Using the P-Chain to understand the Evolution of Language

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To understand the evolution of language, it is necessary to link biological mechanisms for learning with meaning-based language processing and in this talk, I will present a P-Chain framework that can help to link these components (Dell & Chang 2014). The first link in the P-chain is that *Processing involves Prediction* and this refers to the fact that during comprehension, people often generates expectations for upcoming linguistic elements (Altman & Kamide, 1999). If you can predict a sentence from meaning, then you can do sentence production (*Prediction is Production*). When predictions are wrong, then *Prediction leads to Prediction error* and error is important in many learning algorithms (*Prediction error is used in Implicit Learning,* Rumelhart, Hinton, & Williams, 1986). Thus, in this model *Implicit Learning creates Priming* and there is evidence for this type of priming in adults in tasks such as structural priming. As the changes due to learning accumulate, this same process can also explain the acquisition of language (*Priming accrues in Acquisition*). The final link argues that Prediction error can explain Event-related Potentials like the N400 and P600, and this demonstrates that the learning signals in this framework can be seen in the electrical activity of the biological brain. Thus this framework helps to bridge between meaning-based production/processing/acquisition of language and biological systems that were under evolutionary pressure.

Sequence-based prediction can be modelled in simple recurrent neural network models that use back-propagation to learn sequential regularities. The fact that these networks can model a wide range of studies of how language influences the electrical activity in the brain (N400 and P600 studies, Fitz & Chang, 2018) demonstrates that these algorithms are approximating biological mechanisms in human brains. Furthermore, these algorithms have been used to model hierarchical structure across a wide range of different sequence learning tasks (e.g., music, action), so these mechanisms could have been under evolutionary pressure before language ability fully evolved (Conway & Christiansen, 2001). But these mechanisms are not sufficient to explain meaning-based sentence production and a new architecture was created that combined simple recurrent networks with message meaning. This new architecture, called Dual-path model, was used to instantiate the links in the P-chain framework. Here I argue that the key change in the development of human language was not due to the evolution of sequence learning per se (sequence prediction/implicit learning), but instead was the results of the evolution of social abilities to understand and convey meanings to others (Tomasello, 2010). The change in human social motivations to communicate can only support the evolution of language when encoded into an architecture like the Dual-path model which links sequencing learning abilities to structured meaning. In this talk, I will discuss the learning abilities of different types of neural network architectures and how meaning fundamentally changes the nature of the representations in these models.

References

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