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## Abstracts

### 1. A collaborative game-based approach to documenting linguistic variation in Brazil

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We present a Game With A Purpose (GWAP) for the collection of speaker judgements relating to complementation alternations in Brazilian Portuguese (BP). Online data collection methods for linguistics are by now well established as a fast and cost-effective way to gather data from large numbers of speakers. One of the main benefits is the likelihood of collecting linguistic judgements from speakers of more varied demographics than traditional fieldwork. This is of particular relevance to Brazil, where a diglossic situation of cultured versus popular norms holds, and furthermore there is a great deal of variation between different social speaker groups.

An online game offers great potential for wide-reach data collection. Brazil, the world's fifth most populous country, is a Latin American champion of interactive entertainment. Where the worldwide Internet penetration currently stands at 32%, Brazil's Internet penetration recently reached 50%, making the country a perfect market for digital games. According to Statista, Brazil's mobile user base is over 130m users and smartphone penetration is close to 50%. These statistics demonstrate how familiar Brazilians are with online games and the potential of a linguistic GWAP.

The specific linguistic area we are interested in is BP complementation; in particular, the patterns with the verb 'want' in (i) co-reference (1) and (ii) disjoint reference (2).

(1) (context) Then main character:

Vocês ...

you

- a) querem levar  
want.3PL lift.INF
- b) quer levar  
want.3SG lift.INF
- c) querem levarem  
want.3PL lift.INF.3PL
- d) quer levarem  
want.3SG lift.INF.3PL

'You want to pick up'

(2) (context) Then main character:

João<sub>i</sub> quer que ...

John wants that

- a) compra  
buy.IND.3SG
- b) compre  
buy.SUBJ.3SG
- c) ele<sub>j</sub> compra  
he buy.IND.3SG
- d) ele<sub>j</sub> compre  
he buy.SUBJ.3SG

'John wants that he buys the house'

We aimed to collect acceptability judgements for settings such as the ones above. For this purpose, we set up a narrative based around popular Brazilian funk musicians, introduced gamification elements and aimed to make the interface visually appealing and fun to use. In addition we will collect user metadata such as age,

gender and geographic information, with users either registering for free or connecting with a Facebook account. The app is currently in demo form, and we plan further development to make it ready for research use.

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## 2. Developing a prototype web-app for numeracy assessment and teaching

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We present a web-based application ('web-app') for primary-aged students in India to develop verbal reasoning, problem solving and English literacy. Solving word problems in mathematics depends on not only students' understanding of mathematical concepts but also their ability to linguistically understand what the question is trying to ask. In an example question, Jake runs at 2 metres per seconds. If Jane is \_\_\_\_\_ than Jake by 1 metre per second, at what speed is Jane moving at? It is not possible for us to answer this question if we do not understand the meaning of the word "faster", which was blanked out above. This situation, however, is not uncommon when word problems are posed in a language that is not of the child's native language. This is the struggle faced by many Indian children who learn in English but speak other languages as their mother tongue.

We chose India as the target of this web-app because (a) we have experience working in the region, and (b) demand for literacy in English is especially high in the Indian school system, as evidenced by the increase in (low-cost) English-medium instruction schools across the country. Although many schools teach in English, teachers' English proficiency is not universally high and learning outcomes can be lower than expected given the age of the children and their years of schooling. We therefore intend to provide a web-app with scaffolding for students' learning and improvement: both dictionary definitions for complex English words, and text translations into Indian languages such as Hindi and Telugu with the expectation that the facility to read a question in the child's mother tongue(s) will help them understand the question and demonstrate their numeracy skills. In addition, the web-app allows for video lessons to accompany each question, so that the learner can independently learn to solve the questions they find difficult.

Students' use of these scaffolding features is logged for researchers to analyze, which can in turn help to personalize such guidance in the future. Our web-app is a scalable solution that currently includes a thousand questions from an open-source dataset and can be customized to include questions from an external source. Future work includes personalizing the experience based on the mathematical attainment of the student and converting the web-app into an offline Android app that is useful in regions where Internet connections are hard to find and/or unstable.

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## 3. Developing prototype assistive listening technology for remediating developmental dyslexia

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The aim of this project is to investigate the effectiveness of targeted signal processing of the speech signal for ameliorating the phonological deficit found in developmental dyslexia. Developmental dyslexia is a learning difficulty affecting reading and spelling in approximately 7% of school children, presenting a major obstacle to their educational success. Across languages, those with developmental dyslexia have poor phonological processing skills, which impairs their ability to identify and manipulate parts of language, e.g. syllables, rhymes and phonemes.

The amplitude modulation (AM) is where most of the important speech information in the acoustic signal occurs, in low frequency energy modulations between 0.4-30 Hz. Our previous research established the existence of impaired neural encoding of low frequency speech modulation at the ~0-3Hz (Delta) band in

children with developmental dyslexia. This impairment was related to sensory impairments in processing amplitude envelope rise time (AERT) and phonological difficulties. Our data suggest low frequency auditory neural and sensory processes are impaired in dyslexia, resulting in speech-based representations that make the acquisition of literacy difficult.

Neural encoding of speech depends on the synchronous activity of oscillating networks of neurons at different rates and frequency bands, i.e. the Multi-Time Resolution Model of cortical speech processing (MTRM) (Poehpel et al., 2008). Adult studies of speech processing have demonstrated that the AERTs act to phase reset the brain's oscillations that encode the speech signal (Gross et al., 2013). The oscillatory temporal sampling framework model of dyslexia suggests impaired temporal sampling at low frequency, i.e. theta and delta oscillations (range 1.5 – 10 Hz), that may lead to the observed phonological deficits (Goswami, 2010).

In this project we will investigate the effectiveness of targeted signal processing of the speech signal which will boost the salient low frequency AM and the AERTs. In this manner we hope to remediate the auditory difficulties in phonological processing in a group of children with developmental dyslexia. Using EEG and MEG we will explore the relative neurological impact of two forms of intervention:

1. targeted signal processing of the speech signal delivered via age-relevant literacy material
2. using targeted signal processing to deliver a previously developed behavioural intervention, based on 2Hz rhythms in poetry, music and motor routines.

The behavioural remediation for intervention 2 was shown to successfully enhance phonological awareness in children with poor reading skills (Bhide et al., 2013). Since phonological skills govern reading development it follows that improving AERT processing and related oscillatory entrainment could offer an auditory target for focused remediation.

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#### 4. Functional Distributional Semantics: learning linguistically informed representations from a precisely annotated corpus

*Guy Emerson and Ann Copestake*

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The aim of distributional semantics is to design computational techniques that can automatically learn the meanings of words from a body of text. The twin challenges are: how do we represent meaning, and how do we learn these representations? The current state of the art is to represent meanings as vectors -- but vectors do not correspond to any traditional notion of meaning. In particular, there is no way to talk about truth, a crucial concept in logic and formal semantics.

