

Embodied and Situated Language Processing: Stepping out of the Frame

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Keynotes

Levels of Representation in Mind/Brain: What Good are Sensory-Motor Representations?

Alfonso Caramazza * ¹

¹ Harvard University [Cambridge] – Massachusetts Hall Cambridge, MA 02138, United States

The notion of representation is central to the mind-brain sciences. Behavioral and neuroimaging studies have demonstrated that the sensory and motor systems are activated during cognitive and linguistic processing, encouraging the view that thought can be reduced to sensory-motor processes and representations. This view is well exemplified by current theories of action perception and interpretation, which assume that such understanding is realized through motor simulation of the perceived action. Similar arguments have been made for language processing. However, damage to sensory-motor systems does not result in conceptual or linguistic deficits, indicating a clear division between sensory-motor representations and the abstract, symbolic representations that underlie conceptual and linguistic processing. I discuss the contrasting views about the nature of representations in cognitive processing also in the light of recent neuroimaging and behavioral studies.

*Speaker

Mapping the sensorimotor system: from sensorimotor to language maps

Michel Desmurget * ¹

¹ Centre de neuroscience cognitive (CNC) – CNRS : UMR5229, Université Claude Bernard - Lyon I
(UCBL) – 67 Boulevard Pinel 69675 BRON CEDEX, France

Direct electrical stimulation (DES) of the human brain has been used by neurosurgeons for almost a century now. Although this procedure serves only clinical purposes, it generates data of great fundamental interest. Had DES not been employed, our comprehension of the neural bases of sensorimotor functions and language processes would have been greatly undermined. At least, this is what I will try to demonstrate in this talk where I will discuss the unique contribution of DES for understanding language and sensorimotor organizations in humans. Based on recent evidence, I will tackle several key issues related to the existence of large inter-individual variability in neural maps, the limitations of the commonly used "group averaging" procedures and the danger of neglecting the importance of neural plasticity when interpreting clinical data.

*Speaker

Language and the brain: from one century to the next, from centres to margins

Jean-François Démonet * ¹

¹ Department of Clinical Neuroscience, CHUV University Hospital – Lausanne, Switzerland

While sustained developments of brain imaging and of a number of other brain mapping methods (e.g. cortical stimulation), as well as advances in computing neuroscience and modelling have complemented the neuropsychological approach to brain/language relationships, many aspects of the cerebral underpinnings of language functions remain unclear. Far from being overridden by functional imaging in healthy participants, the lesion-based method also have benefited from technical advances, and other lesion models have been developed especially primary progressive aphasia. From the pioneer times of the classical authors who hypothesized centers for word meaning or word images, the neuroscience of language evolved to much more comprehensive and sophisticated conceptualizations; however, the boundaries of the supposedly specific domain of language tend to be more and more uncertain regarding both the functional specificity and the precise implementation of cellular processing in the brain that support language functions.

*Speaker

The Embodied Lexicon

Vyvyan Evans * ¹

¹ Bangor University – Bangor University - Bangor -Gwynedd - LL57 2DG, United Kingdom

The emergence of simulation-based accounts of language understanding (beginning with e.g. Barsalou et al. 2008; Zwaan 2004, amongst others) has provided a promising perspective on the relationship between language and conceptual structure in facilitating linguistically-mediated meaning construction. However, these accounts have tended to largely equate semantic structure—semantic representation associated with language—with conceptual structure. This potentially confuses the respective roles of the linguistic and conceptual systems in meaning construction. In the first part of the talk I address this issue, and develop an architecture for an embodied lexicon. This builds on and extends the perspective developed under the aegis of the Theory of Lexical Concepts and Cognitive Models (LCCM Theory; Evans 2009, 2013). I argue and present evidence for thinking that there is a distinction between what I refer to as ‘analogue’ concepts, and ‘parametric’ concepts. Language encodes the latter (=lexical concepts), which provide a schematic representational format, which facilitates access to more richly-specified and embodied non-linguistic representations (=cognitive models). In the second part of the talk I provide a case study of the nature of semantic polysemy within such a framework. In particular, I consider the role and function of both non-linguistic and language-specific knowledge in giving rise to polysemy. The overall argument is that there exists a principled distinction between linguistic semantic units—lexical concepts—and non-linguistic linguistic semantic representations—cognitive models. Both conspire, together, to produce simulations during linguistically-mediated communication. However, the two types of semantic representation are qualitatively different, a distinction that is largely not understood in extant theoretical models within the psychology of language literature.

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*Speaker

Oral Sessions

Keeping grounded: A longitudinal study exploring immersive strategies to improve children’s comprehension of narrative texts

Molly Berenhaus ^{*† 1}, Jane Oakhill ¹, Jennifer Rusted ¹

¹ University of Sussex – United Kingdom

In support of the grounded nature of discourse-level comprehension, encouraging children to immerse themselves in a story’s content has been found to improve their reading comprehension ability (de Koning & van der Schoot, 2013). The current study explored the long-term benefits of two immersive strategies, storyboard construction (SC) and active experiencing (AE), on children’s overall comprehension of narrative texts. Fifty-six children between the ages of 9-10 participated in the study over the course of an academic year. At the beginning of the year, one third of participants learned how to use SC (the active recreation of a story using plastic cut-outs), one third learned how to use AE (to act out a story using emotional expression and movement) and one third participated in a session with no specific training. After training, participants read two short stories, using their respective strategy, and then answered a combination of emotion-based and spatial-based comprehension questions. The children who used AE performed better than the control group on emotion-based questions ($p < .05$) and children who used SC performed better than both of the other groups on spatial-based questions ($p < .01$). The advantages were maintained, but to a lesser extent, when children used imagery-based versions of the strategies with novel stories. The differential benefits of the two strategies support the grounded, multi-dimensional nature of children’s mental representations of narrative texts.

*Speaker

†Corresponding author: m.berenhaus@sussex.ac.uk

The nature of sensorimotor facilitation by subliminal words. Embodied or disembodied?

Roberto Bottini * ¹, Madalina Bucur ², Davide Crepaldi ³

¹ Center for Mind/Brain Sciences (CIMEC) – CIMEC - Centro interdipartimentale Mente/Cervello
Palazzo Fedrigotti - corso Bettini 31, I-38068 Rovereto (TN), Italy

² University of Milan-Bicocca – Italy

³ Scuola Internazionale Superiore di Studi Avanzati / International School for Advanced Studies
(SISSA / ISAS) – via Bonomea, 265 - 34136 Trieste - Italy, Italy

Theories of Embodied Semantics (ES) suggest that an important and critical part of understanding what a word means consists in the re-instantiation of the sensorimotor experience related to the word’s referent. Perceptual and motor areas of the brain are therefore involved in representing and accessing words meaning. Some proponents of ES have suggested that these sensorimotor activations are mandatory and highly automatic during semantic processing. This hypothesized automaticity has been recently tested using masked priming, a technique that allows to investigate unconscious semantic processing. In masked priming a word (the prime) is presented briefly between two masks (e.g. #####) so that participants are not aware of its presence. Nevertheless, invisible primes (e.g. “joy”) can facilitate or inhibit responses to subsequent visible target words that may be semantically congruent (e.g. “happiness”) or incongruent (e.g. “sorrow”). Such priming effect provides evidence for semantic processing in very early and automatic stages of word recognition. Evidence so far seems to support the hypothesis that the semantic processing of

words necessarily draws upon underlying sensorimotor representations. That is, unconsciously presented prime words can directly influence the execution of an action on the basis of the prime long-term meaning. For instance directional actions like moving an arm upward or downward is either facilitated or inhibited by the subliminal presentation of congruent and incongruent spatial words such as “above” and “below”. The fact that task-irrelevant unconscious spatial words can influence action execution has been interpreted as evidence for an early and highly automatic activation of the sensorimotor system during language processing.

In this study we cast some doubts on this conclusion. We will show how the extant evidence is weakened by two major problems:

(1) Both motor facilitation and motor inhibition elicited by congruent prime-action pairs (e.g. “up” – upward movement) is interpreted as evidence for ES, with the result that (a) contradictory findings across experiments are simply ignored or interpreted as convergent evidence; (b) in each experiment any finding different from the null hypothesis would support ES.

(2) Priming effects interpreted as “embodied” can actually be explained in disembodied terms, such as symbolic priming or simple stimulus-response associations that do not need to reach the

*Speaker

semantic level of analysis.

We investigated the nature of sensorimotor modulation by subliminal words in 6 experiments. In our experiments, when a significant effect of priming was found, congruent prime-action pairs always facilitate responses and never inhibit them. Therefore, our study failed to conceptually replicate inhibitory effects interpreted as evidence for ES. Moreover, we showed that when the possibility of symbolic priming is prevented, allowing only for a genuinely embodied effect, neither facilitation nor inhibition is observed. Conversely, in the same experimental paradigm, when embodied priming is prevented and symbolic priming is allowed a facilitation effect emerges. We conclude that there is no convincing evidence that unconsciously perceived words can activate sensorimotor processes, although these words are indeed processed at the semantic level. Sensorimotor activations might need conscious access to emerge during language understanding.

Embodied Numerosity and Sign Language Letters in Deaf Population

Zahira Cohen ^{*† 1}, Shachar Hochman^{‡ 1}, Avishai Henik ¹

¹ Ben Gurion University of the Negev (BGU) – Beer Sheva, Israel

The representation of the fingers is embodied in our cognition and influences performance in enumeration tasks. Among the deaf population the fingers are, also, a tool for communication in sign language. We examine whether the language-hand association modulates performance in fingers enumeration tasks. Previous studies have found numeric-spatial representation (i.e., the SNARC effect; Iversen et al. 2006, Chinello et al. 2012) for sign language representation as well as for symbolic numbers. Moreover, Morford et al. (2010) found that deaf people activate signs in sign language while processing written words, and specifically that the spatial-phonology of the signed word interacts with their semantic meaning. In this study, we examined to what extent the shared use of fingers for counting and for sign language signs manifests in the embodied mental representation. We used enumeration tasks of 1) pictures of fingers, 2) dots, 3) vibro-tactile stimuli on the fingertips. We also used an unmasked priming task of written letters and numbers 4) prior to enumerating vibro-tactile stimuli and 5) prior to detecting a tactile stimulus. Preliminary results show slower reaction times when the fingers used for enumeration were congruent with the sign language letters. This pattern was found for the deaf group but not for the hearing group. We concluded that, for the deaf population, the shared use of the same finger patterns for both counting and spelling, may cause a conflict between the two embodied finger representations. This conflict indicates that there may be two competing mental structures; one for numbers and one for sign language letters, using the same fingers.

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*Speaker

†Corresponding author: zahiraci@gmail.com

‡Corresponding author: shacharh@post.bgu.ac.il

Strongly versus weakly grounded: Why the abstract/concrete distinction isn't really helpful in language processing

Louise Connell * ¹, Dermot Lynott ¹

¹ Lancaster University – Department of Psychology, Fylde College, Bailrigg, Lancaster. UK LA1 4YF, United Kingdom

Concrete words are read more quickly and accurately than abstract words, which is traditionally assumed to be due to concrete concepts possessing perceptual information that abstract concepts lack. Recently, Connell and Lynott (2012) showed that concreteness ratings are a poor reflection of the perceptual basis of concepts, and that perceptual strength (i.e., how strongly a concept's referent is experienced through its dominant perceptual modality) is a better predictor of word processing performance than concreteness, all of which casts doubt on the usefulness of "concreteness" as a theoretical construct. However, since concreteness often exerts its greatest benefit on low-frequency words, it is possible that its true predictive power, relative to perceptual strength, has not been fairly assessed to date.

In the present studies, we compare the abilities of concreteness and perceptual strength to predict response time and accuracy in lexical decision tasks across two languages: English and Dutch. Critically, we also allow concreteness (and perceptual strength) to interact with word frequency in order to capture the potential for low-frequency words to benefit more from semantic facilitation. Megastudy regression analysis of English data ($n = 770$ words) showed that the interaction of concreteness \times frequency explained more variance in lexical decision performance than concreteness alone, but that perceptual strength (plus its interaction with word frequency) still outperformed concreteness. Moreover, the same effects emerged in analysis of Dutch data ($n = 605$ words), even though we used a noisier form of perceptual strength ratings that were derived by translating norms from English. These findings suggest that so-called concreteness effects in word processing emerge from the perceptual strength of a concept's representation, and that the ontological distinction between abstract and concrete concepts is of less relevance to language processing than whether concepts are strongly or weakly grounded in perceptual experience.

