Language and the brain
Lecture series at the *Berlin School of Mind and Brain*
Lecturers: Pia Knoeferle & Friedemann Pulvermüller

Course code: 32851 (Humboldt Universität zu Berlin, HU), 16843 (Freie Universität Berlin, FU)

Time: Summer term 2024, Mondays 12:15-13:45; start: 24. April 2024

Venues: Bernstein Center Lecture Hall at HU Berlin and on zoom

Language has been investigated from a range of perspectives. Linguists have described it as a formal system focusing on levels that range from phonology to syntax, semantics and pragmatics. Both linguists and psychologists worked on models focusing on the time course of linguistic processing, so that these psycholinguistic models could be tested in behavioral experiments. Neuro- and cognitive scientists have attempted to spell out the brain mechanisms of language in terms of neuronal structure and function by specifying language-relevant areas, 'networks', neuronal assemblies and their interactions. Most recently, explicit biologically inspired modelling and neural network research aim at imitating and explaining language circuits in the human brain, following Feynman's insight that "What I cannot create, I do not understand". These efforts are founded in neuroscience data about the event-related brain potentials and the brain loci that activate when specific linguistic operations occur, the time course of their activation and the linguistic effects of focal brain lesions.

The lecture series will provide a broad introduction into these linguistic, psycholinguistic and neurolinguistic research streams and highlight a variety of cutting-edge behavioral, neuroscience and computational findings addressing a broad range of linguistic issues, including, for example, the recognition of words, the parsing of sentences, the computation of the meaning and of the communicative function of language. Likewise, language development and language disorders will be in focus. Further emphasis will lie on theoretical and computational models of language processing built by psycho- and neurolinguists, which range from abstract box-and-arrow diagrams of the language (processing) system to computationally implemented models and neural network models mimicking the structure and function of the human brain. To evaluate these models, we will review experimental findings involving a broad range of behavioral (reaction time studies, eye tracking), neuroimaging (EEG, MEG, fMRI, NIRS) and neuropsychological methods (patient studies, TMS, tDCS).

Complementing the lecture series, a tutorial will be offered jointly by Johanna Knechtges, research assistant at the Brain Language Laboratory of the Freie Universität, and Li Dandan, PhD candidate in the Psycholinguistics group at Humboldt-Universität zu Berlin. The tutorial will deepen the lecture contents, in part by discussing relevant articles with theoretical and experimental focus. Together with the lectures, the tutorial will familiarize students with current research in the field of language and the brain.

This lecture series is open to students at the Berlin School of Mind and Brain as well as for students of linguistics at HU and FU Berlin.

Readings (recommended for course preparation):

Knoeferle, P., & Guerra, E. (2016). Visually situated language comprehension. *Linguistics and Language Compass*, *10(2),* 66–82. doi: 10.1111/lnc3.12177

Knoeferle, P. (2021). Grounding language processing: The added value of specifying linguistic/compositional representations and processes. *Journal of Cognition*, *4*, 1-14, doi: 10.5334/joc.155.

Pulvermüller, F. (2018). Neural reuse of action perception circuits for language, concepts and communication. *Progress in Neurobiology*, *160,* 1-44. doi: 10.1016/j.pneurobio.2017.07.001

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. doi: 10.1038/s41583-021-00473-5

Lecture Series "Language and the Brain"

Berlin School of Mind and Brain, Summer Term 2024

Lecturers: Friedemann Pulvermüller (FP) & Pia Knoeferle (PK)

PK's lectures will be given in the lecture theater of the Berlin Center of Computational Neuroscience, BCCN, and they will also be available on-line via zoom. Likewise, FP's lectures will be on zoom and broadcasted into the lecture room at BCCN. Please note: References highlighted by an asterisk (*) are required readings and form, together with the content of the lectures, the basis of the final exam. Additional recommendations for background readings (references without the asterisk) are listed for interested participants who would like to deepen their understanding.

01. FP   From Brain Structure to Linguistic Function   22.04

* Pulvermüller, F. (2018). Neural reuse of action perception circuits for language, concepts and communication. *Progress in Neurobiology*, 160, 1-44, doi: 10.1016/j.pneurobio.2017.07.001 *Please read pp 2-11 and pp 20-25.*

Schomers, M. R., Garagnani, M., & Pulvermüller, F. (2017). Neurocomputational consequences of evolutionary connectivity changes in perisylvian language cortex. *Journal of Neuroscience*, 2693-16. doi: 10.1523/JNEUROSCI.2693-16.2017

[*Basic background in neuroscience of language:* Pulvermüller, F. (2002). The neuroscience of language: on brain circuits of words and serial order (pp. 9–32). Cambridge University Press, Chapters 2 and 3.]