We present a framework for distributional semantics which answers this challenge. The meaning of a word is not represented as a vector, but as a function, mapping entities (objects in the world) to probabilities of

truth (the probability that the word is true of the entity). Such a function can be interpreted both in the machine learning sense of a classifier, and in the formal semantic sense of a truth-conditional function. This simultaneously allows both the use of machine learning techniques to exploit large datasets, and also the use of formal semantic techniques to manipulate the learnt representations. We define a probabilistic graphical model, which incorporates a probabilistic generalisation of model theory (allowing a strong connection with formal semantics), and which generates semantic dependency graphs (allowing it to be trained on a corpus). This graphical model provides a natural way to model logical inference, semantic composition, and context-dependent meanings, where Bayesian inference plays a crucial role. We demonstrate the feasibility of this approach by training a model on WikiWoods, a parsed version of the English Wikipedia, and evaluating it on three tasks. The results indicate that the model can learn information not captured by vector space models.

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## 5. Historical codeswitching and language mutability in the history of English: creating a corpus of multilingual accounts from London Bridge, 1380-1480

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There is an enormous amount of medieval mixed-language writing as used for business purposes in Britain between the Norman Conquest of 1066 and 1500, when monolingual writing in English became the norm, in archives around the country (and indeed on the continent, where the same system prevailed with different vernaculars, i.e. Medieval Latin/Middle Dutch, Medieval Latin/Middle Low German), but there is very little of it published in print format, and no searchable corpus. Despite mixed-language business writing being the main text-type produced by later medieval scribes, the history of Standard English has been written from the perspective of monolingual English texts – mainly literary ones. As well as gaining a better understanding of the mixed-language text-type, the larger question behind a corpus-based study of mixed-language writing is: did the Medieval Latin/Anglo-Norman/Middle English system of 450 years influence the subsequent emergence of Standard English? This poster presents the procedure we have developed to annotate this complex multilingual corpus.

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## 6. How clever are the models exhibiting ‘super-human’ performance on VQA datasets?

Huiyuan Xie, Alexander Kuhnle, and Ann Copestake

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Visual question answering (VQA) is a multimodal task that aims at automatic question answering of visual information. Given an image and an open-ended natural language question about the image, the task of a VQA system is to automatically produce an answer to the question, thus connecting natural language processing with computer vision. Correctly generating answers to visually grounded questions is non-trivial. It requires computers to have a good ability to understand natural language questions as well as the capacity to capture detailed information from images.

Several real-world datasets (Antol et al., 2015; Gao et al., 2015; Malinowski, 2014) have been introduced for training and evaluating VQA models. A problem with these datasets is that they have strong biases that models can take advantage of to answer questions without explicit language understanding and visual reasoning. To address this problem, diagnostic datasets such as CLEVR (Johnson et al., 2017) and ShapeWorld (Kuhnle et al., 2017) have been proposed. In these datasets, visual and lexical complexity are reduced to a minimum and the difficulty of the task focuses on visually grounded language understanding.

In this paper, we evaluate the FiLM VQA model (Perez et al., 2017) on ShapeWorld datasets. By analysing the model's performance with regard to different linguistic constructions, we hope to shed light on some

empirical questions: (1) which types of linguistic structures can be handled successfully by the model; (2) which types of linguistic structures might not be sufficiently covered; (3) how well does the model cope with object relations such as spatial relations and counting. This work will also present some highlights of follow-up work (Kuhnle et al., 2018) which investigates the effectiveness of two approaches that aim to improve model performance on complex instances: augmenting training data with instances that are easier to learn, and pretraining the model on simpler instances before moving to more complex instances.

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## 7. Indefinite NPs as subjects in L2 and L3 Mandarin grammars

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More and more people in the world are becoming multilingual. However, in the area of language acquisition, research has been, to a large extent, focusing on second language acquisition (L2A) or bilingualism, and the number of studies of third language acquisition (L3A) is relatively small. In particular, studies on L3 acquisition in the literature mostly involve at least two Roman-Germanic languages, and little attention has been paid to language triads with more than one Asian languages (Ranong & Leung, 2009; Ian Tsang, 2009). In this poster, we are going to report on a study of L3 processing of Mandarin (in)definite subjects by L1 Cantonese L2 English speakers in comparison with L2 processing of Mandarin (in)definite subjects by L1 English speakers. With a less-studied language triad, our aim is to contribute to one of the most important tasks in the research of L3A: identifying the source of transfer in L3 grammars (Alonso and Rothman, 2016).

As is well-known, articles are one of the locations for marking referentiality and are used in languages like English. In English, the article *a* marks the [-definite] feature of noun phrases (NPs), while the article *the* marks the [+definite] one. In contrast, in Mandarin and Cantonese—two article-less languages, definiteness is represented through categories such as bare nouns, numerals, classifiers, etc. In particular, Mandarin bare nouns and Cantonese classifier-noun phrases (Cl-NPs) can represent both the [+definite] and [-definite] features, while Mandarin Cl-NPs and Cantonese bare nouns can only represent the [-definite] feature. In both languages, numeral-classifier-noun phrases (Nume-Cl-NPs) are used as indefinite NPs unless under certain licensing conditions (Li, 1998; Li and Thompson, 1989; Lee, 1986). Among all the properties regarding definiteness, our current article focuses on one property in Mandarin: the definiteness constraint on subjects. Different from English, in Chinese languages, indefinite noun phrases (NPs) are generally not allowed in subject or topic positions (Li and Thompson, 1981).



Our online data of self-paced reading tasks show that L1 Cantonese L2 English L3 Mandarin speakers do not take longer time to process indefinite subjects, which is similar to L1 English L2 Mandarin speakers and different from L1 Mandarin speakers. Such results suggest that L1 Cantonese speakers' L3 Mandarin grammars are influenced by their L2 English. Therefore, we argue that transfer to the L3 may come from an L2 that is typologically different from the L3, and that L3 development is determined by a number of factors on a property-by-property basis.

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## 8. Indirect corpus applications: collecting data and using it in ELT materials development

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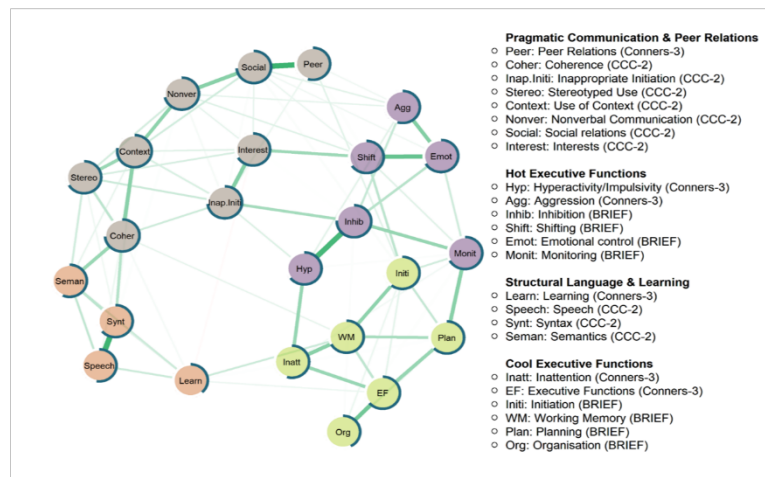
Recognising the role we play in the indirect application of corpus linguistics to language teaching and learning, this poster shows how Cambridge University Press responded to learners' needs by working with Lancaster University on an ESRC funded project to create the SpokenBNC2014 – a corpus of spoken casual conversation totalling over 11 million words. After outlining why we created the SpokenBNC2014, we move on to how, and situate it among the many other corpora housed at Cambridge University Press. Following that, we present 3 case studies which are intended to show the various ways we can use corpus data, and corpus diachronic data to inform our practices as materials writers. Through a comparison of our new SpokenBNC2014 with the previous BNC from 1994, each case study presents changes overtime for one of the adverbs, LIKE, WELL and JUST and considers how they would be used in informing coursebooks, exam preparation material and teacher training, materials respectively. These case studies are supported by interviews with editors and materials writers who have engaged with corpus research, revealing the processes involved in informing materials with corpus data. We found that there was a significant increase in the use of each of adverb over the course of 20 years. We also found that they are often used in more varied ways nowadays with LIKE, for example, now being used as an adverbial discourse marker and a device for reported speech. With such a notable change, our courses such as *Talent*, a secondary level ELT course, have included these findings in "Everyday English" sections to help inform learners of the ways that language has changed and is currently used. Overall, the contribution of this research is twofold. First we present a database of contemporary spoken British English, which we have made freely available to teachers and researchers alike. Second, we illuminate a formerly opaque area of applied linguistic research, demonstrating the principled approach adopted by large-scale materials writers for the collection and application of corpora to ELT materials development.