*Speaker

Perceptual simulation of temperature-related language: cross-modal facilitation in a sentence-sensibility task

Czech Dawid * ¹

¹ University of Wrocław (UWr) – Poland

The past three decades of research on embodied cognition and embodiment semantics have established a substantial body of evidence, showing that brain resources devoted to perceptual and motor processing are involved, and in fact indispensable, in language comprehension and production (see, inter alia, Kaschak et al. 2005, Hauk et al. 2004, Aziz-Zadeh & Damasio 2008, Boulenger et al., 2009; Raposo et al. 2009, Hauk and Pulvermüller 2011). A similar connection has also been hypothesized for temperature perception and emotions (Williams & Bargh 2004, Zhong & Leordelli 2008, Cooper et al. 2014). In this regard, most psychological studies have focused on emotional judgments and non-linguistic material, while typical linguistic studies of emotions have been predominantly corpus in nature. Behavioral and imaging studies showing a clear link between the linguistic realizations of metaphors for emotions, such as PHYSICAL WARMTH IS INTERPERSONAL WARMTH, and their physical substrate are still scarce and often preliminary. Therefore, by combining the cross-modal facilitation effect with an experimental design similar to the one introduced by the widely cited study on social cognition by Williams and Bargh (2004), this paper strives to provide another piece to the embodied cognition puzzle. It attempts to investigate whether temperature perception constitutes another component of embodied simulation and whether manipulating physical temperature can affect the processing of temperature-related language. In the experiment, the participants judged the sensibility of a number of sentences (some of them temperature-related, others neutral), after putting their hand into cold or hot water. It was hypothesized that participants would react quicker in matching conditions (e.g. hot water and an expression connected with high temperature) and slower in mismatch conditions (e.g. cold water and an expression connected with low temperature). Preliminary experimental results seem to support this hypothesis.

*Speaker

Understanding sentential negations shares neurophysiological processes with response inhibition. A time-frequency analysis of theta rhythms

Manuel De Vega * ¹, David Beltrán , Inmaculada León , Manuel Martín-Loeches , Yurena Morera , Pilar Casado

¹ Universidad de La Laguna (ULL) – Facultad de Psicología. Campus de Guajara. La Laguna 38205, Spain

Negations like “not” or “don’t” reduce the accessibility in memory of the concepts under their scope. Moreover, negations applied to action contents (e.g., I don’t write the letter) impede the activation of motor processes in the brain, inducing “disembodied” representations (Liuzza, et al. 2011; Aravena et al. 2012; Bartoli et al. 2013). These facts provide important information on the behavioral and neural consequences of negations. However how negations themselves are processed in the brain is still poorly understood. We explored the neural processes of sentential negation by means of electrophysiology. Participants read for comprehension action related sentences in affirmative or negative form (“now you will cut the bread” vs. “now you will not cut the bread”). At the time of the sentence verb presentation they received a visual cue to perform a go/nogo task. Event-related potentials (ERP) and oscillatory rhythms analysis were time-locked to the presentation of the go/nogo cue. The ERP analysis revealed enhanced N2 and P3 for the nogo trials. Convergently, the time-frequency analyses found increased power of theta oscillations picking about 300 ms after the cue onset over fronto-central electrodes for nogo trials, confirming previous findings in the literature. Most important, the P3 and the theta oscillations for nogo trials were significantly reduced in the context of negative sentences. Given the fact that the P3 and the theta oscillations are often considered as neural markers of response inhibition processes, their modulation by negative sentences strongly suggests that negation employs neural resources of response inhibition. We propose a new explanation for negations: they are embodied processes that rely on the neural machinery of action inhibition rather than being a purely symbolic operator.

*Speaker

Learning is better with the hands free: the effect of verb on memory of manipulable objects

Léo Dutriaux ^{*† 1,2}, Xavière Dahiez ^{*}

^{1,2}, Valérie Gyselinck ^{*}

^{1,2,3}

¹ Laboratoire Mémoire Cognition – Université Paris V - Paris Descartes, Inserm : UMRS894 – Institut de Psychologie, Université Paris Descartes, 71 avenue Edouard Vaillant, Boulogne-Billancourt, France

² Centre de Psychiatrie et Neurosciences (CPN) – Inserm : U894, Université Paris V - Paris Descartes – 2 ter Rue d’Alésia - 75014 PARIS, France

³ Laboratoire de Psychologie des Comportements et des Mobilités (IFSTTAR/AME/LPC) – IFSTTAR – 25 allée des Marronniers, 78000 Versailles - Satory, France

Embodied cognition claims that representations share processing resources with sensorimotor systems. More specifically, it has been proposed that language comprehension relies on an internal simulation of the meaning (e.g. Barsalou, 1999). For instance, numerous studies have shown that the processing of action-related concepts involves a motor activation similar to when the action is actually performed (for a review, see Coello & Bartolo, 2012). However, even if these studies clearly show that action-related concepts involve a motor activation, such activations may be incidental to the activation of their representations, rather than part of it (e.g., Mahon & Caramazza, 2008). Yet, in a series of experiment (Dutriaux & Gyselinck, submitted), we tried to constrain the body of the participant in order to interfere with motor simulation during the memorization of objects, by asking them to put their hands behind the back. This interfering posture decreased the memory of manipulable objects but not of nonmanipulable objects. It suggests that motor simulation has a role in motor-related concepts representations. But when it comes to human language, we do not process solely individual words, but sentences. In the embodied view of language comprehension, the understanding of a sentence relies on the mental simulation of the whole sentence meaning. The aim of the present study is to further show that the integration of a manipulation object in a sentence will modulate the motor simulation. For this purpose, 40 manipulable object names were distributed in 4 lists. Twenty verbs were selected, among which 10 were manipulation verbs (e.g., “to catch”) and 10 were observation verbs (e.g., “to see”). Objects of each list were presented one by one, half with a manipulation verb (e.g., “to catch a mug”), and half with an observation verb (e.g., “to see a mug”). These sentences were presented during 3.5 s each, with an inter-stimuli interval of 1 s. Participants were instructed to memorize the sentences while adopting different postures.

*Speaker

†Corresponding author: leodutriaux@gmail.com

They had either to put their hands on the desk, or to put their hands behind the back. After each list, participants had to perform a distractive task of two minutes, and finally a cued recall task. In this task, verbs were presented one by one, and participants had to recall the object associated with each verb. First, results confirmed that holding the hands behind the back results in a decrease of the memory of manipulable objects. Second, this effect is more important when objects are associated with a manipulation verb than when they are associated with an observation verb. This interaction suggests that the sentence is simulated as a whole, and that this simulation results in a modulation of the motor simulation of the object, and thus of the memory of the object. Therefore, those results are consistent with the ideas that representations shares processing resources with sensorimotor systems, and that comprehension relies on internal simulation of the meaning of the sentences.

Meaning and prosody of a sentence: How they affect the successive motor feed sequence executed by an observer/listener

Maurizio Gentilucci * ¹

¹ Department of Neuroscience (DEPT.NEUROSCI) – via Volturno 39, Italy

Can emotional prosody of a sentence pronounced by a conspecific, affect the kinematics of a feed sequence executed by another conspecific? Are the effects of meaning comparable with those of prosody? Healthy participants, after listening to a sentence, reached-grasped and placed a sugar lump on the mouth of an individual sitting in front of the participant. The meaning as well as prosody could express happiness, anger, or no emotion. We compared congruent pairs of meaning and prosody (positive and negative) with incongruent pairs of meaning and prosody (positive or negative versus neutral). Positive compared to negative valence did not affect kinematics when meaning and prosody were congruent or meaning was only presented (i.e. the prosody was neutral). In contrast, in the case of sole prosody (the meaning was neutral), variation in reach parameters was observed comparing positive with negative prosody. Specifically, positive prosody favoured faster approaching the conspecific. The lack of an effect of meaning could be due to weak relevance of sentence meaning with the aim of the sequence (feeding). In contrast, the prosody effect could be due to activation of approaching and avoidance according to prosody positive and negative valence, the sentence meaning was neutral. Since prosody valence affected the sequence kinematics only when meaning was neutral, the data are in favour of behavioural dissociation between meaning and prosody.

*Speaker

Embodying Affect in Narrative Discourse: a facial EMG study on simulating affective language in context.

Björn 't Hart *¹, Marijn Struiksma¹, Anton Van Boxtel¹, Jos Van Berkum²

¹ Utrecht University - UU (NETHERLANDS) (UU) – Trans 10, 3512 JK, Utrecht, the Netherlands, Netherlands

² Tilburg University [Tilburg] – PO Box 90153, 5000LE Tilburg, Netherlands

In this experiment we examine the role of facial muscle activation (fEMG) in the online comprehension of affective language. fEMG research has shown that the corrugator supercillii (‘frowning muscle’) is a reliable indicator of affective valence in processing all manner of stimuli, with activation indicating negative affect and deactivation indicating positive affect (e.g., Larsen, Norris, Cacioppo, 2003). Research into embodied language processing has previously used this method to show simulation effects at the lexical and phrasal level. Crucially, the inhibition of specific facial muscle activation resulted in impaired or delayed processing, suggesting a causal role in language comprehension (e.g., Foroni & Semin, 2009, Niedenthal et al., 2009, Havas et al., 2010).

The current experiment extends the work mentioned above to richer, multi-sentence narratives. Apart from increasing ecological validity, richer narratives also present interesting opportunities to explore a more complex situation, where valence is no longer unambiguously positive or negative (as in the typical lexical/phrasal level experiment), but a layered phenomenon involving different perspectives. For example, although a particular event may have positive valence for the protagonist in focus (e.g., something good happens to him or her in the story), it may in the end have negative valence for the reader (e.g., when something good happens to a character that the reader has cause to dislike).

Using fEMG, we investigated whether the simulation of a particular linguistic stimulus (such as “Mark was happy when he found out he’d won the lottery”) could be influenced by the evaluative context, by having 60 participants read 64 short narratives that orthogonally contrasted protagonist valence with evaluative reader valence. In each narrative, we manipulated reader valence by depicting a protagonist as likeable or dislikeable, after which this person experienced a positive or negative event. Our hypothesis was that the likeability manipulation would tease out protagonist and reader valence and that we would see this reflected in the fEMG response. For instance, we predicted that something bad happening to a disliked character should result in a positive fEMG pattern rather than a negative one.

We used a mixed model linear regression analysis to build a growth curve model of the fEMG response; this analysis preserved information regarding the temporal development of the response. We found a significant effect of the evaluative context on the fEMG response pattern

*Speaker

at the affective event. We found that positive events resulted in increased corrugator activity (negative affect) and negative events in decreased corrugator activity (positive affect) when the character was dislikeable. Moreover, the time course of the response reveals that this influence is immediate. This result not only confirms that evaluative appraisal of affectively salient language is an integral part of language processing (e.g., *schadenfreude* in the case of a disliked character experiencing something negative), but also constrains ideas on how facial muscles are involved in language processing at the protagonist level.

Simulation and mental imagery of complex events: differences and communalities.

Franziska Hartung *¹, Peter Hagoort^{2,3}, Roel Willems^{3,4}

¹ Max Planck Institute for Psycholinguistics (MPI for Psycholinguistics) – Wundtlaan 1 6525 XD
Nijmegen The Netherlands, Netherlands

² Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour – Netherlands

³ Max Planck Institute for Psycholinguistics – Netherlands

⁴ Donders Institute for Brain, Cognition and Behaviour – Radboud University Nijmegen – P.O. Box
9101 6500 HB Nijmegen The Netherlands, Netherlands

How do our brains construct a narrative when reading fiction? The nature of mental representations, e. g., when comprehending language is a highly debated issue. Despite sometimes being considered controversial, effects of mental simulation are a robust and frequent finding in neuroimaging and behavioral research. Yet, which underlying processes those effects reflect is a matter of dispute. It is often assumed that simulation is a reduced form of mental imagery. However, experimental evidence suggests that imagery and simulation do not necessarily recruit the same brain regions (Willems et al 2009).

It is reasonable to assume that simulation plays a relevant role in language comprehension at the discourse level, where more complex information needs to be integrated in order to construct situation models. Moreover, contextually embedded information is likely to decrease variance between subjects in event representations, e.g. throwing without context can activate very different action representations, while throwing a dart or throwing a tennis ball reduces the probability that subjects activate different types of events. Especially stories seem to be highly appropriate to test simulation in language comprehension, as they promote situation model construction and deep-level processing while warranting adequate similarity across individuals.

In the present study, we used functional MRI to investigate simulation during natural listening to literary stories compared to mental imagery in 1st and 3rd person perspective. First, subjects (N=60) listened to two literary stories without a specific task. Then, they listened to the stories again and were asked to ‘imagine being the main character’ (1st person imagery) and ‘imagine being an uninvolved observer’ (3rd person imagery) in two subsequent runs. A baseline condition with unintelligible speech was used to subtract irrelevant activation for all conditions in the data analysis. The order of tasks was counterbalanced across participants. In the analysis, we used an event related design with action and mentalizing events as canonical examples of simulation to compare brain activations in natural comprehension with imagery.

The results show partial overlap of the brain regions activated in simulation and imagery. Listening shows recruitment of additional areas in frontal and temporal regions compared to the two imagery tasks, whereas activation patterns during mental imagery averaged across perspective are to a large degree included in the network active when subjects listen to a story without task. Looking at 1st and 3rd person perspective imagery separately reveals a more differentiated

*Speaker

picture: 1st person imagery shares substantial overlap in activation with listening, whereas in 3rd person imagery temporal regions are less pronounced and additional left posterior middle frontal regions are recruited. Comparing the two imagery conditions confirms this finding that 1st person imagery is more associated with temporal regions while 3rd person imagery is more associated with posterior middle frontal regions in story comprehension.

