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ON LANGUAGE, COGNITION, AND THE BRAIN: AN INTERVIEW WITH PETER HAGOORT

SOBRE LINGUAGEM, COGNIÇÃO E CÉREBRO: UMA ENTREVISTA COM PETER HAGOORT

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Managing Director of the Max Planck Institute for Psycholinguistics, founding Director of the Donders Centre for Cognitive Neuroimaging (DCCN, 1999), and professor of Cognitive Neuroscience at Radboud University, all located in Nijmegen, the Netherlands, PETER HAGOORT examines how the brain controls language production and comprehension. He was one of the first to integrate psychological theory and models from neuroscience in an attempt to understand how the human language faculty is instantiated in the brain.

Prof. Hagoort is the proponent of an influential neurocognitive model of language processing, the Memory, Unification, and Control model (MUC). A crucial aspect of the MUC model is its emphasis on the dynamic nature of the language-ready brain, both in terms of the complex integration of brain regions that support the various aspects of language processing and of the interface between language, other cognitive systems such as memory and executive control, and the environment where human interaction takes place.

Dr. Peter Hagoort's thoughts on language, cognition, and the brain have been presented in countless theoretical and empirical articles published in the most important journals of Linguistics, Psychology, and Cognitive Neuroscience, as well as in books, edited volumes, and at conferences.

He has been awarded various prestigeous (international) Prizes for his scholarly contributions to the field, among them the NWO([1]) Spinoza prize. Already a member of several learned societies, he has recently been elected to the U.S. Academy of Sciences (NAS) as a Foreign Associate "in recogniztion of [his]

[1] *Nederlandse Organisatie voor Wetenschappelijk Onderzoek*, the Netherlands Organization for Research, is the major state-funded organization that provides research funding in the Netherlands.

distinguished and continuing achievement in original research" ([2]). In this interview, Dr Peter Hagoort shares some of his ideas on language, cognition, and the brain.

[2] Disponível em: <http://www.nasonline.org/news-and-multimedia/news/May-1-2018-NAS-Election.html>.

INTERVIEW WITH PETER HAGOORT

Revista da Anpoll (RA): *Considering the state-of-the-art of your field, how do you think speakers generate linguistic utterances, both in production and comprehension?*

Peter Hagoort (PA): To generate linguistic utterances, two requirements are crucial. We need linguistic knowledge in memory, which has been acquired during the first years of life. In addition, we need ways to retrieve this information and—in order to generate novel utterances—to combine it with knowledge that was retrieved a few milliseconds earlier. To realize this expressive power, the language capacity is based on a cognitive architecture that is tripartite in nature, with levels of form (speech sounds, graphemes in text, or manual gestures in sign language), syntactic structure, and meaning as the core components of our language faculty. These three levels are domain-specific but at the same time they interact during incremental language processing.

RA: *How does language—both production and comprehension—relate to other cognitive systems such as perception and executive control?*

PA: Of course language does not operate in isolation. Our words and sentences refer to states of affairs in our environment as represented by our sensory systems. Moreover, when we talk we instruct about 100 muscles via our motor cortex. Which language I speak, in case I can speak more than one language as most people in the world do, is controlled by the system that determines the goals of my communication. In short, language interacts continuously with all the other cognitive systems that collectively make up the human mind.

RA: *Could you elaborate a little more on your (current) model? What would you say is necessary for the model to develop?*

PA: The MUC model distinguishes three functional components of language processing: Memory, Unification, and Control. The Memory component refers to the linguistic knowledge that in the course of language acquisition gets encoded and consolidated in neocortical memory structures. It is the only language-specific component of the model. The knowledge about the building blocks of language (e.g., phonological, morphological, syntactic building blocks) is domain specific and hence coded in a format that is different from, say, color and visual object information. However, language processing is more than memory retrieval and more than the simple concatenation of retrieved lexical items. The expressive power of human language derives from the possibility to combine elements from memory in novel ways. In the model this process of deriving new and complex meaning from the lexical building blocks is referred to as Unification. Unification thus refers to the assembly of pieces stored in memory into larger structures, with contributions from context. Traditionally, psycholinguistic studies of unification have focused on syntactic analysis. But, crucially, unification operations take place not only at the syntactic processing level, but are a hallmark of language across representational domains. Thus, at the semantic and phonological levels, too, linguistic elements are combined and integrated into larger structures. Hence I distinguish between syntactic, semantic and phonological unification. Finally, the Control component relates language to joint action and social interaction. Executive control is invoked, for instance, when the contextually appropriate target

language has to be selected, for handling the joint action aspects of using language in conversational settings, for selecting the appropriate register in different social situations, etcetera. In addition, languages also have built-in linguistic devices that trigger the attentional control system into operation. In my model, the Memory component is subserved by parts of temporal and parietal cortex. The left inferior frontal cortex is crucial for Unification. The dorsolateral prefrontal cortex is one of the structures relevant for executive control.