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## 9. Inter-symptom relationships across linguistic, cognitive, and behavioural problems in a developmentally at-risk population: a network approach

Silvana Mareva, Joni Holmes, and the CALM team

Objective: Associations across Executive functions (EF), language, and behavioural difficulties are commonly reported in the literature, but the picture is mixed in terms of evidence for specificity and mechanisms. For example, children's abilities to use language in social contexts (i.e. pragmatics) is often reported to be negatively related to behavioural problems such as hyperactivity. One possibility is that pragmatic skills and the ability to regulate impulsive behaviours may both rely on executive functions (EF). Alternatively, difficult behaviour might directly limit opportunities for social interaction, thereby impairing the development of communication skills. To gain further insight into this complex system of interacting behavioural, cognitive, and language difficulties we apply a network analysis approach to explore direct and indirect inter-relationships with the goal to identify transdiagnostic mechanisms.



Method: The sample consisted of 472 (Mage=9.22, SD =2.16, 70% male) children identified by health and educational professionals as struggling with attention, learning, and/or memory. The sample was heterogeneous and included children with both diagnosed (37%) and undiagnosed difficulties. The partial correlation network of the sub-scales of three parental reports of behaviour, cognition, and language skills was estimated.

Results: A clustering coefficient identified four clusters of symptoms broadly corresponding to (1) structural language and learning; (2) peer relationships and pragmatics; (3) behavioural and emotional difficulties; and (4) cognitive skills. Network centrality indices highlighted the importance of inhibition skills, which had the highest strength and betweenness in the network.

Discussion: Emotional and hyperactive behaviour symptoms were strongly linked to pragmatic abilities and cognitive problems, but not to structural language skills or learning. Most paths across the cognitive skills and social communication clusters were mediated by symptoms of emotional and behavioural difficulties. Poor structural language and cognitive skills, and particularly working memory difficulties, were associated with learning problems, consistent with many previous findings. The high network centrality of inhibition skills could suggest that inhibitory control may be targeted to alleviate interconnected symptoms of emotional difficulties, hyperactivity, and social communication problems.

## 10. Investigating mechanisms of change in children's social-attribitional thinking: a frame semantics approach to sociocultural discourse analysis

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Between four and six years of age, children in western cultures develop 'correspondence bias' (i.e. they tend to over-attribute people's behaviour to character traits while underestimating the influence of external factors (Seiver et al., 2013). This finding, considered with other evidence of cross-cultural variations in

children's development of correspondence bias (e.g. Seiver, 2013), signals the powerful influence of early social milieu on children's normative representations of social behaviour (i.e. cognitive frames) and the potential for early intervention in the formation of implicit bias.

In my PhD dissertation, I am examining how early years and primary teachers can effectively question children's emergent cognitive frames in the context of shared-reading and in doing so, broaden children's social-attribitional thinking. I have partnered with two early-years settings and two reception classrooms (a total of six teachers) in Cambridgeshire to carry out a series of eight-week professional development programmes, supporting teachers to guide dialogue within small reading groups with a mutual focus on answering this question. I have adopted an ethnographic design-based approach within which I apply sociocultural discourse analysis (SDA) of the dialogue (Mercer, 2004) to investigate mechanisms of collective learning and change in children's cognitive frames and attribitional thinking.

In this poster, I present a frame semantics approach to SDA of the discussions, which involves: 1) inductive coding and semantic analysis of children's cognitive frames of social behaviour (c.f. Fillmore and Baker, 2010) 2) inductive coding of children's correspondence biases that emerge in the dialogue, situating them within the previously identified cognitive frames and 3) line-by-line annotation of episodes of talk around instances of correspondence bias in which I examine the ways in which the conversation flows toward a shift in the children's thinking, while appraising the function of particular strategies employed by teachers to support these shifts. Importantly, within this final step I also map the progression of children's thinking within an episode of dialogue to parallel evidence of broader shifts in the associated cognitive frames, looking carefully at how teachers help children make meaning by connecting the dialogue to previous story discussions and/or to related interpersonal experiences. I present examples from one case study demonstrating each key phase of analysis, and I discuss the applications of this analytic approach to future research around reducing bias through classroom dialogue.

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## 11. Language, Brains & Machines: an initial literature review

Anna Samuel<sup>1</sup>, Andrew Caines<sup>2</sup>, and Paula Buttery<sup>2</sup>

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Language, Brains & Machines (LBM) is a new Research Strategy Forum founded by members of the Cambridge Language Sciences Interdisciplinary Research Centre. LBM has a focus on experiments which use language technology to produce controlled experimental stimuli, on works testing hypotheses based on the mechanisms of language technology, and on works testing hypotheses based on the properties of language (as discerned by information theory / signal analysis). We also see potential for interdisciplinary research building neural network models to solve a problem and seeking to understand their functioning, relating it to cognitive function where possible. We can also set about reinterpreting previous experimental findings in the light of new language processing technology. Works in these various areas have tended to be published and disseminated in distinct citation networks – computer science and cognitive science publication venues among others. We recently undertook an initial survey of state-of-the-art research in the area defined by LBM, attempting to synthesise the bodies of research from all areas, to find common ground and to highlight

complementary findings. This survey is intended as a non-exhaustive sample of recent literature to provide an idea of commonalities, complementary methods, and future directions for research. We will present the main findings of the review, point interested parties to our online publication, and indicate how readers may contribute to future versions of the document by submitting their own notes on publications not included in our initial survey. The latest version of the review may be found online at: [www.cl.cam.ac.uk/~apc38/camlangsci\\_langbrainsmachines\\_litreview.pdf](http://www.cl.cam.ac.uk/~apc38/camlangsci_langbrainsmachines_litreview.pdf)

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## 12. Language processing of personal beliefs

*Kaili Clackson, Tristan Bekinschtein, and Valdas Noreika*  
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The N400 event-related potential is a neural marker of semantic processing typically triggered by an unexpected semantic violation (e.g., “She spread the bread with socks”). Interestingly, recent studies have shown that the N400 is also evoked by sentences that are semantically congruous but contradict participants’ autobiographical facts (I finished primary school in Alaska), general knowledge about the world (London buses are green) or specific moral beliefs (Euthanasia is acceptable).