Our results give evidence that simulation in language processing partially overlaps with mental imagery. Simulation during natural story comprehension shows a more global network distribution whereas imagery tasks recruit specific areas. Moreover, participants seem to prefer 1st person perspective when engaging with stories without task requirements.

Embodiment, Empathy and Their Interaction

Karine Jospe ^{*† 1}, Michal Lavidor ¹

¹ Department of Psychology and The Gonda Multidisciplinary Brain Research Center, Bar Ilan University, Israel (BIU) – Max and Anna Webb st. Ramat Gan Israel, Israel

Research suggests that the mirror neuron system plays a part in both empathy and embodiment mechanisms. In the current study, we tried to understand where empathy and embodiment interact, hypothesizing that restricting the embodiment will impair performance in a gesture recognition task, and that empathy levels will modulate this effect. Sixty participants with various empathy scores performed a semantic decision task of hand gesture comprehension under restricted and unrestricted hand conditions. As expected, empathetic participants performed better under the unrestricted condition. Interestingly, however, participants with low empathy significantly improved their performance under the restricted hand condition. This selective interaction suggests that empathy modulates individual differences in the way people employ embodiment. We hypothesized that for participants with low empathy scores, restricting the hand movement enhanced attention to their motor area and thus facilitated the embodiment process. Under this hypothesis we used transcranial direct current stimulation (tDCS) to activate the motor area, aiming to replicate the hand restriction effects. Sixty additional participants were divided to three groups; 20 participants received anodal stimulation over the C1 area, 20 participants received anodal stimulation over the C3 area, that served as a control site as we included a control task of facial emotion recognition, and 20 received sham stimulation. The results showed that for participants with low empathy scores, stimulation of the C1 area facilitated hand gesture recognition, and C3 stimulation facilitated facial emotion recognition. As expected, the same stimulation, inhibited the performance of the high empathy participants, in the corresponding tasks. We argue that empathetic people use embodiment efficiently when observing gestures and facial expressions, while this ability is impaired for people with low empathetic scores. However as our results suggest, motor training and stimulation might improve impaired embodiment representations.

*Speaker

†Corresponding author: karinejospe@gmail.com

The body language: The spontaneous influence of congruent bodily arousal on the awareness of emotional words

Anne Kever ^{*† 1}, Delphine Grynberg ², Martial Mermillod ³, Carole Fantini ⁴, Nicolas Vermeulen^{‡ 2}

¹ Université Catholique de Louvain (UCL), Institut de recherche en sciences psychologiques (IPSY) (UCL) – Belgium

² Université Catholique de Louvain (UCL), Institut de recherche en sciences psychologiques (IPSY) – Belgium

³ Université Grenoble Alpes, LPNC CNRS – Université Grenoble Alpes – France

⁴ Université Libre de Bruxelles (ULB), Center for Social and Cultural Psychology – Belgium

Nowadays, the idea of a reciprocal influence of physiological and psychological processes seems to be widely accepted. For instance, current theories of embodied emotion suggest that knowledge about an emotion concept is not reducible to an abstract description but involves simulations of bodily experienced emotional states relevant to the concept. In line with this framework, the present study investigated whether actual levels of physiological arousal interact with the processing of emotional words.

Participants performed 2 blocks of an attentional blink task, once after a cycling session (increased physiological arousal) and once after a relaxation session (reduced physiological arousal). Concretely, participants were asked to detect and report two target words (T1 and T2) presented for 67 ms each among a series of nonword distractors. The SOA between target words was set to 268 ms. T1 were always neutral (e.g., chair) whereas T2 were either neutral, high arousal (e.g., orgasm, herpes) or low arousal (e.g., friend, tear) words. Results revealed that increased physiological arousal led to improved reports of high arousal T2 words, while reduced physiological arousal led to improved reports of low arousal T2 words. Neutral T2 remained unaffected by the arousing conditions. These findings emphasize that actual levels of physiological arousal modulate the cognitive access to arousal (in-) congruent emotional concepts, and suggest a direct grounding of emotion knowledge in our bodily systems of arousal.

Of interest too, results showed that heart rate variability measures (i.e., RMSSD and HF index) significantly correlated with the magnitude of the observed interaction between the physiological arousal condition (cycling vs. relaxation) and the type of words reported (high arousal vs. low arousal vs. neutral). Heart rate variability provides information about autonomic flexibility and thereby represents a physiological index of emotion regulation ability. Consequently, it can be assumed that better capacities for adaptive and regulated emotional responding are related to better detection of emotionally arousing stimuli that are congruent with ones level of physiological arousal.

*Speaker

†Corresponding author: anne.kever@uclouvain.be

‡Corresponding author: nicolas.vermeulen@uclouvain.be

Is a listener's gaze following behaviour influenced by the intentions of a speaker?

Ross Macdonald *¹, Maria Staudte

¹ Universität des Saarlandes – Universität des Saarlandes Campus D-66123 Saarbrücken, Germany

Humans have a tendency to follow gaze cues. Gaze cues affect our understanding of a speaker's intentions and thus our interpretation of their utterances (Nappa et al., 2009). However, it is not clear if the opposite effect also occurs; do perceptions of a speaker's intentions influence the utilisation of their gaze cues? We manipulated the intention of a gaze-cue-provider during a search task to investigate this question. In an eye-tracking study, 48 participants viewed videos of a woman gazing at two of eight objects, while a male voice referred to two objects. After each video, participants answered a question concerning one of the objects (target). We informed 24 participants that the woman was listening to the same sentences and carrying out the same memory task (shared intention), and informed the other 24 that she was listening to different sentences and carrying out a different task (distinct intention). The first gaze and noun cued the same non-target object. However, we manipulated whether or not the second gaze and language cues were to the target.

We divided our analysis into three sections: 1) looks to the face (an indicator of gaze seeking), 2) looks to the gazed at object (an indicator of gaze following) and 3) performance in the memory task (an indicator of indirect behavioural benefit from our conditions). The face fixation duration and time to first fixate the face were not affected by language, gaze or intention (all p s > .160). However, of the trials with looks to the face, more participants fixated the gazer's face after the first gaze cue in the shared intention condition ($p=.017$) suggesting they may have been seeking out the gazer's cues.

Fixation duration on the gazed at object was longer when language was congruent with gaze ($p=.019$), but intention condition had no effect ($p=.984$). There were fewer trials with fixations to the gazed at object in the shared intention condition, but this difference was not significant ($p=.101$). For overall question accuracy, there was no significant effect of intention ($p=.289$). However, for colour questions only, gaze cues to the target increased accuracy when language cued a competitor in the shared intention condition ($p=.031$), but not the distinct intention condition ($p> .999$). This suggests that gaze cues in the shared intention condition were used more than cues in the distinct intention condition. Some of our measures showed an effect of intention, but others did not. While these results may appear to suggest very little effect of intention on gaze seeking and following, it is possible that the difficulty of the memory task and the subtlety of the intention manipulation masked some potential intention effects. We are currently conducting a follow-up study using a simpler task and a clearer intention manipulation to address this possibility.

*Speaker

Rich Event Representations: Situated Comprehension and Action in a Humanoid Robot

Carol Madden-Lombardi ^{*† 1}, Grégoire Pointeau ², Anne-Laure Mealiar ², Peter Dominey ¹

¹ INSERM U846 Stem Cell Brain Research Institute (SBRI) – Institut National de la Santé et de la Recherche Médicale - INSERM, Université de Lyon, Centre National de la Recherche Scientifique - CNRS – Inserm U846 - Stem Cell and Brain Research Institute Integrative Neuroscience Robotics 18, avenue du doyen Jean Lépine 69675 Bron cedex, France

² INSERM U846 Stem Cell Brain Research Institute (SBRI) – Institut National de la Santé et de la Recherche Médicale - INSERM, Université de Lyon – Inserm U846 - Stem Cell and Brain Research Institute Integrative Neuroscience Robotics 18, avenue du doyen Jean Lépine 69675 Bron cedex, France

Research on humans suggests that representations are perceptual and dynamic simulations of experience, and subtle distinctions in the words we choose can have a significant impact on these simulations. While semantic features of verbs (e.g. speed, location, manner of action) have been shown to have important consequences for human representations, they are not often considered in the cognitive architecture of artificial agents. Because robots rarely take into account these linguistic features, their event representations are invariant and lack precision in temporal structure and event focus, often resulting in awkward human-robot communication. The present study showcases the integration of representational features such as temporal adverbs (quickly, slowly) and spatial adverbs (north, south, east, west, center) into an iCub humanoid robot, yielding richer and more dynamic event representations.

In the current experiment, the iCub learned the meaning of temporal and spatial modifiers through situated human-robot interaction. The iCub was exposed to 50 action-sentence pairs in which a human experimenter described an action (“I slowly pushed the cube south, I put the mouse to the north quickly”) while performing that action on a tactile table. The iCub used a reservoir network model of language processing (Hinault and Dominey, 2013) to comprehend the sentences. Upon perceiving the actions performed by the human experimenter, prior experience allowed the iCub to map the known agents, actions, and objects to their appropriate word counterparts in the sentence, but novel spatial and temporal modifiers were not understood. The iCub recorded two dimensions of the perceived event: temporal (the event onset and offset times) and spatial (displacement vectors and endpoint locations of objects moved on the tactile table). After all 50 action-sentence pairs were presented, the iCub attempted to resolve the meaning of unknown modifier words in the temporal domain by computing the difference between the durations for events mentioning the unknown word vs. all events. If a significant difference was found (as was the case for the temporal adverbs, quickly and slowly) this duration information, shorter or longer than average, became the “meaning” of the modifier. If no significant difference was found, the iCub attempted to resolve the meaning in the spatial domain. If a significant

*Speaker

†Corresponding author: Carol.Madden@inserm.fr

difference was found in displacement vectors and endpoint locations for events mentioning the unknown word vs. all events (as was the case for the spatial modifiers, north, west, etc.) this spatial information became the “meaning” of the modifier.

These new learned meanings were stored in the iCub’s memory and were used to direct later actions, for instance, when the iCub was asked to move objects quickly or slowly. A short video clip demonstrates the iCub’s preliminary “understanding” of the new modifiers. This work presents a foundation for enriching the cognitive architecture of a humanoid robot to allow for the representation of semantic features of events that qualify the manner of actions in comprehension and production.

The Integration of Social Contextual and Linguistic Referential Cues into Situated Language Processing

Katja Münster ^{*† 1,2}, Pia Knoeferle ^{1,2}, Maria Nella Carminati

¹ Cognitive Interaction Technology Excellence Cluster (CITEC) – Germany

² Department of Linguistics, Bielefeld University – Germany

Two visual world eye-tracking studies investigated the effect of emotions and actions on sentence processing. Previous research has demonstrated the effect of action depiction on sentence processing of OVS sentences (Knoeferle, Crocker, Scheepers, & Pickering, 2005). Additionally, research showed that social contextual cues (facial expressions) can incrementally modulate adults' processing of emotional subject-verb-object (SVO) sentences (Carminati & Knoeferle, 2013). Yet, in this study the referential integration of emotional valence was purely semantic. However, using OVS sentences, the present studies focus on the anticipation of a target agent prior to it being mentioned in a sentence-initial role ambiguous situation. These insights lead to the hypotheses that participants would not only profit from depicted events, but that processing of OVS sentences might also be positively affected by emotional cues.

In everyday comprehension, we do not only use linguistic referents, such as depicted actions denoted by a verb for sentence processing but also exploit many social cues such as emotional facial expressions in order to facilitate language comprehension. The link between social cues (e.g., a smile) and their associated scene aspects (other smiles or a positively valenced action) is naturally more subtle than the link between an action and its corresponding verb. Moreover, we do not yet know to which extent the portrayal of facial emotions and action events relative to one another modulates visual attention and language comprehension and in how far these cues can be used to facilitate the processing of grammatically challenging sentences.

Positively valenced German non-canonical object-verb-subject (OVS) sentences were paired with a scene depicting three characters (agent-patient-distractor) as performing an action described by the sentence (vs. not performing any actions). These scene-sentence pairs were preceded by a positive prime, i.e., a happy looking smiley (vs. no smiley) in experiment 1 and a natural positive facial expression (vs. a negative facial expression) in experiment 2. Thus, we also assessed the degree of naturalness the emotional face needs to possess to affect sentence processing.

Results replicate the predicted effect of action depiction (vs. no action depiction). The expected facilitatory effect of emotional prime as a more subtle cue is trending in both experiments. However, it is more pronounced in the natural face version (exp. 2) than in the smiley version (exp. 1). These subtle emotional priming effects could be due to the different processes investigated. Thematic role assignment is arguably a cognitively more challenging task than semantic-referential processing. Having to process non-canonical OVS sentences and assign thematic roles may result in weaker integration of the social cue since attentional resources needed

*Speaker

†Corresponding author: kmuenster@cit-ec.uni-bielefeld.de

for the processing of OVS (vs. SVO) sentences are higher. However, our results suggest that a schematic smiley already provides sufficient information to facilitate sentence processing together with depicted actions. More so, our results provide first evidence for the view that a natural facial emotional expression can lead to a somewhat stronger priming effect and thus is better integrated into the interpretation of emotional sentences.

