Mechanisms of Reward-Learning Learning in the Basal Ganglia within a Cognitive Architecture

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Cognitive architectures are large-scale models that capture multiple aspects of cognition with a small, restricted set of assumptions. Cognitive architectures typically combine independent “modules” that abstract the computations of different brain circuits. However, brain circuits often have peculiar dynamics that are not independent of each other. Although frequently overlooked, these effects can have large and unexpected effects across cognitive domains.

In this talk, I will focus on how the functional constraints of cognitive architectures and the findings of neuroscience can mutually inform each other. First, I will show how the assumptions of the ACT-R cognitive architecture make unique and interesting predictions about the relationship between the basal ganglia and the cortex, and how we can test these predictions with functional neuroimaging. Then I will consider what happens when we take the opposite route and include an important but neglected feature of the basal ganglia (the existence of two opposite pathways that are differentially modulated by dopamine) within the ACT-R cognitive architecture. Specifically, I will show how Implementing the interplay of these pathways within a cognitive architecture has large repercussions, which extend to the way we model higher-level cognitive. To illustrate the point, I will show how including the dynamics of the basal ganglia makes ACT-R capable of reproducing otherwise puzzling experimental findings in the fields of decision-making, selective attention, and problem-solving.