The present study aims to investigate whether semantically congruous sentences which strongly contradict personal religious beliefs evoke a similar N400. Furthermore, we hypothesise that sentences violating individual beliefs or knowledge will evoke EEG frontal alpha asymmetry, which is an established marker of negative affect.

A set of religious sentences were created where the last word (i.e. the critical word expected to trigger the N400) supports either a Christian or an Atheist worldview (1). To control for critical words, sentences were created in sister-pairs with reversed pairing of critical word and worldview (2), so that the only difference in the processing of the two versions of each sentence should be whether a given participant, Christian (N=30) or Atheist (N=30), believes in its meaning.

1. The claim that God listens to prayers is true/wrong.
2. The claim that praying to God is a waste of time is true/wrong.

For comparison, further sets of sentences were created (following the same sister-pairs pattern) on topics where beliefs were expected to be decreasingly personal to the individual. These related to a) moral beliefs (e.g. Throwing an empty beer can into the bushes is wrong/good.), b) abstract scientific knowledge (e.g. The planet Mars orbits around the sun/Earth), and c) empirical everyday knowledge (e.g., Wearing ear plugs can make an annoying noise seem louder/quieter). 120 sentences were created in each of the four conditions.

Participants’ beliefs will be probed by providing a 5 point response scale from ‘strongly disagree’ to ‘strongly agree’ after the audio presentation of each sentence as well as EEG.

We hypothesise that the strength of neural response across conditions will be reversed for N400 amplitude (measuring semantic expectancy) and alpha asymmetry (measuring negative affect) so that:

N400 Amplitude:

Empirical everyday knowledge > Abstract scientific knowledge > Moral beliefs > Christian/Secular beliefs

Alpha asymmetry response:

Empirical everyday knowledge < Abstract scientific knowledge < Moral beliefs < Christian/Secular beliefs

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## 13. L2 English genitive choices of L1 Spanish speakers

*James Algie*

Previous studies have shown evidence of cross-linguistic transfer in early L2 acquisition of the Saxon genitive among L1 Spanish speakers, including an erroneous or non-native-like overuse of the prepositional genitive in its place. Little research exists on how long these difficulties persist and whether the advanced L2 English speaker still struggles with the necessary distinctions between Saxon genitive and prepositional genitive constructions.

This study uses judgement data tasks to elicit responses from a group of L1 Spanish speakers with an advanced level of L2 English regarding the acceptability of Saxon genitive and prepositional constructions, using a control group of L1 English speakers. Both groups responded first with acceptability judgements of sentences containing either Saxon or prepositional genitive constructions. The groups were then given sentence pairs that differed only in their choice of genitive construction and asked to assess which sentence was more acceptable.

The results revealed that native language did indeed influence participants' genitive choices. The L1 Spanish participants judged the prepositional genitive constructions more harshly than the L1 English speakers did, while there was no significant difference in their respective judgements of the Saxon genitive constructions. Further, the L1 Spanish speakers were more discerning in their judgements of the sentence pairs, assessing only one of the two genitive constructions acceptable in their given contexts more frequently than the L1 English speakers did, while the L1 English speakers were more likely to find both forms acceptable.

Overall, the study provides evidence for cross-linguistic transfer persisting into the latter stages of L2 acquisition, while suggesting that the L1 Spanish speakers' non-native use of genitive constructions may develop into overuse of the Saxon genitive and underuse of the prepositional genitive construction.

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#### **14. Matrix Language variation in a Canberra corpus of Vietnamese-English code-switching**

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As widely understood in language-mixing literature, the contribution of two languages is assumed to be asymmetrical in any given bilingual Complementizer Phrase (CP). The language that contributes the morphosyntactic frame for the utterance is the Matrix Language (ML) and the other one is the Embedded Language (EL). In this study, I probe the validity of the ML as a dependent variable in a variationist analysis of Vietnamese-English conversations; and test a hypothesis that cross-generational effects are the extralinguistic factor accounting for variation in the choice of the ML.

Specifically, I seek to answer two research questions:

- 1) How does the MLF model apply to Vietnamese-English mixed speech? (Myers-Scotton, 2002)
- 2) Is there a difference in the distribution of the ML across generations?

Conversational data from 46 Vietnamese and English bilinguals in Canberra were collected between June and September 2017. Subjects range in age from 10 to 64, split between first generation speakers (N=27, 58%) and second-generation speakers (N=19, 42%). All speakers are literate in English and Vietnamese. The corpus contains 13,734 clauses in total: just over half of these are monolingual Vietnamese (N=7749, 56%), almost a quarter are monolingual English (N=3247, 24%), and a fifth are bilingual Vietnamese-English clauses (N=2738, 20%). In answering Research Question 1, initial analysis shows that the original criteria for identifying the ML are of limited value in Vietnamese-English mixed speech, due to the structural nature of the language pair involved. With shared basic word order and limited inflectional morphology in both languages, the Morpheme Order principle and the System Morpheme principle prove to be operationally restrictive. On this basis, I propose the Uniform Structure Principle and additional language-specific criteria

including Null Subjects/ Null Objects, Serial Verb Construction and Missing Obligatory Functional Elements in Vietnamese to supplement Myers-Scotton's original criteria for the ML. Results show that the traditional MLF criteria can only solve 1/3 of the bilingual dataset, whereas the supplementary criteria successfully assign the ML to another one third of cases. The remaining one third of the bilingual clauses in the corpus stays ambiguous due to conflicting evidence or lack of evidence for the presence of a ML. In relation to Research question 2, preliminary results show that although speaker types (i.e. first generation versus second generation) and the choice of the ML are statistically dependent (i.e. second-generation speakers are more likely to choose English as the ML in mixed discourse); there exists a strong preference for Vietnamese across the community whenever a ML can be clearly established. This gives impressionistic evidence for a 'community norm' trumping purely linguistic considerations. Further statistical investigations of the correlation (or lack thereof) between the dependent variable – the ML - and other independent extralinguistic variables however are needed for conclusive evidence of such norms.

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## 15. Mobile-based Dictionaries (MBDs): investigating Chinese EFL learners' use and the effectiveness in incidental English vocabulary learning

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L2 vocabulary acquisition, as an essential aspect of second language acquisition, is a popular focus of great research interest. Vocabulary knowledge is one of the most sizable and unmanageable aspects of language learning. In China, university students attach much importance to vocabulary learning. Profiting from the rapid development of mobile-assisted language learning (MALL), mobile-based dictionaries (MBD) which is flexible and convenient, is increasingly popular for Chinese university EFL learners.

As Miller and Wu (2018, p.7) propose, "much more needs to be given to how students use strategies in their informal mobile learning." This learner-initiated study not merely aims to explore how three types (monolingual, bilingualised and bilingual) of MBD facilitate two groups (English major and non-English major) of learners' incidental English vocabulary learning but also underlines how learners use MBDs while reading.