The influence of gender related information in visual attention during sentence comprehension: insights from eye-tracking

Alba Rodríguez ^{*}, Michele Burigo[†], Pia Knoeferle^{‡ 1,2}

¹ Cognitive Interaction Technology Excellence Cluster (CITEC) – Germany

² Department of Linguistics, Bielefeld University – Germany

Research on gender perception claims that we constantly use gender dimorphic cues as a basic categorization for individuals (Stangor, Lynch, Duan, & Glass, 1992). Among the visual cues we have faces and hair length (Macrae & Martin, 2007), but also hands (Gaetano, van der Zwan, Blair, & Brooks, 2014). And yet for language comprehension, much remains to be learned about how such cues shape our expectations and how their effects compare to those of other visual cues (e.g., actions and gender knowledge). To explore this, we run two eye-tracking experiments using a video-sentence verification paradigm. Participants (n=32x2) first inspected videos of pairs of hands performing an action, and then listened to German object-verb-adverb-subject sentences while inspecting the faces of two agents (one male, one female). We recorded the eye movements to the faces to observe participants' anticipation of the upcoming agent, as well as their response times. In Experiment 1 we manipulated the match between the videotaped action and the action described by the sentence on the one hand, and the match in stereotypicality between the gender of the agent in the video (conveyed only by the hands) and the verbally described action (e.g., when female hands performed the action in the video, the following sentence could either be about a stereotypically female or male action) on the other (Table 1). In Experiment 2, instead of having action-verb mismatches, it was the gender cued by the videotaped hands that could match or mismatch the sentential subject; the gender-stereotypicality factor from Experiment 1 was retained (Table 2). If visual gender information is actively used during sentence comprehension, we should see an early preference for inspecting the face whose gender matched that of the hands seen in the video (i.e. the target face) during sentence comprehension. We also expected an effect of both action-verb and hands-subject gender congruence on this preference. If gender stereotypicality is routinely activated, it could also potentially modulate visual attention during comprehension. As expected, participants overall preferred to inspect the target faces. the competitor during sentence comprehension, as reflected in positive log gaze probability ratios. Gender stereotypicality did not seem to modulate visual attention. However, when there was a mismatch between the sentence and the previous video, participants tended to look away from the target face. This mismatch effect emerged at the post-verbal region in Experiment 1 and at the sentence-final subject region in Experiment 2 (Figures 1 and 2). Participants were faster and more accurate for judging action-verb mismatches compared to matches in Experiment 1, presumably due to facilitation for utterly mismatching action-verb pairs compared to matches (see also Vissers et al., 2008); no reliable effects emerged

*Speaker

†Corresponding author: mburigo@cit-ec.uni-bielefeld.de

‡Corresponding author: knoeferl@cit-ec.uni-bielefeld.de

in Experiment 2. These results reveal that participants rapidly integrated gender information from actions and different dimorphic cues, and used this information when verifying the match in gender of a depicted agent and the subject (Exp 2), but also when verifying another aspect of world-language congruence, i.e. actions with verbal information (Exp 1).

Easy to please: Abstract action language comprehension after motor priming

Franziska Schaller ^{*† 1,2}, Sabine Weiss ^{1,2}, Horst Mueller ^{1,2}

¹ Experimental Neurolinguistics Group, Bielefeld University – Universitaetsstrasse 25, 33615 Bielefeld, Germany

² Center of Excellence Cognitive Interaction Technology (CITEC), Bielefeld University – Germany

Crossmodal motor-speech priming works for abstract language. It has been shown that the action-sentence compatibility effect is valid for sentences expressing abstract movement (Glenberg et al., 2008). The respective study thus focused on the implied direction expressed in the sentence. As for motor priming of action verbs in metaphoric contexts, Wilson and Gibbs (2007) had participants execute movements before they listened to a metaphoric phrase containing an action verb. They reported shorter response times if the movement matched the action verb than if it did not match or if no movement was performed. However, the symbols that cued the respective movements might not only have cued a motor but a lexical representation of the corresponding verb as well. If this was the case, a priming effect would not be surprising. Additionally, Wilson and Gibbs (2007) did not describe how the given movements were defined or evaluated.

Therefore, in the current response time study, we used prototypical movements to prime action verbs that were surveyed in a preliminary study and evaluated according to certain characteristics (Weiss & Müller, 2012). We presented those movements to 32 German right-handed participants with a mean age of 25 in short video clips. Alternatively, we presented unrelated movements and videos showing no movements as control. Participants were instructed to execute the movements as parallel to the video as possible. We thereby aimed at preventing them from forming a lexical representation of the corresponding verb. Subsequent to the video participants listened to a target sentence. Sentences contained an action verb either in a concrete (“Ich habe die Handbremse gezogen” – “... have pulled the handbrake”) or in an abstract context (“Ich habe die Konsequenz gezogen” – “... have drawn the consequence”) or were abstract control sentences without an action verb (“Ich habe die Konsequenz gekannt” – “... have known the consequence”). Participants then indicated a sensibility judgment by stepping on a foot-pedal. The resulting response times showed that comprehension of the concrete action stimuli was significantly facilitated by the related movements only (-90 ms difference to control). However, comprehension of the abstract action sentences was significantly facilitated by related (-70 ms difference to control) and unrelated (-50 ms difference to control) movements. No effect of movement was observed for the abstract control sentences.

We conclude that the motor representations activated during concrete action language processing are a very detailed representation of the corresponding action. Only actions with the same semantic content as the action verb facilitate comprehension. To the contrary, the motor representations activated during abstract action language processing might be rather broad.

*Speaker

†Corresponding author: franziska.schaller@uni-bielefeld.de

Our behavioral findings complement the results of fMRI studies investigating this matter (Desai et al., 2013; Romero Lauro et al., 2013).

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Every story its own pattern of brain activity: Beta synchronization while listening to fiction

Paul Soullié * ¹, Anne Cheylus ¹, Anne Reboul ¹, Tatjana A. Nazir ¹

¹ Laboratoire sur le langage, le cerveau et la cognition (L2C2) – CNRS : UMR5230, Université Claude Bernard - Lyon I (UCBL) – Institut des Sciences cognitives 67 bd Pinel 69675 Bron cedex, France

Depending on the content, discourse and narratives can provoke activity in modality specific brain regions. For instance, activity in neural systems associated with visual, motor, and affective processing are selectively modulated during listening to stories with visually, action-based and emotionally charged content (Chow et al. 2013). Behavioral studies further show that consuming “literary” fiction - as opposed to “popular” fiction - instantly increases our theory of mind capacity (Kidd & Castano, 2013). Content and style of fiction thus seem to selectively modify activity in specific brain regions, and - as a consequence - affect cognition. How exactly this happens is largely unknown though.

The present study is part of a bigger project that aims at investigating the mechanisms by which narratives can cause cognitive enhancement. One critical step towards such endeavor is the elaboration of experimental/analytical techniques that allows comparing brain activity provoked by different types of fictions in a convenient and economical way. Here we thus present a new way to analyze EEG data (beta band oscillations; 17-23Hz) recorded while participants were listening to excerpts of 2-3 minutes, taken from various novels. Instead of analyzing the time-frequency representation on a millisecond basis and locked to a specific stimulus, our method consists of averaging a limited number of time-frequency values taken randomly within large temporal windows of 10 seconds. The analysis focuses on beta oscillations because previous research suggests that beta-band synchronization could reflect the active maintenance of content during language comprehension (see Lewis et al. 2015).

Our results reveal three intriguing points. First, for a given excerpt a relative stable pattern of beta synchronization (over a set of electrodes across the scalp) can be identified throughout the successive temporal windows. Second, this stable pattern of beta synchronization is distinctive of a story, i.e. it differs from one excerpt to the other. Third, for some excerpts this distinctive pattern is maintained at least for 2-3 seconds after the offset of the story. A tentative interpretation of these data is that the distinctive pattern of beta synchronization seen for a given excerpt has to do with the elaboration of a “mental model” of the described situation (e.g. van Dijk & Kintsch, 1983). This situation model is maintained throughout the excerpt but differs from one excerpt to the other. The fact that the excerpt-specific patterns of beta synchronizations are sometimes maintained beyond the offset of the story support this interpretation and allows discarding the possibility that differences seen between excerpts are caused by factors related to physical characteristics of the stimulus.

*Speaker

Poster Sessions

Temple Run: An Informative Jog Through the Brain’s Word Processing Pathways

Prince Asare-Agbo * ¹, Coralie Rotival ¹, Anne Cheylus ¹, Tatjana A. Nazir ¹

¹ Laboratoire sur le langage, le cerveau et la cognition (L2C2) – CNRS : UMR5230, Université Claude Bernard - Lyon I (UCBL) – Institut des Sciences cognitives 67 bd Pinel 69675 Bron cedex, France

Word processing in the brain seems heavily intertwined with pathways associated with other forms of processing. Moreover, depending on word content (e.g. action, perception, abstraction) distinct processing mechanisms appear to be in charge. The hypothesis underlying the present work is that in order to make sense of verbal stimuli, language processes can make use of brain structures involved in mental imagery (perceptual and motor). Consequently, words that score high on imageability ratings (concrete words) should profit from these structures, while words that score low (abstract words) should not. To test this, we asked participants to perform a language task while concurrently taxing their perceptual and motor systems. If our hypothesis is correct this dual task should affect the processing of concrete words, but not abstract words. Participants were asked to perform a go/no-go task to assess the validity of spoken word definitions (e.g. ‘An orange vegetable that has a long, edible root is a CARROT’ or ‘A natural capacity to sense or perceive something is an INSTINCT’). Target words were words with high (concrete words) and low (abstract words) imageability ratings, controlled for relevant linguistic variables. Participants were instructed to vocally respond with the word ‘correct’ when the definition preceding the target word was correct, and refrain from responding when the definition was incorrect. Two equivalent lists of definitions (containing 50% of correct definitions each) served as stimuli in two successive experimental blocks. In the second block, in addition to the word definition task, participants were asked to simultaneously play “Temple Run”, a movement-inducing, visually rich, and attention demanding iPad game. Data analysis via Signal Detection Theory confirmed that the concurrent “Temple Run” game had an effect on performance for concrete words only. Measure of sensitivity (non-parametric A’) significantly decreased with the introduction of “Temple Run”. Response bias also dropped when estimated through the non-parametric B”. However, when estimated through the decision variable C the difference in response bias was no longer significant. For abstract words the introduction of “Temple Run” had virtually no effect on the measured variables. Our results thus support the assumption that distinct mechanisms are used to process abstract and concrete words, and that the mechanism for concrete words involves brain systems for perceptual and motor processes.

*Speaker

The processing of motion verbs in 11-year olds

Larissa Balduin *¹, Sabine Weiss¹, Horst M. Mueller¹

¹ Experimental Neurolinguistics Group, University Bielefeld – AG Experimentelle Neurolinguistik apl. Prof. Dr. Dr. Horst M. Müller Fakultät für Linguistik und Literaturwissenschaft Universität Bielefeld Universitätsstraße 25 33615 Bielefeld, Germany

According to Embodied Cognition Theories language is embedded in a multimodal network in which cognition is created by simulating neural representations (Barsalou, 2010). Motion verbs for example are likely to be processed by simulating mental representations of real movements. Glenberg et al (2008) were able to show an Action-Sentence Compatibility effect also in the case of language describing abstract motion. Furthermore motoric regions in the cortex are active while processing motion verbs in abstract but not to the same degree as in concrete context (Desai et al., 2013; Romero Lauro et al., 2013).

There are strong indications for the embodiment of language processing in adults while this concept is not widely studied in its developmental aspects. Only few studies on the processing of motion verbs in children exist and more information on the development of the embodiment of language is needed for the understanding of neural networks cooperating in language perception. The present study deals with the processing of motion verbs in 65 11-year olds in a reaction time paradigm. We obtained data on observation and execution of movements while 11-year olds were listening to 48 language stimuli. Participants were to imitate movements presented in a video, which had been identified as prototypical movements for a certain motion verb by a previous study (Weiss & Müller, 2012). Afterwards participants listened to a target sentence that contained the same motion verbs in either concrete or abstract contexts (“Ich habe den Hund begraben/den Plan begraben” = I buried the dog/abandoned the plan). The motion verb in the target sentence fitted the executed movement in half of the stimuli. In the other half non-motion videos were presented which participants also imitated in sitting motionlessly. The 11-year olds decided on the sensibility of each sentence by pressing a button.

The processing of motion verbs in an abstract context increased reaction times significantly and led to a high number of errors in a semantic judgement task while motion verbs in a concrete context were processed faster and mostly correct. Strikingly, the results from the group of 11-year old children are quite different from data collected in a control group of 35 adults. Reaction times in general were longer for 11-year olds ($t(87,5) = -17,781$; $p = ,000$) and the number of errors was significantly higher. Concerning the movement condition of the experiment, children’s reaction times increased marginally, but not significantly, by the imitated movement in both conditions while adults only slowed down in the abstract condition.

We conclude that 11-year olds are likely to fail in processing motion verbs in an abstract context and are still in process of building up networks for the representation of abstract language. Comparable results can be drawn from association studies in which children and young adults with

*Speaker

different age defined abstract terms (Nippold et al., 1999). The accuracy and information about abstract nouns increased at least till adolescence and illustrates that mental representations on the abstractness of language is not fully developed with 11 years.

