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Lecture

The mapping from language in the brain to the language of the brain

Peter Hagoort

Abstract

Human language consists of at least three levels of representation, namely sound patterns, syntactic patterns, and semantic information. These three different levels of representation are acquired and stored in neocortical brain structures during the first years of life. They form the representational primitives at Marr's computational level. During language processing, these representational primitives are retrieved and unified on-line (i.e. in real time and from left to right), to produce and comprehend the complex utterances that speakers and listeners are capable of exchanging. This requires a specification of Marr's algorithmic level of analysis, here referred to as Unification. A system with the capacity to show complex language generation and interpretation has to meet these representational and algorithmic requirements. However, when it comes to neural implementations, it requires a mapping of representational and algorithmic levels onto the informational language of the brain itself. This mapping remains one of the major, and largely unmet challenges for a neurobiological account of human language.

As a way into this mapping problem, I will outline a computational approach to modeling language processing in spiking recurrent. Sequential input is non-linearly mapped into a high-dimensional neural state-space and the internal dynamics is subsequently decoded onto a set of read-out neurons using machine learning techniques. Read-outs are viewed as a measurement device to characterize the encoded information and provide a theory bridging between neuronal processes and concepts at computational and algorithmic levels. The approach is well-suited for testing the computational role of various neurobiological features, adaptation mechanisms, and network architectures. This will help to elucidate the role of (a) brain connectivity, (b) memory at various time-scales and (c) unsupervised, local learning and adaptation mechanisms supporting the language system›s capacity to reconstruct hierarchically structured interpretations from sentence input. I will exemplify this approach within a neurobiologically motivated model which maps sentence input onto sequences of thematic roles and integrates these into sentence-level semantic representations.

Peter Hagoort is director of the Max Planck Institute for Psycholinguistics (since November 2006), and the founding director of the Donders Institute, Centre for Cognitive Neuroimaging (DCCN,1999), a cognitive neuroscience research centre at the Radboud University Nijmegen. In addition, he is professor in cognitive neuroscience at the Radboud University. His own research interests relate to the domain of the human language faculty and how it is instantiated in the brain. In his research he applies neuroimaging techniques such as ERP, MEG, PET and fMRI to investigate the language system and its impairments as in aphasia, dyslexia and autism. For his scientific contributions, the Royal Netherlands Academy of Arts Sciences (KNAW) awarded him with the Hendrik Mullerprijs in 2003. In 2004 he was awarded by the Dutch Queen with the «Knighthood of the Dutch Lion». In 2005 he received the NWO- Spinoza Prize (M€ 1.5). In 2007 the University of Glasgow awarded him with an honorary doctorate in science for his contributions to the cognitive neuroscience of language. In 2008 he was awarded with the Heymans Prize. In 2012 the KNAW awarded his career contribution to the cognitive neuroscience with the Academy Professorship Prize (M€ 1.0). Peter Hagoort is member of the Royal Netherlands Academy of Arts and Sciences (KNAW), and of the Academia Europaea.