02. FP   Meaning in mind and brain   29.04

* Pulvermüller, F. (2013). How neurons make meaning: Brain mechanisms for embodied and abstract-symbolic semantics. *Trends in Cognitive Sciences*, 17(9), 458-470. doi: 10.1016/j.tics.2013.06.004

Patterson, K., Nestor, P. J., & Rogers, T. T. (2007). Where do you know what you know? The representation of semantic knowledge in the human brain. *Nature Reviews Neuroscience*, 8(12), 976-987. doi: 10.1038/nrn2277

03. FP   Speech Acts and Communication   06.05

*Tomasello, R. (2023). Linguistic signs in action: The neuropragmatics of speech acts. *Brain and Language*, *236*, 105203. doi: 10.1016/j.bandl.2022.105203

Hagoort, P., & Levinson, S. C. (2014). Neuropragmatics. In M. S. Gazzaniga (Ed.), The cognitive neurosciences (pp. 667-674). Boston, MA: MIT Press.

04. FP   Language Breakdown and Therapy   13.05

* Pulvermüller, F., & Berthier, M. L. (2008). Aphasia therapy on a neuroscience basis. *Aphasiology, 22(6)*, 563-599.

Blumstein, S. E. (2016). Psycholinguistic approaches to the study of syndromes and symptoms of aphasia. In G. Hickok & S. L. Small (Eds.), *Neurobiology of language* (pp. 923-933). Amsterdam: Elsevier.

05.   FP   Brain Constrained Neural Language Modelling   27.05

* Pulvermüller, F. (2024). Neurobiological Mechanisms for language, symbols and concepts: Clues from brain-constrained deep neural networks. *Progress in Neurobiol*ogy, 102511. doi: 10.1016/j.pneurobio.2023.102511

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. doi: 10.1038/s41583-021-00473-5

06.   PK   Knowledge and processing   03.06

*Knoeferle, P. (2021). Grounding language processing: The added value of specifying linguistic/compositional representations and processes. *Journal of Cognition*, *4*, 1-14, doi: 10.5334/joc.155.

Knoeferle, P., & Guerra, E. (2016). Visually situated language comprehension. *Linguistics and Language Compass*, *10(2),* 66–82. doi: 10.1111/lnc3.12177

Traxler, M. J. (2012). Speech Production and Comprehension. In: *Introduction to Psycholinguistics: Understanding Language Science* (First, pp. 37–78). Blackwell Publishing Ltd.

07.   PK   Methods: Eye-tracking and ERPs   10.06

*Pyykkönen-Klauck, Pirita, and Matthew W. Crocker. (2016). Attention and eye movement metrics in visual world eye tracking. In: P. Knoeferle, P. Pykkönnen-Klauck and M.W. Crocker (eds). *Visually situated language comprehension*. (67-82). Amsterdam: John Benjamins Publishing.

*Kutas, M., & Federmeier, K. D. (2007). Event-related brain potential (ERP) studies of sentence processing. In: G. Gaskell (Ed.), *The Oxford Handbook of Psycholinguistics.* doi:10.1093/oxfordhb/9780198568971.013.0023

08.   PK   Processing syntactic structure   17.06

Knoeferle, P., Habets, B., Crocker, M. W., & Münte, T. F. (2008). Visual scenes trigger immediate syntactic reanalysis: Evidence from ERPs during situated spoken comprehension. *Cerebral Cortex*, *18(4),* 789–795. doi:10.1093/cercor/bhm121.

*Van Gompel, R., & J. Järvikivi (2016). The role of syntax in sentence and referential processing. In: P. Knoeferle, P. Pykkönnen-Klauck and M.W. Crocker (eds). *Visually situated language comprehension*. (83-126). Amsterdam: John Benjamins Publishing.

09.   PK   Semantic interpretation   24.06

*Engelhardt, P. and F. Ferreira (2016). Reaching sentence and reference meaning. In: P. Knoeferle, P. Pykkönnen-Klauck and M.W. Crocker (eds). *Visually situated language comprehension*. (127-150). Amsterdam: John Benjamins Publishing.

Knoeferle, P., Urbach, T. P., & Kutas, M. (2014). Different mechanisms for role relations versus verb-action congruence effects: Evidence from ERPs in picture-sentence verification. *Acta Psychologica*, *152*, 133–148. doi:10.1016/j.actpsy.2014.08.004

10. PK   Social aspects in language processing   01.07

*Münster, K., & Knoeferle, P. (2018). Extending situated language comprehension (accounts) with speaker and comprehender characteristics: Toward socially situated interpretation. *Frontiers in Psychology*, *8.* doi: 10.3389/fpsyg.2017.02267

Van Berkum, J. J. A., Van den Brink, D., Tesink, C., Kos, M., and Hagoort, P. (2008). The neural integration of speaker and message. *Journal of Cognitive Neuroscience*, *20*, 580–591. doi:10.1162/jocn.2008.20054

[Non-mandatory reading on register in language: Pescuma V., Serova D., Lukassek J., Sauermann A., Schäfer R., Adli A., … Knoeferle, P. (2023) Situating language register across the ages, languages, modalities, and cultural aspects: Evidence from complementary methods. *Frontiers in Psychology, 13:964658*. doi: 10.3389/fpsyg.2022.964658]

11. PK & FP   Exam Review   08.07
12. Final exam   15.07