More than words? An Investigation of the Embodiment of Adjective-Noun-Constructions

Eduard Berndt ^{*† 1}, Fritz Günther ¹, Barbara Kaup ¹

¹ Eberhard Karls Universität Tübingen – Eberhard Karls Universität Tübingen, Psychologisches Institut, Schleichstraße 4, 72076 Tübingen, Germany

According to the experiential-simulations view of language processing, words automatically activate multi-modal experiential traces that stem from the reader’s interactions with their referents. Many previous studies have provided evidence for this view, in particular for isolated word reading. In one of these studies, which was conducted in our own laboratory, it was shown that reading a word like “airplane” (which refers to an entity that is typically encountered in the upper visual field) facilitates subsequent upward-directed responses whereas reading a word like “mouse” (which refers to an entity that is typically encountered in the lower visual field) facilitates subsequent downward directed responses. This facilitation effect presumably reflects the fact that people often focus their visual attention to the upper visual field, possibly even performing an upwards directed pointing gesture, when encountering an entity like an airplane whereas they typically focus their visual attention towards the floor, possibly even pointing downwards, when encountering an entity such as a mouse. In the present study, we wanted to investigate whether this facilitation effect is only present during single word reading or if it can also be observed for adjective-noun-constructions (e.g., “flying airplane”). In addition, we were interested in whether the facilitation effect is purely word-based or whether it also reflects combinatory comprehension processes. To test these questions, we first had participants rate a number of nouns and adjectives as well as adjective-noun constructions with respect to vertical position. Based on these ratings, we created five different groups of adjective-noun constructions: Up-nouns paired with up-adjectives (e.g. “flying bird”), up-nouns paired with neutral adjectives (e.g. “red balloon”), up-nouns paired with neutrally rated adjectives that reverse the implied position of the noun (e.g. “broken kite”), down-nouns paired with down-adjectives (e.g. “tiny mouse”) and down-nouns paired with neutral adjectives (e.g. “red ant”). These adjective-noun-constructions were then used in an experiment involving participants who had not taken part in the previous rating study. In this experiment, participants saw the adjective-noun constructions in one of two colors and their task was to respond to the colors by pressing an upper or a lower button on a vertical keyboard. To make sure that participants were reading the stimuli for comprehension, some trials contained a control-question (e.g. “Is it edible?”). Preliminary results show clear facilitation effects. However, these facilitation effects seem to be purely word based. Upward-responses are faster for constructions involving up-nouns and downwards responses are faster for constructions involving down-nouns, more or less independent of the adjectives used in the constructions.

*Speaker

†Corresponding author: eduard.berndt@uni-tuebingen.de

Visual Properties of Object Semantics are Experience Related

Peter Boddy ^{*† 1}, Yee Eiling ^{1,2}

¹ Basque Center on Brain and Language (BCBL) – Spain

² University of Connecticut (UConn) – United States

Because sensorimotor accounts hold that object representations are experience-based, they predict that representations of objects with which we have relatively more visual experience should involve brain areas supporting vision more than those with which we have relatively less. In line with this, accessing representations of "more-visually-experienced" objects should interact with performance on a concurrent visual task more than "less-visually-experienced objects", because of competition for shared neural substrates in brain areas supporting both visual task performance and representations of "visually-experienced" objects.

In the current study, participants performed a Multiple Object Tracking visual task while making verbal concreteness judgments about auditorily presented object names which varied (according to ratings from separate participants) in the relative amount of visual experience with which they are associated (e.g. "fork" = less-visual, "photo-frame" = more-visual).

In experiment 1, accessing representations of "more-visual" objects elicited more interference to the correct performance of the visual task than "less-visual" objects. In experiment 2, participants had greater difficulty, as indexed by RT latencies, making concreteness judgments on "more-visual" objects than on "less-visual" objects while performing the visual task. Thus, thinking about "more-visual" objects can interfere with performing a visual task, and performing a visual task can interfere with thinking about "more-visual" objects.

When taken together, these complementary results suggests that: (a) the conceptual representations of frequently seen objects share resources with parts of the visual system required to perform Multiple Object Tracking, (b) visual information is accessed when performing concreteness judgments on "more-visual" words, (c) experience determines how much of an object's representation is encoded in regions that support visual processing.

*Speaker

†Corresponding author: p.boddy@bcbl.eu

Touched by words: How tactile verbs can affect somatosensory perception?

Cécile Bouvet ¹, Santiago Moreno Jaureguizar ¹, Anne Cheylus ²,
Alessandro Farnè ³, Véronique Boulenger ^{*† 1}, Alice Roy ^{* ‡ 1}

¹ Dynamique Du Langage (DDL) – CNRS : UMR5596, Université Lumière - Lyon II – INSTITUT DES SCIENCES DE L’HOMME 14 Avenue Berthelot 69363 LYON CEDEX 07, France

² Laboratoire sur le langage, le cerveau et la cognition (L2C2) – CNRS : UMR5304, Université Claude Bernard - Lyon I (UCBL) – Institut des Sciences cognitives 67 bd Pinel 69675 Bron cedex, France

³ IMPACT - Centre de Recherche en Neurosciences de Lyon (IMPACT) – Inserm : U1028, CNRS : UMR5292 – 16 avenue Doyen Lépine 69676 Bron Cedex, France

Theories of embodied language suggest that understanding words’ meaning relies on sensorimotor brain mechanisms similar to those at play during action execution. The modulation of mainly the motor system during sensorimotor-related word processing has been taken as the hallmark of language embodiment. In the present study, we examined the effect of word processing on a sensory dimension that has only been scarcely investigated so far: tactile perception. We addressed whether ‘tactile’ verbs (e.g. to touch) can affect tactile perception, and if so, how and when this occurs. In a first behavioral experiment, 20 healthy adults were asked to silently read verbs depicting (or not) tactile properties and to respond as quickly as possible to a tactile stimulation delivered on their right forearm 170, 350 or 500 ms following verb onset. Results revealed shorter reaction times after tactile verb presentation, as compared to non-tactile verbs. Moreover, the later the stimulation was delivered after verb onset, the earlier participants gave their response, indicating stronger interference between the two processes during word lexical access (i.e. within 170-200 ms). The delay between verb display and tactile stimulation, though affecting response times, did not interact with the type of verbs, suggesting that tactile meaning can affect tactile perception independently of the stage of verb recognition. To disentangle the effects pertaining to the sensory versus the motor meaning, both conveyed by tactile verbs, we conducted a second behavioral experiment also including verbs related to an action but not to a tactile sensation (e.g. to water vs to tickle). This second experiment replicated the delay effect but most importantly the priming effect exerted by tactile verbs on ensuing tactile stimulation processing. Moreover, motor verb processing was not associated with earlier response but on the contrary with a lower accuracy in tactile stimulation detection. Again, despite an effect of stimulation delay, this factor did not interact with the type of verbs. In conclusion, our findings suggest that processing tactile meaning through verbal description can enhance tactile stimuli detection whatever the stage of verb processing. Future studies will determine whether the effect of tactile verbs on tactile perception reflect on altered somatosensory event-related potentials.

*Speaker

†Corresponding author: veronique.boulenger@cnrs.fr

‡Corresponding author: alice.roy@cnrs.fr

Releasing Strength in Imagination Constructs Implicit Association of Simulated Action and Response Index

Sau-Chin Chen * ¹, Jon-Fan Hu ², Ya-Yun Chuang ², Ching Chu ²,
Chi-Lin Yu ²

¹ Department of Human Development, Tzu-Chi University – Taiwan

² Department of Psychology, National Chung-Kung University – Taiwan

This presentation introduces a paradigm integrating sentence-picture verification and word color discrimination. The verification task requires participants to match the target picture and response index after reading the probe sentence. The probe sentence illustrated the situational cues for the function of actions and target objects. One kind of action was assumed to release strength on the objects (twist), and the other kind of action was assumed to feel the texture of the objects (touch). The object followed ‘twist’ was ‘jar’ that would cause the feelings ‘tight’ and ‘loose’, and the corresponding response indexes were ‘close jar’ and ‘open jar’. The objects followed ‘touch’ was ‘cube’ and ‘sponge’ that would cause the feelings ‘solid’ and ‘soft’, and the corresponding response indexes were ‘pick cube’ and ‘pick sponge’. For the two participant groups, one was exposed to ‘twist-tight’ and ‘touch-soft’ whereas the other was exposed to ‘twist-loose’ and ‘touch-solid’. Based on our pilot study, the participants’ responses were faster for the target picture matching the consequence that are implied by the probe sentence.

The word color discrimination task compares the participants’ responses to the words presented in compatible versus the words presented in incompatible colors. The compatibility was decided by the word meaning and the response key in common with verification task. For the group exposed to ‘twist-tight’ and ‘touch-soft’, the response key for first color was compatible with ‘twist’ and ‘tight’, and the response key for second color was compatible with ‘touch’ and ‘soft’. For the group exposed to ‘twist-loose’ and ‘touch-solid’, the response key for first color was compatible with ‘touch’ and ‘solid’, and the response key for second color was compatible with ‘twist’ and ‘loose’. In use of these words as the target, the compatibility effects shows which association implicitly established in the verification task. Based on our pilot study, only the action exhausted strength would associate the representations of action and feeling. Therefore, the compatibility effect would be found only for the group exposed to ‘twist-tight’ and ‘touch-soft’.

Our primary study confirmed the matching effects and compatibility effects as our prediction for the group exposed to ‘twist-tight’ and ‘touch-soft’. A negative but insignificant compatibility effect for ‘pick’ was found for this group. In addition, a positive but insignificant compatibility effect for ‘tight’ was found for the group exposed to ‘twist-loose’ and ‘touch-solid’. In our replication study, the results supported our prediction was replicated, and the negative but insignificant compatibility effects in our primary study were confirmed in the same statistical procedure.

*Speaker

Our findings encourage the theory that assumes the sentence-picture verification as the measurement of explicit embodied simulation processing and the word-color discrimination as the measurement of implicit embodied simulation processing. The explicit processing is assumed available for the tasks evoked action, emotion and perception systems. The implicit processing is assumed available for the tasks emphasizing interactions of body and environment. Based on this theoretical framework, we suggest a plausible paradigm to integrate two experimental approaches of embodied simulations.

An Embodied Cognition Approach to Studying the Impact of Negative Facial Experiences on Semantic Properties of Emotional Words

Ya-Yun Chuang ¹, Chi-Lin Yu ¹, Ching Chu ¹, Yueh-Lin Tsai ¹, Jon-Fan Hu ¹, Sau-Chin Chen ^{* 2}

¹ Department of Psychology, National Cheng Kung University [Taiwan] (NCKU) – No.1, University Road, Tainan City 701, Taiwan, Taiwan

² Department of Human Department, Tzu-Chi University (TCU) – Taiwan

Theories of Embodied Cognition emphasize the importance of sensorimotor experiences for cognitive processing. To further examine related issues, the present study focused on how the facial expression manipulation influences the property judgments toward emotional words. 41 college students were divided into “pout to clip the pen” group and “none-expression” control group and asked to rate the same 26 emotional words chosen from a Chinese Emotions Corpora (Cho, Chen, and Cheng, 2013). After expressing the instructed facial response (or not), participants evaluated six semantic dimensions of emotional words immediately. The findings show that the “pout to clip the pen” group has lower rating values for all dimensions for the ‘happy’ words, and reaches the significant level at the ‘valence’, ‘continuance’, ‘frequency’ and ‘typicality’ semantic dimensions. Furthermore, the rating values for ‘frequency’ and ‘typicality’ dimensions were significantly lower than ‘control group’ in most of negative words due to the experimental manipulation. It is concluded that negative facial expression indeed influenced the semantic properties of words, especially for the ‘happy’ words. The study results are valuable for investigating children’s language acquisition or clinical applications in diagnosing emotional disorders.

