Symposium on Cognitive Linguistics and the Cognitive Neuroscience of Language

Thu, 3.3.2022, 13:30-15:30h

13:30h: *Friedemann Pulvermüller*, Brain Language Laboratory, Department of Philosophy and Humanities, Freie Universität Berlin: Neural mechanisms of form meaning assemblage in construction learning

When learning novel meaningful signs and constructions, information about their form and meaning is processed simultaneously. At the neural level, co-activation leads to binding and, in one theoretical perspective, to the formation of neuronal assemblies acting as cognitive and linguistic representations [1]. Computer simulations using brain-constrained neural networks and biologically realistic associative learning indeed indicate that the learning of linguistic forms in semantically relevant contexts of perceptions and actions leads to the formation of neural circuits for form-meaning pairs, and that the cortical topographies of these circuits reflect aspects of the stored meanings [2].

It may be criticized that an associative account of linguistic knowledge is problematic [3]. However, such criticisms failed to consider the explanatory power of now well-established biological learning mechanisms, which underlie any type of learning, language learning included. In addition to associative binding (strengthening of links between co-activated units and, hence, representations), these include anti-associative dissociation (weakening of links between units if one is active but the other inactive). In this talk, I will show how associative binding and dissociation mechanisms can provide a biological explanation for aspects of lexical, conceptual, semantic and construction learning.

First, the well-known linguistic concepts of entrenchment and statistical pre-emption [4] will be related to, and mechanistically founded in the biological mechanisms of associative binding and dissociation. Second, mechanisms of semantic learning will in focus and an explanation for the relative prominence of specific and category specific semantic features in the learning of labels for individual objects (proper names) and category terms will be proposed [6]. Third, I will discuss recent computer simulations of the learning of concrete and abstract concepts and words based on biologically constrained neural networks [6].

[1] Pulvermüller, F. (1999). Words in the brain's language. *Behavioral and Brain Sciences, 22*, 253-336.
[2] Pulvermüller, F., Tomasello, R., Henningsen-Schomers, M. R., & Wennekers, T. (2021). Biological constraints on neural network models of cognitive function. *Nature Reviews Neuroscience, 22*(8), 488-502.
[3] Chomsky, N. (1959). Review of "Verbal behavior" by B.F. Skinner. *Language, 35*, 26-58.
[4] Goldberg, A. E. (2006). *Constructions at work: The nature of generalisation in language*. Oxford: Oxford University Press.
[5] Pulvermüller, F. (2018). Neurobiological mechanisms for semantic feature extraction and conceptual flexibility. *Topics in Cognitive Science, 10*(3), 590-620. doi: 10.1111/tops.12367
[6] Henningsen-Schomers, M. R., & Pulvermüller, F. (2022). Modelling concrete and abstract concepts using brain-constrained deep neural networks. *Psychological Research, in press*.

14:15h: ***Véronique Boulenger, Laboratoire Dynamique du Langage, CNRS, Lyon:*** **From tactile perception to tool use: on the sensorimotor grounding of semantics and syntax**

In the framework of embodied cognition, action words have provided a fantastic opportunity to investigate the grounding of word meaning in the sensorimotor system. Motor cortical regions are activated during processing of action-related words or sentences [1], even in an idiomatic context [2], and action word reading can interfere with or facilitate motor performance. Studies have also examined the embodiment of language in the perceptual system (mostly vision, but also audition, olfaction and taste), yet the case of words referring to touch remains largely overlooked. In this talk, I will first present evidence for functional links between processing of words denoting tactile sensations and tactile perception: reading tactile-related verbs can speed up the mere detection of tactile stimulations [3]. The second part of the talk will be dedicated to another language domain, syntax, which has also been proposed to be embodied [4]. I will present new fMRI evidence that tool use, which adds a further hierarchical level into the motor plan, shares neural substrates with syntax in language in the basal ganglia [5]. Behaviorally, this is reflected by cross-domain learning transfer: training one ability specifically improves the other. These findings suggest the existence of a supramodal syntactic function shared between language and motor processes.

[1] Hauk, O., Johnsrude, I. & Pulvermüller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron, 41*, 301–307.

[2] Boulenger, V., Hauk, O. & Pulvermüller, F. (2009). Grasping ideas with the motor system: Semantic somatotopy in idiom comprehension. *Cerebral Cortex, 19*, 1905-1914.

[3] Boulenger, V., Martel, M., Bouvet, C., Finos, L., Krzonowski, J., Farnè, A. & Roy, A.C. (2020). Feeling better: Tactile verbs speed up tactile detection. *Brain and Cognition, 142*.

[4] Roy, A.C. & Arbib, M.A. (2005). The syntactic motor system. *Gesture, 5(1-2)*, 7-37.

[5] Thibault, S., Py, R., Gervasi, A.M., Salemme, R., Koun, E., Lövden, M., Boulenger, V.*, Roy, A.C.* & Brozzoli, C.* (2021). Tool use and language share syntactic processes and neural patterns in the basal ganglia. *Science, 374(6569)*.

