) model with side (left, right, inter) and each time point as fixed effects. To localize the learning-induced connectivity change across each time point to specific connections and subnetworks, we used the Network-Based R-statistic (NBR) mixed-effects models (p-threshold = 0.01, K = 3000 permutations)(Zeus Gracia-Tabuenca, -Tabuenca, & Alcauter, 2020).

Results: The initial lateralization test, showed leftward lateralization of the network for the initial and the middle timepoint. (TP0: Left >> Right, t= 3.11, p= 0.003; TP1: Left > Right, t = 2.04, p= 0.046; TP2: Left ⊁ Right, t = 1.79, p= 0.08) (Fig. 1b). The longitudinal analysis in a linear mixed effects (LME) model statistic showed a significant dynamic decreased inter-hemispheric connectivity during leaning with the strongest effect in the second half of the learning period (TP0-TP1: t = -1.1, p = 0.27 (n.s.); TP1-TP2: t = -6.2, p = 1.4e-08, TP0-TP2: t= -8.1, p =1.2e-12) (Fig. 1c). Finally, the NBR showed an increased intra-hemispheric connectivity in sub-networks, including the bilateral parietal-temporal system and the right IFG (Fig. 2a-c) mainly in the second half of the learning period. Additionally, the connectivity of sub-networks including connections of orbital IFG – aSTG, parahippocampal- lateral temporal lobe and inter-hemispheres were decreased (Fig. 2d-i).
Conclusion. The present study showed a dynamic reorganization of multiple sub-networks during second language learning. During the initial learning period, the intra-hemispheric connectivity of phonological-semantic related sub-networks increased, while subnetworks related with lexical retrieval and long-term memory showed a decrease in connectivity. In addition, we found a crucial role of the right hemisphere in second language learning and a reduced transcallosal connectivity between hemispheres related to a stronger intra-hemispheric specialization of both hemispheres.

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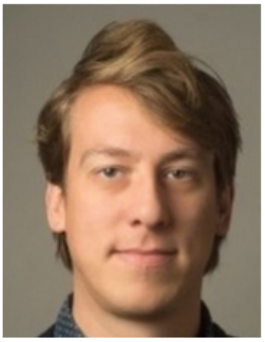
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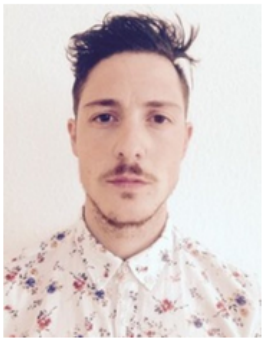
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