*Speaker

EMG-recorded hand motor response during passive action sentence processing

Melody Courson ^{*† 1,2}, Joël Macoir ^{1,2}, Pascale Tremblay ^{1,2}

¹ Université Laval, Faculté de Médecine, Département de Réadaptation, Québec, Canada – Canada

² Centre de recherche de l'Institut universitaire en santé mentale de Québec, Québec, Canada
(CR-IUSMQ) – 2601, de la Canardière Québec (Québec) Canada G1J 2G3, Canada

Functional neuroimaging [1,2], electroencephalography [3] and transcranial magnetic stimulation [4] studies have shown a response of the cortical motor system during the processing of action language, such as action verbs and tool names. There is, however, debate regarding whether or not the motor system is necessary to comprehend action language, and whether it plays a role in early linguistic processes or in later conceptual processes [5]. More recently, sub-threshold peripheral motor activity has been recorded during passive manual action language processing through a hand-held force sensor, and has been shown to vary as a function of linguistic parameters [6]. The present research aims to (1) determine whether the motor cortex's response to hand action sentence processing, captured through electromyographic (EMG) recordings of the FDI muscle activity, is modulated by specific linguistic parameters (sentence type [affirmative, negative], semantic context [action, non-action, neutral], prosody [ascending, descending]), and (2) characterize the time-course of this motor response. To this aim, 23 healthy, right-handed adults, aged 20 to 50 years, passively listened to action sentences containing a manual action verb in the second phrase of the sentence (e.g. “With her scissors, Sarah cuts the newspaper”), while completing a visual distraction task to prevent them from focusing on the linguistic stimuli. Our results show that motor response recorded through EMG during and after action verb processing varies as a function of semantic context, and that this motor response occurs during action sentence processing (early activation). When the semantic context of the sentence was neutral (e.g. “In her garden, ...”) or action-related (e.g. “With her scissors, ...”), the motor response significantly increased during the processing of the phrase containing the action verb (e.g. “...Sarah cuts the newspaper”), while it significantly decreased when the semantic context was non-action related (e.g. “Without her scissors, ...”). These results suggest that motor response during passive processing of manual action sentences is automatic and online but non-systematic. [1] Tremblay & Small (2010) *Cerebral Cortex*. [2] Hauk et al. (2004) *Neuron*. [3] van Elk (2010) *Biological Psychology*. [4] Tremblay, Sato & Small (2012) *Neuropsychologia*. [5] Mahon & Caramazza (2008) *Journal of Physiology*. [6] Aravena et al. (2012) *PlosOne*.

*Speaker

†Corresponding author: melody.courson@crulrg.ulaval.ca

Do time-related words automatically activate the mental timeline in a Stroop-like task?

Verena Eikmeier * 1

¹ Eberhard Karls Universität Tübingen – Eberhard Karls Universität Tübingen, Schleichstraße 4, 72076 Tübingen, Germany

Theories of Grounded Cognition suggest that abstract concepts, like time, are represented in terms of concrete dimensions, such as space (Barsalou, 2008). Following these suggestions the existence of a mental timeline running from back (past) to front (future) has been proposed. Consistent with this assumption response time (RT) studies provide support for this time-space association, indicating that time evokes spatial representations that may facilitate or impede responses to time-related words or sentences (e.g., Torralbo, Santiago, & Lupiáñez, 2006; Ulrich et al., 2012). These studies documented a space-time congruency effect during the processing of time-related information: when participants judged the temporal reference of linguistic information they responded faster to future-related information with forward arm movements than with backward arm movements and faster to past-related information with backward arm movements than with forward arm movements. This pattern of results indicates an influence of temporal information processing on spatial responses. For time-related sentences it has been shown that this time-space association does not occur automatically during the processing of the sentence content (Ulrich & Maienborn, 2010; Ulrich et al., 2012). However, it remains unclear whether the temporal content of single words produces an automatic response activation.

In two experiments we assessed this question employing a Stroop-like paradigm. In Experiment 1 past and future related words were presented in four different colors and participants were asked to respond to the color of the word with a forward or backward arm movement. The temporal reference of the words was irrelevant for the task. Nevertheless a time-space congruency effect emerged hinting towards an automatic activation of the mental timeline during reading of time-related words. However because only time-related words were employed in this task participants might have focused on the temporal reference of the words although this was not task relevant. Therefore, Experiment 2 employed filler items that were not time or space-related in addition to the time-related words from Experiment 1. No space-time congruency effect was found in this experiment supporting the idea that participants attended to the temporal content of the words in Experiment 1 although this was not required.

Taken together the results of the two experiments do not support the notion that time-related single words produce automatic response activation on the back-front axis.

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ERPs modulations of lexical-semantic processes during word production in context

Raphael Fargier * ¹, Marina Laganaro ¹

¹ FPSE, University of Geneva – 42, Boulevard du Pont d’Arve, Switzerland

Concepts can be seen as a collection of many features that rely on different sensory modalities. Concepts are thus thought to be represented through distributed neural networks encompassing modality-specific regions. However, recent observations suggest that these neural networks are differentially activated as a function of the situational context in which words (or concepts) are processed. Most of the work investigating this issue focused on language comprehension assuming that knowledge about linguistic context plays a direct role in the comprehension of words and sentences. It is the retrieval of modality-specific semantic information that seems to be constrained by linguistic or even extra-linguistic context.

Although the flow of information differs between comprehension and production, semantic information is also necessarily retrieved throughout the language production process. In this study, we sought to examine whether flexibility in neural dynamics of semantic retrieval can also take place in the speaker’s brain in the course of word production.

For this, we investigated event-related potentials (ERPs) during a picture naming task which is known to allow the activation of the concept. This task was adapted such that pictures of concrete multimodal objects (i.e. “violin”; “drill”) were presented as the completion of a sentence introducing either visual or auditory situations. Crucially, participants were presented with a sentence in which only the last word (i.e. a verb) determined the context; followed by the picture of an object which the participant was asked to name (e.g. “In the workshop Mary hears/watches”; for respectively auditory/visual contexts; followed by a picture of a drill). Each picture of object appeared in the different contexts that varied according to the location and agent’s name of the situation on a counterbalanced order. We performed waveform analyses as well as spatio-temporal segmentation analyses on epochs aligned to the picture and to the response.

We did not find any significant difference in production latencies for words produced in the auditory context compared to the visual context. However, waveform amplitudes significantly differed between these two conditions in the short time-window ranging from 200 to 220 ms after picture presentation principally over left lateralized central-temporal electrodes. Moreover, spatio-temporal segmentation indicated different topographies in the same time-window.

Given the absence of differences in production latencies, the ERPs effects might be solely attributed to the generated contexts that preceded picture presentation. Moreover, our effects are found in a time-window that is commonly associated with lexical-semantic (lemma) retrieval. Our results indicate that despite relatively brief effects, producing the word “drill” in a visually elicited context differs from producing the word “drill” in an auditory generated context. Our

*Speaker

data suggest that the neural correlates of lexical-semantic retrieval in the course of word production are also context-dependent. This study offers new perspective for embodied/situated theories in providing insights to how the meaning of words is encoded in the speaker's brain.

Where am I in my mental model? Matching gender of pronouns and participants influences perspective taking

Anne Karina Feldmeth * ¹, Lars Konieczny ¹

¹ University of Freiburg, Center for Cognitive Science – Germany

Theories of embodied language processing argue that understanding language involves representing the information given in a multimodal situation model. A decisive factor in constructing this mental representation is the perspective a comprehender adopts within this model. In two experiments we investigated if and how gender modulates the adopted perspective: Does the ease of a comprehender’s identification with different thematic relations influence the mental model?

Adopting the action-sentence compatibility paradigm, participants judged the plausibility of auditorily presented German sentences. Participants hold down a button while listening to the sentences and evaluated each of them with a button press that required a movement either towards or away from the body. Dependent measure is the release time of the middle button.

72 participants listened to 32 (plausible) target sentences describing a directed action between two referents. All sentences were recorded with a male and a female speaker. Action verbs were rated beforehand according to their implicit direction.

In Experiment 1, agent position was realized by 3rd person pronouns and recipient position by 1st person pronouns.

(1) Er/Sie wird mir das Buch geben. (He/She will give me the book.)

Experiment 2 included 1st person pronouns in the agent and 3rd person pronouns in the recipient position.

(2) Ich werde ihm/ihr das Buch geben. (I will give him/her the book.)

Ease of identification with agent or recipient was operationalized as match or mismatch between gender of participant and (a) either gender of the speakers, or (b) gender-marked 3rd person pronouns.

The action-sentence compatibility effect (ACE) predicts faster release times if hand movement and directed action of the sentence are compatible. If ease of identification influences the adopted perspective within the situation model, the implicit direction of the stimulus verbs should interact with the match in gender between participant and pronoun referent. This interaction

*Speaker

should modulate the ACE according to the underlying mental model which combines adopted perspective and verb direction.

Experiment 1 revealed a significant main effect of compatibility of verb direction and movement. No interactions of compatibility with either agent or recipient gender match were found. This result replicates the ACE with sentences involving future tense. However, identification by way of gendered pronouns either in agent or recipient position does not seem to influence reaction times.

Analysis of Experiment 2, however, revealed a significant interaction of compatibility and recipient gender match: When participants' gender matched the gender of the 3rd person pronoun representing the recipient (e.g. "I will give him the book", male participant), release times were faster for compatible items. In non-match conditions (e.g. "I will give her the book", male participant) incompatible items led to faster release times. Gender of the speaker did not interact with compatibility.

In two experiments we investigated the influence of identification by gender on the structure of embodied mental representations. Speakers' gender did not result in measurable differences of the action-sentence compatibility effect. However, the match between gender marked pronouns in recipient relation and comprehenders' gender can modulate the internal structure of a mental representation.

Sensory Constraints on Perceptual Simulation in Reading

Xuefei Gao * ¹

¹ Max Planck Institute for Psycholinguistics – Wundtlaan 1 6525 XD Nijmegen The Netherlands, Netherlands

Resource-constrained models of language processing predict that perceptual simulation during language understanding would be compromised by

sensory limitations (such as reading text in unfamiliar/difficult font), while strong versions of embodied theories of language would

predict that simulating perceptual symbols in language would not be impaired even under sensory-constrained situations. In this study,

sensory decoding difficulty was manipulated by adopting both easy and hard font (Arial vs. Bodoni) to study perceptual simulation during

sentence reading (Zwaan et al., 2002). A lexical decision task was administered to a different group of participants to ensure that

participants were able to recognize single words in isolation in both fonts and that reading comprehension was not necessarily constrained

by data-limited processes. Results indicated that simulating perceptual symbols in language was not compromised by surface-form decoding

challenges such as difficult font, lending support to the theories proposing that embodied language processing is obligatory. Further

implications for learning from text, and individual differences in/aging effects on language processing will be discussed.

*Speaker

Spatial distance between objects affects the interpretation of semantic similarity: evidence from eye movements during spoken sentence processing

Ernesto Guerra* ¹, Jasmin Bernotat ^{† 2}, Pia Knoeferle ^{2,3}

¹ Experimental Psycholinguistics Lab, Pontificia Universidad Católica de Chile – Chile

² Cognitive Interaction Technology Excellence Cluster (CITEC) – Germany

³ Department of Linguistics, Bielefeld University – Germany

One important challenge for situated and embodied language models is how to link perceptual representations to abstract semantic content. Recent evidence, however, demonstrated that visually perceived distance modulated reading times for abstract sentences expressing similarity between nouns (Guerra & Knoeferle, 2014; Guerra et al., 2014). Against this background, we asked whether the link between spatial distance and the abstract notion of semantic similarity could be relevant for the interaction between spoken sentence comprehension and visual attention.

In an eye-tracking experiment, participants (n=47) inspected visual displays with six objects each, as they heard spoken sentences in German. On critical trials, participants heard sentences describing two objects from the display as similar (or different), such as ‘...a cat[NP1] is similar[ADV] to a dog[NP2]’. The visual context contained a single referent of the NP1, but there were two exact copies of the NP2 referent on the display; crucially, one NP2 referent appeared close to the NP1 referent (NP2-close) and the other was far away from it (NP2-far). Based on previous findings, we predicted that if spatial distance is relevant for the interaction between spoken abstract language and visual attention, then participants should look more to the NP2-close referent when sentences express similarity between the displayed objects; when sentences express difference between the displayed objects, more attention should go to the NP2-far referent.

The eye-tracking results (fixation proportion analysis) revealed an early effect of spatial distance even before the critical adverb; around 500 ms after NP1 onset, participant preferred to look at the NP2-close referent relative to distractors and the NP2-far referent. This preference dominated visual attention across the rest of the trial. However, as the critical spoken ADV and NP2 unfolded, the fixation proportion toward the NP2-close object significantly decreased when sentences expressed difference (vs. similarity). In turn, fixation proportions to the NP2-far referent significantly increased when sentences expressed difference (compared to similarity), but only during the spoken NP2. Finally, analysis of the gaze proportion difference between critical objects and corresponding competitors showed that while the NP2-close referent was always preferred (relative to the close distractor) during the spoken ADV and NP2, the NP2-far

*Corresponding author: erguerrag@uc.cl

[†]Speaker

object was indeed preferred during the spoken NP2 (relative to the far distractor) only when sentences expressed difference and not when they expressed similarity.

In sum, when processing a concrete spoken noun participants preferred to look at a related object close in space to the referent of that noun (relative to the same referent located further away). However, this trend was modulated by an abstract adverb expressing similarity or difference. These results are the first evidence showing that visuospatial information and abstract semantics can be integrated on the fly, and modulate language-mediated visual attention. Our findings are relevant for accounts of situated language processing, extending the linking hypothesis between visual contextual information and language beyond a referential link, and for embodied theories of language showing online effects of visuospatial representations on sentence comprehension.

Priming of hand and foot motor reactions by reading action verbs

Anne Klepp *¹, Valentina Niccolai¹, Peter Indefrey¹, Alfons Schnitzler¹, Katja Biermann-Ruben¹

¹ Heinrich Heine University Duesseldorf (HHU Duesseldorf) – Germany

Language-motor interaction effects have been described to reflect motor simulation during language understanding (Boulenger et al., 2006). Importantly, studies employing double dissociation paradigms to investigate the motor specificity of effects are as of yet rare. The present study used hand and foot action verbs in a task requiring either hand or foot responses. Reaction times and accuracy were expected to depend on the compatibility of the body part involved in the action described by a verb and the body part used to execute the response.