In total, 66 English majors and 59 non-English majors participated. Self-report questionnaire and pre- & post-vocabulary test were used to collect data on MBD use and the effects of MBD.

Results of the self-report questionnaire show that participants generally prefer to look up word definition, especially only read one definition and the Chinese translations (if available), as well as part of speech. Non-English majors used MBD more often, particularly with respect to word spelling, part of speech and Chinese translation with significant differences. The bilingualised group looked up more word spellings, definition (especially one definition and the first definition, with significant differences), part of speech and pronunciation.

According to the pre-, immediate and post-vocabulary test scores, participants made significant progress in vocabulary learning (including spelling, meaning and use and pronunciation), both in short and long term. However, their vocabulary retention significantly weakened as time went by. Non-English majors and the bilingualised group improved more on the spelling and pronunciation tests, while English majors and the monolingual group improved more on the meaning and use tests. Overall, there was a strong positive correlation between participants' MBD use and their vocabulary test performance.

This learner-initiated study highlights the influence of noticing (Schmidt, 1990) from the cognitive perspective and the importance of learners' use of mobile devices (Ma, 2015) from the strategic perspective. Results of

the vocabulary tests have verified the level of processing effect (Craik and Lockhart, 1972) and the L2 lexical representation and development process (Jiang, 2000). Drawing from this study, more-effective dictionary using strategies should be determined, and more-suitable vocabulary learning applications should be developed for varying learners.

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## 16. Modelling lexical decision in adults with and without acquired dyslexia and semantic dementia

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Lexical decision is an important paradigm in studies of visual word recognition yet the underlying mechanisms supporting the activity are not well understood. While most models of visual word recognition focus on orthographic processing as the main locus of the lexical decision, a number of behavioural studies have suggested a flexible role for semantic processing dependent on the nature of the nonword foil. Here we developed a computational model that interactively combines visual-orthographic, phonological and semantic processing to perform lexical decisions. Importantly, the model was able to differentiate words from nonwords by dynamically integrating measures of polarity across the key processing layers. The model was more reliant on semantic information when nonword foils were pseudowords as opposed to consonant strings, reproducing the graded semantic effects in lexical decision. Damage to the model also resulted in behavioural patterns observed in patients with pure alexia, phonological dyslexia, and semantic dementia. The simulation provides evidence for semantic access in lexical decision – both in normal and neurologically-impaired reading.

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## 17. Modelling polysemy in distributional semantic models

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Pre-trained word embeddings are used in a wide range of tasks in Natural Language Processing, and improve performance over simply treating words as symbolic features. These embeddings take the form of vectors, with the resulting vector space having the property that semantically similar words are close to each other. An embedding for each word is learned on the basis of the distributional hypothesis, which defines word meaning as a function of the contexts in which it appears. However, word meaning is continuous and irregular; polysemous words will vary in meaning in each specific context. These different senses are discretised by sense inventories like WordNet. Despite this variation, common approaches to creating word embeddings create just a single embedding for each word that averages over all of its senses. This leads to an impossible situation where, for example, the embedding for “interest” must be close to those of “charge” and “curiosity”, which themselves should be distant.

I show that by moving away from using just word embeddings to using embeddings for each sense as well, performance measurably improves in a language modelling task. In this task, the model must predict the next word in a sequence given the words up to that point. Performance is measured as average perplexity - an approximate measure of the number of words the model is considering as viable candidates at each step in the sequence. I introduce a novel way of using sense embeddings with recurrent neural network (RNN)-based language models, and show that perplexity drops compared with a model that uses only word embeddings. Although RNNs are the basis of most state-of-the-art systems in NLP, most previous work on sense embeddings has demonstrated their use only in simpler models. Consideration of sense in RNNs may be useful in areas like machine translation, where a polysemous word in the source language may be translated differently depending on the intended sense. I also introduce a novel method for learning the sense embeddings, based on a large unlabelled corpus and WordNet. This method supports a dynamic number of senses for each word (Chen et al., 2014; Huang et al., 2012), and learns word and sense embeddings jointly rather than doing post-hoc processing of pre-trained word embeddings (Pilehvar et al., 2016; Rothe et al., 2015). Our positive result of a decrease in language modelling perplexity shows that it is possible and advantageous to consider sense in language modelling.

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## 18. Modulating speech processing with alternating current stimulation

*Benedikt Zoefel, Isobella Allard, Megha Anil, Alan Archer-Boyd, and Matthew H. Davis*  
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Alignment between neural oscillations and speech rhythm, “entrainment”, is often observed to be enhanced during speech comprehension (e.g., Peelle et al., 2013, Cereb Cortex). In these experiments, speech stimuli are typically manipulated to reduce intelligibility. Importantly, these stimulus manipulations might destroy critical acoustic cues that the brain entrains to (such as “acoustic edges”; Doelling et al., 2014, NeuroImage) and hence the reported association between entrainment and speech intelligibility might only be epiphenomenal; i.e. both decline due to the same manipulation, without any necessary causal link between the two. Only if we manipulate entrainment as a dependent variable and observe consequences for speech processing, can we conclude that there is a causal relation between the two. This is possible using transcranial alternating current stimulation (tACS): tACS has been shown to impose a rhythm on neural oscillations (e.g., Herrmann et al., 2013, Front Neurosci) and can thus be used to manipulate entrainment in an experimental setting.

In a first study, we combined tACS over left lateral temporal regions with concurrent fMRI to measure BOLD responses to intelligible (16-channel vocoded) and unintelligible (1-channel vocoded) rhythmic speech stimuli. We manipulated entrainment by systematically varying the phase relation between tACS and speech rhythm, and measured the consequences for neural activity by comparing BOLD responses during true and sham tACS



in speech-specific and auditory brain regions. We found that, for intelligible speech, the phase relation between tACS and speech rhythm significantly modulates the magnitude of the BOLD response in the Superior Temporal Gyrus (compared to a surrogate distribution). Importantly, this modulation was specific to tACS during intelligible speech; a significant interaction showed that the effect was significantly reduced and non-significant for unintelligible speech and during sham stimulation.

In a second study, we measured the consequences of our speech-aligned tACS on performance in a word report task. As a first step, we determined the optimal analysis method for our purpose in a simulation study. We then applied this method to our experimental data and found that, only when tACS is applied bilaterally (but not when applied unilaterally), the phase relation between the applied current and speech rhythm modulates performance in our measure of speech comprehension.

Together, our results demonstrate that neural entrainment has a specific, causal influence on speech processing and comprehension, and add further evidence to the importance of stimulation protocol in the field of electrical brain stimulation.

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## 19. Multilingualism and wellbeing: a scoping review

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How does speaking more than one language have an effect on family and child wellbeing? Speaking more than one language, and in particular, speaking a minority or home language (like Polish, Urdu, or Greek) in a society with a clear majority language (such as English) has many potential consequences for speakers, and not least for their wellbeing. For instance, differing values, attitudes and goals for language use between parents, children and siblings may lead to tension and disagreement; family members may feel excluded or rejected through the language choices of others; and stress and anxiety may be prompted by unrealistic expectations (Little, 2017). On the flipside, regular communication among families has consistently been shown to be the single most important predictor of children and young people's wellbeing (OECD PISA 2015; The Good Childhood Report, 2013) – though language choice has not often been considered as a factor thus far in large-scale studies. This poster presents preliminary results of a scoping review consolidating cross-disciplinary evidence on the links between multilingualism and family wellbeing.

