CHAPTER 29

From a representation of behavior to the concept of cognitive syntax: a theoretical framework

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Abstract: Before we do anything, our brain must first construct a neural correlate of the various mental operations needed. Imaging and recording techniques have vastly improved our understanding of this process by providing detailed insight into how different regions of the brain contribute to behavior. However, exactly how these regions collaborate with each other to form the brain-scale activity necessary to generate even the simplest task remains elusive. Here we present a neural network model based on the hypothesis of a modular organization of brain activity, where basic neural functions useful to the current task are recruited and integrated into actual behavior. At the heart of this mechanism are regulating structures that restrain activity from flowing freely between the different cortical areas involved, releasing it instead in a controlled fashion designed to produce the different mental operations required by the task at hand. The resulting dynamics enables the network to perform the delayed-matching to sample and delayed pair association tasks. The model suggests that brain activity coding for elementary tasks might be organized in modular fashion, simple neural functions becoming integrated into more complex behavior by executive structures harbored in prefrontal cortex and/or basal ganglia. We also argue that such an integration process might take place through an iterative process, by piecing together previously validated behavioral chunks, while creating new ones under the guidance of a partially innate cognitive syntax.

Keywords: computational model; task representation; syntax; electrophysiological data; memory; executive function; cognitive tasks