In the first experiment, 21 healthy subjects took part. Each trial consisted of the presentation of a German hand, foot, or abstract verb (verb meaning was irrelevant to the task) followed after 400 ms by a geometrical star-like shape with either pointed or rounded corners. Half of the subjects responded to pointed shapes using a foot pedal and to rounded shapes using a manual button, or vice versa. Reaction times and accuracy were analysed regarding the compatibility of hand/foot responses preceded by hand/foot verbs.

In the second experiment, 19 healthy subjects performed a comparable task as in experiment 1, but a semantic decision was added in a Go/NoGo fashion: responses were required only in case of concrete verbs (i.e., hand and foot), with abstract verbs as the NoGo condition. This was meant to ensure a deeper level of processing than in experiment 1, increasing putative language-motor interaction effects.

Results showed that positive priming effects depending on the compatibility of the body part referred to by the verb and the responding extremity could be found both in response accuracy and latency. While experiment 2 showed robust effects for both measures, experiment 1 resulted in only marginally significant effects. The additional explanatory power of verb-inherent semantic variables such as imageability is currently being incorporated into the statistical models, potentially refining the subtle priming effects in experiment 1.

These results show that reading action verbs may evoke motor simulations of actions in the corresponding portions of the brain's motor system that interact with a subsequent recruitment of the same or competing brain regions. In line with previous research, this motor simulation appears stronger or more elaborate during conscious semantic processing, corroborating the context-specific flexibility of motor cortex recruitment during language processing.

Taken together, in a paradigm where the lexico-semantic access of verb reading is followed by a motor reaction choice, facilitation of responses in the compatible conditions is observed.

*Speaker

This complements similar findings from other paradigms and languages as well as interference effects that are found when language and motor processing overlap in time (Klepp et al., 2015). Crucially, the use of both hand and foot responses in this study allows double dissociation of effects.

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Language induced emotional effects on self-characterization

Zoltán Kondé ^{*† 1}, József Pántya ², Zoltán Dósa ³, Tünde Polonyi ⁴

¹ University of Debrecen, Institute of Psychology, Department of General Psychology – Debrecen - 4032 Egyetem tér 1., Hungary

² University of Debrecen, Institute of Psychology, Department of Social and Work Psychology – Debrecen - 4032 Egyetem tér 1., Hungary

³ Babeş-Bolyai University, Kolozsvár, Department of Pedagogy and Applied Didactics – Cluj-Napoca, Romania

⁴ University of Debrecen, Institute of Psychology, Department of General Psychology – Debrecen - 4032, Egyetem tér 1., Hungary

The idea of linguistic relativism supposes that language or aspects of linguistic context may exert an influence on what and how we perceive and memorize physical or social events. Any particular language imposes constraints and sets limits quite differently on how we conceptualize our experiences of the world. Consequently, linguistic variations reflect variations in thought, worldviews and mindsets.

The aim of the present research was to investigate empirically a question that is related to the problem of linguistic relativity. We supposed that a linguistic context may have an effect on self-characterisation in a linguistic version of a questionnaire. To our hypothesis, an identity relevant question may be sensitive to linguistic influences when it provides a specific linguistic-cultural perspective. Specifically, we expected differences in self-characterization when questionnaires concerns collective attributes, i.e., that can be interpreted inherently from a linguistic-cultural point of view. For example, characteristics related to a persons' collective-national identity. No effect of language was expected in questionnaires examining personal or identity irrelevant attributes.

A survey was conducted among Hungarian-Slovakian bi-linguals (N=103) with the aim of investigating the individual differences in collective and personal value priorities. Participants completed questionnaires measuring: (a) own-culture preference (Patriotism); (b) ethnocentric proclivity toward other cultures (Generalized Ethnocentrism Scale); and, (c) the relative importance of 10 universal value types (Portrait Value Questionnaire). In two language group the native (Hungarian) and an acquired language (Slovakian) were used for filling out the questionnaires. In a 6-month delay the survey was repeated among the same participant, but for half of them the language of filling changed (e.g. from Hungarian to Slovakian). Between group and within subjects comparisons indicated linguistic effects on ethnocentrism and patriotism but the effects were absent on personal value priorities. The results demonstrated a kind of language generated effect on identity relevant self-characterization.

We supposed that the language sensitivity of cultural/national bias we observed may be mediated by emotional processes, which may indicate the role of language in creating emotional

*Speaker

†Corresponding author: konde.zoltan@arts.unideb.hu

context. In order to examine further the emotional aspect of linguistic-cultural bias a laboratory experiment was carried out by using a Name version of the Implicit Association Test (IAT) in three sessions: (1) Hungarian vs. Slovakian; (2) Hungarian vs. European; (3) Slovakian vs. European. The IAT effect was much more pronounced when the Hungarian category was contrasted with the European category but it was attenuated when the Slovakian category was coupled with either the Hungarian or the European category. The polarity of the IAT effects in each case indicated a positive emotional bias toward the own culture (Hungarian) or the familiar culture (Slovakian). The present observations give support to the supposition that the cultural/national bias may be mediated by emotional processes, and emphasizes the role of language in creating emotional context.

The role of motor simulation on the memory of objects in children: Exploring the effect of posture during encoding

Julie Lebahar ^{*† 1}, Alix Seigneuric ¹, Hakima Megherbi ¹, Steve Bueno ¹

¹ Unité Transversale de Recherches: Psychogénèse et Psychopathologie, psychologie, psychanalyse, anthropologie (UTRPP) – Université Sorbonne Paris Cité (USPC), université Paris 13 : EA4403 – UFR Lettres, Sciences de l’Homme et des Sociétés, Université Paris 13, 99 avenue Jean-Baptiste Clément, F-93430, Villetaneuse, France

In 1997, Glenberg developed the idea that memory representations are embodied, that is they are analogically related to properties in the world. In other words, memory encodes integrated sets of patterns of actions relevant to our body to give meaning to objects and situations. These actions are also referred to as affordances. Affordances are defined by Gibson (1979) as the potential actions that an organism can perform on an object suggested by its use. The meaning of an object is thus what a person can do with the object. One way to test Glenberg’s proposal is to test memory of objects that vary in terms of possibilities for action, namely, non manipulable vs manipulable objects. By using a motor interference paradigm during encoding, Dutriaux and Gyselinck (2014) have found that adults showed a decrease in memory for manipulable objects when a constraining posture was used during the learning phase (their hands held behind their back). These results suggest that the constraining posture has inhibited mental simulations of motor activity associated to the objects to be memorized. They confirm the Glenberg’s theory (1997) considering that world is encoded in terms of affordance and stressing the links between memory and action.

An interesting question raised by these results is whether such a link can be observed in children. This question fits with some developmental frameworks that have accordingly claimed that the function of memory is to support action (Nelson, 1993).

Our experiment investigates the presence of such an effect in children by using the same paradigm as Dutriaux & Gyselinck. Forty children (aged 7-9) were invited to memorize words or pictures of objects varying according to affordance: manipulable objects such as tools, toys, or musical instruments vs nonmanipulable objects such as monuments or buildings. The posture adopted during encoding was manipulated: in the constraining condition, their hands were kept behind their back; in the free condition, their hands were simply put in front of them.

In the picture condition, we found a significant interaction between type of object and posture condition. For manipulable objects, recall performance was higher in the constraining posture condition than in free-hands posture, whereas for nonmanipulable objects, performance was lower in the constraining posture condition compared to the free-hands posture. In the word condition, this interaction was not significant.

*Speaker

†Corresponding author: julielebahar@hotmail.com

Our results confirm the impact of posture manipulation on the memory of object contrasted on affordance feature but they clearly differed from those observed in adults. They highlight the relevance of the question of how the link between affordance and memory evolves during development, and how it is related to the development of language and sensory-motor skills. To move forward on this issue, we will explore the relation between recall performance and individual performance on vocabulary knowledge and body-shape knowledge. Testing older and younger children using the same paradigm would provide a clearer picture of the developmental path of the phenomenon of motor simulation in memory of action-related concepts.

Orofacial electromyographic correlates of induced verbal rumination

Ladislav Nalborczyk ^{*† 1}, Céline Baeyens ², Romain Grandchamp ¹,
Hélène Lœvenbruck ^{* ‡ 1}, Marcela Perrone-Bertolotti ^{* § 1}, Mircea
Polosan ³

¹ Laboratoire de psychologie et neurocognition (LPNC) – CNRS : UMR5105, Université Pierre-Mendès-France - Grenoble II – Université Pierre Mendès-France Bât Sciences de l’Homme et Mathématiques BP 47 38040 Grenoble Cedex 09, France

² Laboratoire InterUniversitaire de Psychologie. Personnalité, Cognition, Changement Social (LIP) – Université Pierre-Mendès-France - Grenoble II : EA4145 – Université de Grenoble 2 BP 47 - 38040 GRENOBLE Cedex 9 - FRANCE, France

³ Grenoble Institut des Neurosciences (GIN - U836) – CEA, CHU Grenoble, Université Joseph Fourier - Grenoble I, Inserm : U836 – UJF - Site Santé La Tronche - BP 170 - 38042 Grenoble Cedex 9, France

Abstract

Background and Purpose: Ruminations involve repetitive, prolonged, and recurrent thoughts about one’s self, concerns and experiences. These thoughts are predominantly verbal and can be considered as a particular case of inner speech. It has been suggested that inner speech is a kind of motor action. In line with this suggestion, we predicted an increase of speech muscle activity during verbal rumination as compared to rest (following a relaxation session). Furthermore, we expected that orofacial relaxation might reduce speech muscle activity and lead to a decrease in inner verbal productions.

Method: We recorded lip (i.e., orbicularis oris superior, OOS), forehead (i.e., frontalis, Front) and forearm (for control) muscle activity in 33 participants, using surface electromyography (EMG). Ruminative state was assessed via subjective reports at three consecutive points: after a first relaxation session (initial resting state), after a rumination induction procedure (involving a forced-failure task) and after a second relaxation session or a distraction task (listening to a story, control condition).

Results: Results showed an increase in EMG activity in the OOS and Front muscles after rumination induction compared to the initial relaxed state. This increase in orofacial EMG activity was associated with positive subjective reports of rumination and was not due to general muscular tension because there was no increase in forearm EMG. Furthermore, preliminary analyses suggested a decrease in orofacial EMG activity following the relaxation session and no decrease after the control distraction condition.

Conclusion: The observed increased OOS activity after rumination induction corroborates the

*Speaker

†Corresponding author: ladislav.nalborczyk@gmail.com

‡Corresponding author: helene.loevenbruck@upmf-grenoble.fr

§Corresponding author: marcela.perrone-bertolotti@upmf-grenoble.fr

hypothesis that verbal rumination is a kind of motor action. The observed increased Front activity further suggests that rumination involves frontalis muscle contraction, as observed in anxious states. This suggests that rumination shares some features with negative thoughts, worry and anxiety. Our results may shed light on the description of verbal rumination in the context of embodied cognition even though further exploration is needed to better describe physiological manifestations of inner verbal productions and more specifically verbal ruminations.

Key Words: ruminations, inner speech, EMG, orbicularis oris superior, frontalis, relaxation

Modulatory effect of motor cortex stimulation on semantic priming

Valentina Niccolai ^{*† 1}, Anne Klepp ¹, Peter Indefrey ¹, Alfons Schnitzler ¹, Katja Biermann-Ruben ¹

¹ Düsseldorf University – Germany

Processing hand and foot verbs has been shown to activate the respective motor areas and to elicit beta desynchronization similarly to movement execution (Aziz-Zadeh et al., 2006; Niccolai et al., 2014). Above that, oscillatory brain responses have shown that motor execution interferes with simultaneous verb processing (Klepp et al., 2015). By exploiting the up- and down-regulation that anodal and cathodal transcranial direct current stimulation (tDCS) respectively exert on motor cortical excitability (Nitsche and Paulus, 2000), we aimed at modulating semantic priming of action verbs. We expected that online anodal stimulation of the left hand motor cortex would slow down the processing of hand verbs by increasing cortical excitability and simulating the previously observed interference effect. The opposite effect was expected for cathodal stimulation. Sham stimulation was used as a control condition in a double-blind within subjects design.

The stimuli set consisted of disyllabic hand, foot, and non-body (abstract) verbs followed by shapes with rounded or pointed corners. Twenty healthy participants (10 females) were required to read the verbs and to perform a go/no-go task: a) to respond only in trials with concrete verbs, 2) by pressing a manual button if the shape prompt had rounded/pointed corners and a foot pedal if the shape had pointed/rounded corners.

Results showed a semantic priming effect consisting in significantly shorter reaction time to congruent verb type - response modality pairs. Whereas hit and miss frequencies were not affected by tDCS, reaction times to shapes following hand verbs were significantly shorter in the cathodal compared to the sham condition when responding with button press. Conversely, button responses in the anodal condition showed significantly longer reaction time to shapes following hand and foot verbs compared to the sham condition. Thus, while cathodal stimulation of the hand motor area appears to selectively improve processing of hand verbs, anodal stimulation showed interference on verb processing, but unrelated to verb type. As button responses were overall faster than pedal responses, the lack of modulation of the latter suggests either that the effect of tDCS on word processing is short-timed or that tDCS influenced both verb processing and hand responses.