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## 20. Multilingualism, Multiculturalism and Implications for Health and Wellbeing

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In this paper we examine the relation between multilingualism, multiculturalism and individuals' intolerance of uncertainty, a tendency to react negatively to uncertain situations and events, a characteristic that is predominantly associated with generalized anxiety disorder (Dugas, Buhr, and Ladouceur, 2004).

We hypothesise that multicultural and multilingual experiences, such as living in a foreign country or speaking multiple languages, provide individuals with numerous opportunities to practice tolerating uncertainty and enhance their ability to do so. We investigate whether a number of distinct variables measuring multilingualism and multiculturalism, such as the experience of having to function in a foreign language and culture for a certain length of time, makes people more tolerant of ambiguity and therefore, less anxious.

Previous studies (although mostly limited by a small number of participants) suggest that this might be the case (Bakalis and Joiner, 2004; Kinginger, 2008).

We conducted an online survey study, measuring multiple variables of multilingualism, multiculturalism and generalised anxiety.

Preliminary results show that individuals' intolerance of uncertainty score, which is also indicative of their levels of generalized anxiety, may be predicted based on the number of foreign languages they learnt and their level of self-identified multiculturalism, suggesting that the more languages one learns and the more multilingual one identifies herself, the lower the levels of generalised anxiety will be.

This finding is important as it has critical implications for individuals' health and wellbeing.

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## 21. Multimodal semantic revision during inferential processing: the role of inhibitory control with story and picture comprehension

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Although language comprehension usually demands the integration of information coming from distinct modalities, no study to date has investigated how comprehenders revise inferential information under multimodal situations. In the present study, twenty-four young adults (M age= 22.33, range = 18-31; 18 females) listened to short stories prompting an inference (polar bear). Subsequently, they were presented with either a consistent picture (a polar bear) or an inconsistent but still plausible picture (a penguin). A final sentence brought the target word, which was either expected ("bear") or unexpected ("penguin") in relation to the auditory linguistic information. Event-related potentials measured in the picture showed larger negativity (N400) in the inconsistent compared to the consistent picture, indicating inferential monitoring. This process was not explained by inhibitory control. On the other hand, ERPs in the target word demonstrated more negativity in the unexpected word coming from the consistent picture (listening to "penguin" after the picture of polar bear) than coming from the inconsistent picture ("penguin" after the picture of penguin), suggesting prior inferential interpretation has been revised. Nonetheless, this effect was explained by individual differences in cognitive control, where better inhibitory control was associated with more efficient ability to maintain the two interpretations (leaving this interpretation open) until the end of the story. Behavioural measures supported these results. These findings signals inhibitory control is essential for the revision process, and shed some light on the relationship between mental flexibility and language comprehension during multimodal situations.

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## 22. Multiple sentence representations in machine translation

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Neural Machine Translation (NMT) involves training a neural network model to translate between human languages, typically by reading and generating sentences. There has been recent interest in improving translation structure and grammar by generating syntax translations. We show that dense representations,

like part-of-speech tags, give better translations than longer representations which can express sentence structure, suggesting language structure may be easier for computers to learn than word choice.

Combining models in ensembles strongly improves translation, as each model's translation is compared and the most likely selected. Different representations, such as a sentence and a parse tree, cannot be directly compared, so NMT ensembles have to date been single-representation.

We express relationships between representations as a known mapping, and extend standard NMT ensembling to map proposed translations before combination. This allows multi-representation ensembles. We find these can generate better translations than a single-representation ensemble, indicating that syntax and plain-text models are complementary. Our approach enables further research into syntax and ensembles in NMT, and more generally into combining different computer representations of language.

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### 23. Neural coding schemes for lexically-driven prediction in superior temporal cortex

*Ediz Sohoglu and Matthew H. Davis*

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In this study we investigated the neural computations by which lexical predictions are combined with speech input in superior temporal cortex (STC). Is expected speech content enhanced to leave a “sharpened” version of the sensory input (McClelland and Elman, 1986)? Or is expected content subtracted away to leave only those parts that are unexpected i.e. “prediction error” (Rao and Ballard, 1999)? Recent work suggests that for degraded speech, multivoxel fMRI patterns in STC are best explained by prediction error representations (Blank and Davis, 2016). However, that study used an artificial listening situation in which speech was highly distorted and strong predictions obtained from prior written text. In the current work we applied similar fMRI analysis methods to a more naturalistic listening situation in which speech is clearly presented and predictions obtained directly from the speech signal itself (i.e. from lexical content).

Native-English listeners (N=21) heard 64 bisyllabic words in which the second (offset) syllable was strongly or weakly predicted by the first syllable based on long-term lexical knowledge e.g. items like “Cac-tus” where “tus” is the only syllable that follows “Cac” (Strong prediction) and items like “Be-ta” where “ta” is amongst many syllables that follow “Be” in English (Weak prediction). By cross-splicing between items, we also created 64 non-words in which the second syllable mismatched with listeners’ predictions (e.g. “Cac-ta” and “Be-tus”). To maintain attention, listeners performed an incidental task and pressed a button every time a brief pause was heard during the spoken word. Using fMRI, we tested how multivoxel representations of offset-syllables differed as a function of prior strength (Strong/Weak) and congruency (Matching/Mismatching). If STC represents a sharpened version of the sensory input, prior strength and congruency should have additive effects on multivoxel representations whereas if STC represents prediction error, these two manipulations should result in interactive influences (Blank and Davis, 2016).

Within a bilateral temporal lobe search volume, offset-syllables could be reliably distinguished in STC bilaterally ( $p < .05$ ). Using the resulting left and right hemisphere clusters as functional regions-of-interest (ROIs), we observed a significant interaction between prior strength and congruency bilaterally such that multivoxel representations of offset-syllables decreased with increasing prior strength when predictions were matching but increased when mismatching ( $p < .01$ ). These preliminary findings suggest that prediction strength and congruency have interactive effects on multivoxel representations of speech, consistent with auditory prediction error representations in STC.

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#### **24. Predictive neural mechanisms of spoken word recognition and learning**

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Spoken word recognition and novel word learning are the foundation of speech comprehension. This study presented is a behavioural preliminary to a future EMEG study that will explore the role of predictive neural computations and prediction error (PE) signals in supporting the recognition of familiar words (captain), and the encoding of new words (captick). The Predictive Coding account (Sohoglu and Davis, 2016) proposes that greater PE for familiar words (captain) leads to delayed recognition and stronger neural response in the STG, while the Predictive Interactive Multiple Memory Systems (PIMMS; Henson and Gagnepain, 2010) suggests that greater PE generated for new words (captick) will enhance episodic encoding of new words in the hippocampus.