What is crucial as a next step for the model is to characterize the ways in which the different areas of the brain that are involved in these three key components of the system (Memory, Unification, Control) interact and integrate their contributions. Because in the end, the brain is a highly dynamic network of interacting regions with relative specialization. Characterizing the dynamics of the system is a major challenge for the future.

RA: *For you as a neuroscientist, how does language as a system of communication differ from other forms of animal communication?*

PA: The crucial and unique aspect of human language and communication is that with a limited set of words we can generate an infinite set of novel utterances. This is the open ended nature of human language. Animal communication is based on a limited set of signals, that do not seem to allow the combinatorial possibilities of human languages. Animals can exchange a fixed set of messages. We humans can communicate an infinite number of linguistic utterances, many of which we might have never heard before but still understand perfectly. That is uniquely human.

RA: *What is the most defining characteristic underlying human language from your perspective as a neuroscientist? Is there any other activity in human behavior that is comparable to language? If so, how should linguists relate to those findings?*

PA: The most defining characteristic is that we can offload knowledge that we acquire to the community, and make it shared knowledge. The invention of writing has allowed humans to accumulate knowledge at a pace that is not seen anywhere else in the animal kingdom. This is what makes culture possible, allows us to have science, and invent new things based on the knowledge that has accumulated about our previous inventions. Many other aspects of human behavior depend on it, such as reasoning, mathematics, etcetera. Moreover, our memories and perceptions might be influenced by our capacity for language, especially because it offers the possibility to categorize sensory input by means of labeling through language. Animals have to categorize as well, but humans are tremendously helped by the language means available.

RA: *Your own research and the research at your Institute is highly multi-disciplinary, situated as it is at a cross-roads of several academic fields that even represent fundamentally different disciplines of research: the sciences (e.g. genetics) and the humanities (i.e. linguistics), which each have their own topics, methods, approaches, and mindsets. The psychology perspective adds an experiment-based research approach to this mix. How do you reconcile these areas: where is this reconciliation successful, where is it less effective? And why?*

PA: Of course this multidisciplinarity is a constant struggle. Each field has its own tradition, its own jargon and its own theoretical framework. Moreover, the experimental methods in different fields such as genetics and neuroimaging are not only highly specialized but also very complex in themselves. Nevertheless, the history of science has shown that major innovations often occur at the intersections of different

research fields. But this interdisciplinarity requires a long haul perspective, and will not be successful overnight. As a Max Planck Director, I am in the fortunate position to be able to have a long haul perspective. If your research is fully dependent on grant income that is more difficult. Nevertheless, I am convinced that if we want a full understanding of the human language faculty, we have to study it at all relevant levels of organization, all the way from the genetic basis of the language-ready brain and the neural infrastructure itself to the cognitive organization and behavior, as well as how language operates and is grounded in interaction between multiple agents.

RA: *How do you perceive the future of your (multi-disciplinary) field?*

PA: I think the field has a bright future. Since in the future interactions between humans and artificial agents will be increasingly important, knowledge about multimodal communication with a central contribution of language is vital. In a society in which knowledge is more pivotal than ever before and manual labor will be less decisive, the role of language will only become more important. In this context, society needs our expertise and insights. In a global world with millions of people migrating to other countries and different language communities, insights into learning a second or a third language is equally vital. In short, the world will need our knowledge more than ever before.

RA: *In your view, how can research in cognitive neuroscience, especially the research related to language, inform the field of education and school learning?*

PA: I think we will see increased insights in the causes of individual variability in language skills. Some children acquire with ease a few languages or more. Others find learning to read and write in their native language already a hard task. If we understand both the neurobiological and the experience-related causes of individual variability, we will be in a better position to tailor our education and teaching programs to the individual talents and limitations.

RA: *Do you have any additional comments or observations?*

PA: The neural organization of language in all likelihood is influenced by literacy, and years of experience in reading and writing. It might be important to investigate the neural basis of language when it solely depends on the evolutionary primary form, namely speech. Research in Brazil could be helpful in providing this piece of the puzzle.

SELECTED FURTHER READINGS

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