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*Speaker

†Corresponding author: valentina.niccolai@hhu.de

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What did you say? Clap with one hand or clap with your both hands”: Action verbs comprehension is modulated by hand motor responses compatibility

Marcela Perrone-Bertolotti ^{*† 1}, Solène Ambrosi , Emilie Cousin , Helena Keracheva , Monica Baciù , Richard Palluel-Germain

¹ Laboratoire de Psychologie et Neurocognition (LPNC) – University Grenoble Alpes, LPNC, F-38000 Grenoble, France : UMR5105 – Université Pierre Mendès-France Bât Sciences de l’Homme et Mathématiques BP 47 38040 Grenoble Cedex 09, France

Work in cognitive neuroscience demonstrates many links between language and action. More precisely, some data suggest that the motor system is crucial for action verbs comprehension. This suggests that similar neural substrate are involved during action execution and during action comprehension described in verbal modality. We tested this idea using a behavioral go-no go paradigm during a French concrete vs abstract verbs categorization task. The concrete verbs were hand-related and were related to both unilateral and bilateral action. Twenty-six French right-handed participants were instructed to manually respond when the presented word was concrete (i.e., go responses) using their right-dominant or their left non-dominant hand. We observed a significant interaction between hand-related verbs (unilateral, bilateral) and hand response (right-dominant, left non-dominant). More precisely unilateral hand-related (UhR) verbs presentations (such as write) induced faster right-dominant hand response; while bilateral hand-related (BhR) verbs presentation (such as clap) induced similar responses for both right-dominant and left-non dominant hand responses (see Fig1 A). Thus, there would be a pre-activation of the related motor cortex during action verbs meaning access that could explain the facilitation observed for the unilateral-related action verbs with the right dominant hand. To test this hypothesis we performed a preliminary fMRI experiment (n=10) in which participants performed a similar task that during behavioral experiment. Our preliminary results show that the left motor cortex (Precentral gyrus including BA 6 and BA 4) and the left premotor cortex (supplementary motor area, SMA) were more involved during UhR verbs than during BhR verbs presentation; while the right motor cortex (Precentral gyrus including BA 6 and BA4) and the bilateral premotor cortex (SMA) were more involved during BhR verbs than during UhR verbs presentation (see Fig 1 B and C). Our behavioral and fMRI results suggest that the meaning of action verbs is embedded in the motor representations

Figure 1: Show result of the behavioral (panel A) and fMRI (panel B-C) experiments. A) Significant interaction between hand-related action verbs and manual response in terms of reaction time (RT, in milliseconds). Panel B and C: functional maps provided by the group analysis comparing unilateral-related verbs (UhR) and bilateral-related verbs (BhR) (n = 10, p < .001

*Speaker

†Corresponding author: marcela.perrone-bertolotti@upmf-grenoble.fr

uncorrected, cluster extend threshold of 15 voxels). The activation is projected onto surface rendering (Panel B) and onto 2D anatomical slices in axial, sagittal and coronal orientation (Panel C) represented in neurological convention (left is left hemisphere, LH). The MNI coordinates of the activation are also mentioned.

Tracking the embodied origin of action verb meaning in early mother-child interactions

Maria Josefa Rodrigo * ¹, Mercedes Muñetón ², Manuel De Vega ³

¹ University of La Laguna (ULL) – Campus de Guajara, La Laguna, Tenerife, Spain

² University of Antioquia (UdeA) – Calle 67 Número 53 - 108, Medellín, Colombia

³ University of La Laguna (ULL) – Spain

Embodied meaning theories posit that action verbs are grounded on perception and action. However, most of the evidence comes from experiments with adult participants who already have their language system developed. To explore the origins of embodied meaning we moved to the early stages of language acquisition and made naturalistic observations, examining whether infants from 1 to 3 years of age and their mothers associate manipulative action verbs with ongoing manual activity in their flow of daily interactions. We found that, above chance, either the mother (from 18 months on) or the child (from 27 months on) produced manipulative verbs while performing their corresponding actions, and the mother also produced these verbs when referring to the corresponding child's actions (from 33 months on). By contrast, other possible contingencies such as the child-mother co-occurrence of actions, or the child-mother co-occurrence of verbs were negative, suggesting a turn-taking pattern. Action-verb co-occurrences were highly synchronic (within 2.9 seconds temporal frames as average), they showed high referential accuracy (most action verbs match the ongoing actions), distinctiveness (only action verbs co-occur with actions but not mental verbs), and redundancy (mother and child tend to produce the same action verbs matched with the actions). These features of the child's early communicative environment seem to be optimal to feed in a Hebbian learning mechanism that establishes neural assemblies between linguistic and motor regions in the brain, as the possible origin of embodied meaning.

*Speaker

Mental simulation during text comprehension: The impact of narrative perspective on the memory of feeling and action verbs

Alix Seigneuric ^{*† 1}, Steve Bueno ², Laure Pourcin ², Julie Lebahar ²,
Hakima Megherbi ²

¹ UTRPP, Université Paris 13 Sorbonne Paris Cité – Université Paris-Nord - Paris XIII : EA4403 – 99
Avenue Jean-Baptiste Clément, 93430 Villetaneuse, France

² UTRPP, Université Paris 13 Sorbonne Paris Cité – Université Paris-Nord - Paris XIII : EA4403 –
France

Understanding a text involves going beyond the representation of the text itself to create mental representations of the described situations. A growing body of research has suggested that readers mentally simulate or embody the actions described in the text and represent the described emotions of the characters (De Vega et al., 1996; Zwaan, 2004). Moreover, recent studies have demonstrated that mental simulation varied as a function of narrative perspective (Brunyé et al., 2009, 2011). Narrative perspective has been found to be easily manipulated through the use of pronouns. Using the pronoun ‘You’ typically promotes simulation from the performer’s perspective resulting in better memory for actions and the internalisation of emotional states compared to text using the pronoun ‘He’ (Ditman et al., 2010).

The present study proposed to extend these results by examining the impact of the manipulation of narrative perspective on the memory of the actions and the feelings of the story’s protagonist by using a verb recall task. Two texts of similar length were devised as parallel texts. Each text described a different scenario supposed to differently promote memory of feelings and actions of the protagonist: a painter working on a canvas vs a cook making a cake. Each text included 20 verbs involving the main character: 10 verbs describing actions and 10 verbs describing feelings or sensations. The feeling verbs were identical in both texts. Half of the action verbs were the same in both texts, while the other half were specific to each text according to the described activity (painting vs cooking). All verbs appeared in the same relative locations in both texts. Two versions (‘You’ and ‘He’) were created for each text. Participants were randomly allocated to one of the four conditions of the 2 (Texts: painter/cook) x 2 (Pronouns: you/he) factorial design. Participants were instructed to read the text carefully. After a 3-min delay during which a filler task was completed, participants were invited to recall as many verbs from the text as possible. An Anova was run on the number of verbs recalled as a function of type of verbs (action vs feeling), text (painter vs cook) and pronoun (you vs he). A significant interaction was found between text and type of verbs showing that the recall of feeling verbs was higher in the painter text than in the cook text. Moreover, the interaction between pronoun and type of verbs was significant: the difference between ‘You’ and ‘He’ was larger for the feeling verbs: The

*Speaker

†Corresponding author: seigneuric@univ-paris13.fr

use of 'You' led to an increase in the recall of these verbs compared to the 'He' version. This effect was observed in both texts.

These results suggest that when using the pronoun 'You', the protagonist's feelings and sensations are more vividly internalised resulting in improved memory for the feeling verbs. These results are in line with previous research showing that a second-person pronoun cued an embodied actor perspective. In this case, mental simulations developed by the reader incorporate multiple sensory, emotional and motoric traces.

Get a grip: Testing for generalized effects of hand posture

David Sidhu * ¹, Penny Pexman * ^{† 1}

¹ University of Calgary – Canada

Several studies have found that information presented in front of the palms, and thus in graspable space, receives increased attention (e.g., Reed et al., 2010). Thomas (2015) elaborated on this finding by demonstrating that the current position of a person's hands, and thus the action afforded, affected what kind of information received this benefit. In particular, when participants held their hands in a precision grip posture they showed benefits on a form detection task. When participants held their hands in a power grip posture they showed benefits on a motion detection task.

Here we investigated the generalizability of this phenomenon to several measures, including a NAVON task. In a NAVON task, participants respond to large letters (global targets) made up of smaller letters (local targets). Given the benefits of a precision grip on spatial processing, we might expect responses to local targets to be enhanced. Moreover, we were curious if the effect of grip posture might go beyond what was described by Thomas (2015). Studies have suggested that bodily experience can promote either low or high-levels of construal, with feelings of precision being related to low-level construal (Maglio et al., 2014). Notably, construal level has been shown to have a differential effect on the processing of local and global targets in a NAVON task (Liberman & Förster, 2009).

We found no evidence that grip posture had an impact on NAVON task performance, suggesting limits on the tasks that can be affected by this manipulation.

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*Speaker

[†]Corresponding author: pexman@ucalgary.ca

Kinematic features of lexical aspect

Marietta Sionti * ¹, Thomas Schack

¹ University of Bielefeld, Cognitive Interaction Technology Institute (CI-TEC) – Germany

This paper focuses on the difficult domain of lexical aspect and examines whether some of its dimensions could be grounded to captured motion data. This analysis and the visualized plots that were exported from various actions offer a sound basis of aspect's understanding in language and motion. Human activity recognition could gain detailed patterns of aspectual characteristics such as duration, iteration and frequency and later on, they could become embedded to videos. Similar tasks, such as event segmentation and labeling of sensorimotor data could be also benefited by the connection of kinematics and linguistics. Especially about labeling, the state-of-the-art claim is that robots better identify events when they are taught with their names (assuming the availability of multi-modal input).

Lexical aspect (aktionsart) is a multidimensional linguistic phenomenon, which encodes temporal and frequency information. It is considered to play significant role to mental simulation of an action both in the execution of the movement -per se- and the linguistic expression of the real world actions (Bergen & Chang, 2005; Matlock, et al. 2005; Barsalou, 2009), which have been previously observed and learnt by mirror neurons (Fadiga, et al. 2006; Arbib, 2008). According to Talmy (2000, II), languages form event temporal information into a particular typology according to the manner of the change or not state and especially the pattern of distribution along time. The graphic representations of the lexical aspect have many similarities with those of the kinetic data. Preliminary results are

- Elicitation of features (duration, iteration) resembling lexical aspect and its allocation to plots of path, direction, velocity (Scheme 2).
- Correlation between kinematic features and linguistic characteristics

Apart from the kinematic features that are crucial for human motion analysis, anaphora resolution (gestures), machine translation (for ASL), automatic event segmentation annotated with linguistic labels, etc, we wanted to directly link sensorimotor and linguistic information. Running correlation matrices for kinematics and linguistic variables-taken from corpus driven analysis-we observed that the two significant correspondences are (i) between variables verb_class (it groups motion verbs according to Levin's (1993) classes) and repetition and (ii) repetition with linguistic duration, a notion that implies lexical aspect but it does not carry the semantic load of the term aspect.

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Experience-specific pitch-space associations: The role of musical expertise during processing of sentences describing auditory events of different pitch heights

Sibylla Wolter * ¹, Carolin Dudschig , Irmgard De La Vega , Barbara
Kaup

¹ Eberhard Karls Universität Tübingen – Eberhard Karls Universität Tübingen, Schleichstr. 4, 72076
Tübingen, Germany

Simulation accounts suggest that language comprehension involves the reactivation of perceptual and body related real world experiences that are associated with the meaning of the words and sentences that are being processed. The core assumption is that the sensorimotor system and the language processing modules are not separate from each other but work in concert forming a multimodal meaning representation of the linguistic stimulus. In the present study we investigated the predictions of this account with respect to auditory events. Studies from physical tone perception show that only pianists automatically associate high tones with the right and low tones with the left side, corresponding to the piano keyboard and the actual experience of producing high tones with the right and low tones with the left hand. Most interestingly, similar results were obtained with regard to the processing of sentences describing auditory events of different pitch heights, such as the bear growls deeply vs. the pianist plays a high note. In a first study with a sensibility judgement task, we found that reading sentences implying an auditory event of a high pitch led to faster responses with the right hand, and reading sentences implying an auditory event of a low pitch led to faster responses with the left hand. Importantly, these differences in response times were not observed for participants lacking any musical experience, neither in a sensibility judgement task nor in a pitch categorization task. Overall, the results thereby suggest that language understanding activates experience-specific pitch- space associations, supporting the simulation account and the notion of multimodal meaning representations.

*Speaker

List of participants

- 't Hart Björn
- Altmann Gerry
- Balduin Larissa
- Berenhaus Molly
- Berndt Eduard
- Bernotat Jasmin
- Boddy Peter
- Bottini Roberto
- Boulenger Véronique
- Connell Louise
- Courson Melody
- De Vega Manuel
- Dutriaux Léo
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