We tested both hypotheses within a single behavioural study, conducted in the lab and on an online platform (Prolific Academic). This allowed us to compare the accuracy and speed of word and nonword recognition and memory by manipulating listeners' predictions: auditory lexical decisions for words/nonwords following presentations of items sharing the same initial syllable (e.g. hearing captain/captick after captive) were compared to an unprimed condition. In the experiment, participants performed an auditory lexical decision task, after which they were presented with individual words and nonwords from the lexical decision task paired with semantic and phonetic lures respectively. Participants were then asked to recall which of the two items was presented in the earlier lexical decision task, and give a confidence rating for their answer.

We found that, consistent with Monsell and Hirsh's results (1998), word priming significantly slowed down the recognition of words sharing the same initial sound. This effect was not apparent for nonword recognition. In contrast, prior presentation of similar sounding nonwords but not words significantly suppressed the encoding of words into episodic memory compared to unprimed condition. These results are consistent with lexical identification leading to changes in prediction and hence PE, which alter the timing of spoken word recognition, while rule out models such as the Neighbourhood Activation Model (Luce et al., 1990) that do not make explicit predictions for changes of speech signals during the time-course. However, dissociations between word recognition and episodic memory tasks suggest different forms of PE supporting word recognition and memory, perhaps consistent with complementary learning systems. We are currently conducting an EMEG study to further investigate how lexical representation, supported by cortical STG, and initial word learning, supported by medial temporal systems, respond to PE signals.

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#### **25. Semantic memory performance after left vs. right anterior temporal lobe resection**

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Unilateral surgical resection of the anterior temporal lobe (ATL) is an effective treatment for drug-resistant temporal lobe epilepsy (TLE). The most common side-effect of surgery is impairments in memory functioning, particularly short-term memory. In contrast, the effect of surgery on semantic memory has received relatively little attention, including the effect of surgery to the left or right hemisphere. Here, for the first time we comprehensively mapped the effects of left versus right ATL resection on semantic cognition. Forty-one post-surgical TLE patients (20 left, 21 right TLE) and 20 control participants completed a comprehensive semantic battery, including tests predicted to show relatively greater impairments following left ATL resection (e.g., picture naming), or right ATL resection (e.g., face recognition). The principal finding was a mild semantic

impairment after left or right ATL resection. Patients showed deficits in expressive and receptive verbal semantic tasks, word and object recognition, naming and recognition of famous faces and perception of emotions. Graded differences in performance between the left and right TLE groups were secondary to the overall mild semantic impairment; primarily, left TLE patients showed weaker performance on tasks that required naming or accessing semantic information from a written word. Right TLE patients were relatively more impaired at recognising famous faces as familiar, although this was less consistent. These results support a model in which the two ATLs act as a bilateral system for the representation of semantic knowledge. Graded hemispheric specialisations emerge from this system as a consequence of differential connectivity to sensory-motor regions.

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## 26. The effects of language contexts on executive function: a pilot study

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It has been extensively proposed that bilinguals present an advantage in executive function and, in particular, the ability to suppress interference (Bialystok and DePape, 2009; Bialystok, Craik, and Luk, 2008; Costa, Hernández, and Sebastián-Gallés, 2008; Bialystok, 2006). This advantage is considered to emerge from increased demands on executive function from inhibiting one language during dual activation of both and thought to extend to non-verbal tasks (Bialystok, 2017).

One of the most influential theoretical frameworks, the Adaptive Control Theory (Green and Abutalebi, 2013) predicts that three different interactional contexts place different demands on cognitive processes for bilinguals: 1) Single language, when two languages are used in separate contexts (e.g. at work and at home); 2) Dual-language, when both languages are used in alternation (e.g. switching within a conversation); 3) Dense code-switching, when both languages are used even within the same utterance. The theory proposes that bilinguals adapt inhibitory processes in order to optimise interactional cost in the corresponding situations.

This pilot study aims to investigate the effects of two language contexts, the single and the dual language, on control processes. Thirty highly proficient Greek/English bilingual adults ( $M = 27.68$  years,  $SD = 5.32$ ; 16 female) were tested using a divided attention task. They were instructed to perform the Flanker task (Eriksen and Eriksen, 1974) while attending a dialogue presented simultaneously in both ears. The dialogues were in English, Greek (single-language contexts) and mixed (dual-language context). After each experimental block, participants were asked to answer eight questions regarding the corresponding dialogue.

Results showed that mean reaction time in the Flanker task was significantly faster when participants attended the dialogue in Greek than the non-native, weaker language, English. The dual language condition was comparable to both single-language conditions, suggesting that demand in a dual context is not higher on the general cognitive system when both languages are used. Interestingly, participants showed a significantly lower score in the comprehension of the mixed dialogue compared to both English and Greek. A more in-depth analysis of the mixed condition revealed that responses to English questions scored higher accuracy than responses to Greek questions.

Results and implications are discussed in relation to the Adaptive Control Hypothesis.

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## 27. The neural representation of colour knowledge entails brain regions beyond the visual cortex

*Rocco Chiou and Matthew Lambon Ralph*

The influential theory of embodied cognition contends that conceptual knowledge about canonical object colour is represented by the same occipitotemporal cortical regions that are recruited for perceiving colour/hue (e.g., knowing a banana is typically yellow requires the colour-sensitive patches of the occipitotemporal visual cortex, Martin, 2007; Martin, 2016). While much research focus is laid on the commonality between the neural representations of colour concept and colour percept within the visual cortex, the role of brain regions beyond the visual cortex has long been ignored. In this poster, I present a series of empirical evidence showing that colour knowledge entails a broad neural architecture for representing semantics, including the anterior temporal cortex (ATL) and inferior frontal gyrus (IFG). Using transcranial magnetic stimulation (TMS), I demonstrate that disrupting the ATL selectively impairs semantic processing of typical object colour while leaving non-semantic performance intact. Using fMRI, I demonstrate that retrieval of colour knowledge depends on the triangular functional connectivity amongst the IFG, ATL, and occipitotemporal colour-related areas. Together, these data show that while colour knowledge requires the modality-specific regions to represent embodied semantic attributes, the full breadth of its neural architecture relies on the cooperation between visual cortex and semantic-related regions.

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## **28. The school experiences of bilingual children on the Autism Spectrum**

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The interaction between bilingualism and autism in mainstream education is an under-researched yet increasingly common experience. Despite the growing consensus that bilingualism is not detrimental to the social and linguistic development of children with autism, multilingual families are frequently advised to adopt a monolingual approach. While existing qualitative studies focus on parental attitudes and language choices for bilingual children on the autism spectrum, very little research gives a voice to the individuals themselves, despite the paradigm shift in autism research towards uncovering the “lived experience”. Research outlining the first-person accounts of pupils with English as an Additional Language (EAL) is equally inchoate, particularly in light of the rising number of multilingual children in the UK.

Given that school environments can often be anxiety-inducing spaces for children with autism and for those with EAL, research that investigates the dual experience of autism and bilingualism in the school setting is long overdue. Accordingly, this research aimed to illuminate such experiences through semi-structured interviews with twelve bilingual children on the autism spectrum. Drawing on previous literature exploring autistic children’s well-being at school, the term “school experience” in this study relates to five domains: language use, socialisation, accomplishment, motivation, and environment.