14:40h: ***Luigi Grisoni, Brain Language Laboratory, Department of Philosophy and Humanities, Freie Universität Berlin:*** **Predictive semantic activity in the brain: New arguments for the relevance of sensory and motor systems in meaning processing**

Theories of semantic and conceptual grounding emphasize functional interaction between perceptual, motor, and conceptual knowledge (Barsalou, 2008). Although, much evidence shows consistent activation in sensorimotor brain areas during language comprehension (Hauk, Johnsrude, & Pulvermüller, 2004), it has been argued that such activations may index post-hoc epiphenomenal re-processing (Mahon & Caramazza, 2008), rather than genuine semantic processing. In recent works (Grisoni et al., 2016; Grisoni, Miller, & Pulvermüller, 2017; Grisoni, Tomasello, & Pulvermüller, 2020), however, we showed evidence for a significant contribution of sensorimotor areas before predictable words appear. Sentence fragments that strongly predict subsequent words induced a slow potential shift before the expected words; this potential was weaker if the preceding fragments were unpredictable. That this Prediction Potential (PP) indexed predictive semantic processing was further demonstrated by the observation of cortical sources in specific sensorimotor brain areas for action-related (e.g., action verbs, tool nouns) words but in posterior, visual, areas for visual-related words (e.g., animal nouns). Furthermore, inverse correlations between the PP and the well-known brain index of semantic processing, N400, suggest that these two responses have a similar semantic discriminatory function. Overall, these data show that activity in sensorimotor brain areas reflect the meaning of expected words and, therefore, it cannot originate from post-semantic re-processing. Rather, it reflects genuine semantic processing and prediction.

Barsalou, L. W. (2008). Grounded cognition. *Annu Rev Psychol, 59*, 617-645. doi: 10.1146/annurev.psych.59.103006.093639
Grisoni, L., Dreyer, F. R., & Pulvermüller, F. (2016). Somatotopic Semantic Priming and Prediction in the Motor System. *Cereb Cortex*. doi: 10.1093/cercor/bhw026
Grisoni, L., Miller, T. M., & Pulvermüller, F. (2017). Neural correlates of semantic prediction and resolution in sentence processing. *J Neurosci*. doi: 10.1523/jneurosci.2800-16.2017
Grisoni, L., Tomasello, R., & Pulvermüller, F. (2020). Correlated Brain Indexes of Semantic Prediction and Prediction Error: Brain Localization and Category Specificity. *Cerebral Cortex, 31*(3), 1553-1568. doi: 10.1093/cercor/bhaa308
Hauk, O., Johnsrude, I., & Pulvermüller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron, 41*(2), 301-307.
Mahon, B. Z., & Caramazza, A. (2008). A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content. *J Physiol Paris, 102*(1-3), 59-70. doi: 10.1016/j.jphysparis.2008.03.004.

15:05h: *Rachel Moseley, Department of Psychology, University of Bournemouth:*
Sensorimotor 'grounding' of emotion words: lessons from the autism spectrum

Much has been written pertaining to the ‘grounding’ of meaning in sensorimotor systems for words with concrete meanings: that is, words denoting perceptual states (smells, tastes, sounds, visual objects) and actions. Emotion perception and recognition, however, also appears to draw on activity generated in sensorimotor and limbic areas by visual and linguistic stimuli (Ross & Atkinson, 2020). In considering the functional importance of this ‘simulation’ activity for comprehension, autism spectrum conditions may present an intriguing case example. Autistic people exhibit pervasive differences in their usage and understanding of emotion words (Lartseva et al., 2015), and their perception and recognition of emotional states (Trevisan & Birmingham, 2016). They also experience pervasive sensory differences and movement impairments, with structural and functional substrates for these differences in brain systems for perception and action. Having previously linked under-activation of sensorimotor areas, in action words, to a specific processing deficit for these words (Moseley et al., 2013), the present talk reconsiders autistic emotion processing differences in light of underpinning sensorimotor and limbic simulation, drawing on research from our group (Moseley et al., 2015) and more recent work.

[1] Lartseva, A., Dijkstra, T., & Buitelaar, J. K. (2015). Emotional language processing in autism spectrum disorders: a systematic review. *Frontiers in human neuroscience*, *8*, 991.
[2] Moseley, R. L., Mohr, B., Lombardo, M. V., Baron-Cohen, S., Hauk, O., & Pulvermüller, F. (2013). Brain and behavioral correlates of action semantic deficits in autism. *Frontiers in human neuroscience*, *7*, 725.
[3] Moseley, R. L., Shtyrov, Y., Mohr, B., Lombardo, M. V., Baron-Cohen, S., & Pulvermüller, F. (2015). Lost for emotion words: what motor and limbic brain activity reveals about autism and semantic theory. *Neuroimage*, *104*, 413-422.
[4] Ross, P., & Atkinson, A. P. (2020). Expanding simulation models of emotional understanding: the case for different modalities, body-state simulation prominence, and developmental trajectories. *Frontiers in psychology*, *11*, 309.
[5] Trevisan, D. A., & Birmingham, E. (2016). Are emotion recognition abilities related to everyday social functioning in ASD? A meta-analysis. *Research in Autism Spectrum Disorders*, *32*, 24-42.