Interviews with pupils employed computer-assisted interviewing (CAI), which served to alleviate the social pressure of a face-to-face interview, and by enabling the pupil to control the pace of the interview. Data were analysed using interpretive phenomenological analysis (IPA), an idiographic, inductive approach that elicits the lived experience of participants, and is gaining momentum as a methodological framework within autism research.

Results indicate that, while children’s school experiences vary widely, there were commonalities in this population’s formation of identity at school and their classroom experiences. Most notably, children educated in more multilingual environments (i.e. in schools with larger bilingual populations) expressed more positive views about multilingualism than those in more monolingual settings. In line with previous studies, limited social circles and classroom anxiety were present in participants’ school experiences. These findings suggest that giving autistic children from bilingual backgrounds opportunities to explore their linguistic identities in the classroom may enhance their experiences of school. Further research should focus on parents’ and practitioners’ attitudes and perspectives towards the support available for this population.

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## 29. Towards a computational model of controlled semantic cognition

*Rebecca Jackson, Timothy Rogers, and Matthew Lambon Ralph  
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The semantic system must satisfy a number of essential properties. Principally, it must 1) learn to form coherent context-invariant conceptual representations by abstracting over episodes across time and by learning the complex non-linear relationships between features across different sensory modalities, and 2) dynamically use subsets of features to create a context-appropriate similarity space and produce context-dependent behaviours. These performance criteria are non-trivial to achieve, particularly because they necessitate the presence of and interaction between context-variant and context-invariant processes. A variety of different architectures can and have been theorised to subserve the semantic system, however, the ability of these architectures to synthesise context-invariant representations and task-specific outputs have never been formally tested. We investigated the importance of five architectural features: a hub, a multimodal hub, depth, hierarchical convergence across modalities and the inclusion of sparse long-range connections. An architecture employing a single, deep multimodal hub with sparse long-range connections from modality-specific inputs, was identified as optimal. We also explored where the control signal should connect into the network, and the consequences of lesioning control and representation regions of the model. Implications for the architecture of the cortical semantic system and its impairment in semantic dementia and semantic aphasia will be considered.

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## 30. Towards automatic grammatical error detection of non-native spoken learner English

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Automatic systems that enable assessment and feedback of learners of English are becoming increasingly popular. One important aspect of these systems is to provide reliable, meaningful feedback to learners on errors they are making. This feedback can then be used independently, or under the supervision of a teacher, by the learner to improve their proficiency. This poster presents an initial investigation into detecting grammatical errors in non-native spoken learner English. This is a challenging problem for a number of reasons. There is no accepted definition of what is correct spoken grammar even for native speakers: we do not generally speak in sentences; we hesitate; repeat ourselves; do not always enunciate clearly; and use more than our words, such as intonation and gesture, to communicate our message. These disfluencies and effects are seen more frequently in learner speech. In free speaking automatic speech recognition (ASR) must be run to obtain the transcription of the learner's speech. Their grammatical errors cause a mismatch with the ASR language model. In addition, learners make pronunciation mistakes which results in a mismatch to the ASR acoustic model. Together this leads to lower recognition performance than can be achieved for native speakers. The resulting ASR errors increase the challenge of detecting spoken grammatical errors. In our experiments we consider the task of building an automatic grammatical error detection (GED) system for non-native learners of English providing free (spontaneous) speech. Initially a baseline deep-learning based, sequence-labeller system (Rei and Yannakoudakis, 2016; Rei et al., 2016) for GED was trained on written texts from the Cambridge Learner Corpus (CLC) (Nicholls, 2003) and tested on manual transcriptions of two spoken tests: NICT Japanese Learner English (NICT-JLE) interview corpus (Izumi et al., 2004); and free speaking data from the BULATS business English test (Caines et al., 2017). Modifying the speech transcriptions by using manual meta-data markup to identify and remove disfluencies was found to be beneficial but the performance on the spoken data is worse than for written data as shown in Figure 1(a) for BULATS. 10-fold cross-validation experiments showed that performance could be boosted by fine-tuning the GED models to the target domain, by running further training epochs on subsets of in-domain data only, with performance close to the matched CLC data achieved (Figure 1(a)). Applying the GED system to automatic transcriptions

of the BULATS data proved challenging. ASR errors increase when there are grammatical errors and disfluencies which causes false positives degrading GED performance. Figure 1(b) shows that fine-tuning helps but cannot fully recover from these errors.

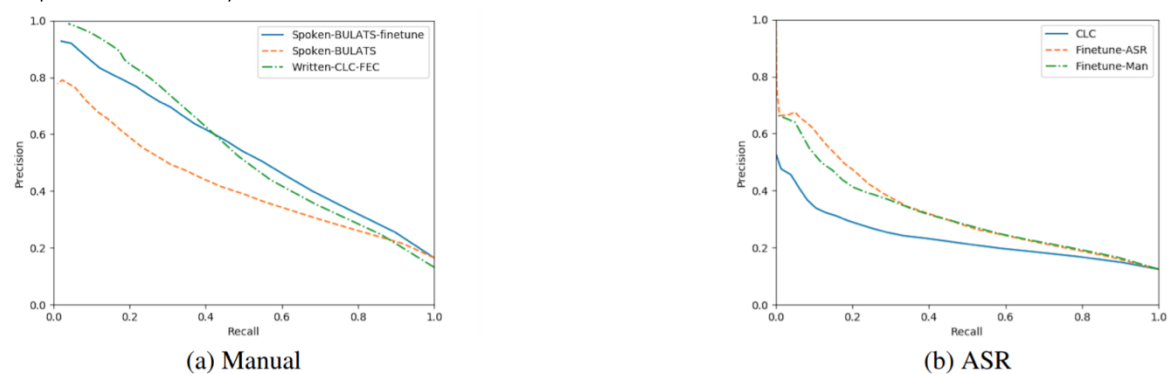


Figure 1: Precision-recall curves on BULATS transcriptions with a CLC trained GED system, and fine-tuned to the BULATS data.

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**31. Why are Asians better in Mathematics? A modern investigation into linguistic relativity on number counting**  
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East Asian pupils have consistently outperformed Western pupils in international comparisons of mathematical performance at both primary and secondary school level. It has sometimes been suggested that a contributory factor is the transparent counting systems of East Asian languages, which may facilitate number representation. The present study compared 35 seven-year-old second-year primary school children in Oxford, England and 40 children of similar age in Hong Kong, China on a standardized arithmetic test; on a two-digit number comparison test, including easy, misleading and reversible comparisons; and on a number line task, involving placing numbers in the appropriate position on four number lines: 1-10, 1-20, 1-100, and 1-1000. The Chinese children performed significantly better than the English children on the standardized arithmetic test. They were faster but not significantly more accurate on the Number Comparison and Number Line tasks. There were no interactions between language group and comparison type on the number comparison task, though the performance of both groups was faster on easy pairs than those where there was conflict between the relative magnitudes of the tens and the units. Similarly, there were no interactions between group and number line range, though the performance of both groups was influenced by the range of the number line. The study supports the view that counting systems affect aspects of numerical abilities, but cannot be the full explanation for international differences in mathematics performance.