Division of labor among multiple parallel cortico-basal ganglia-thalamic loops in pavlovian and instrumental tasks: A biologically-based computational model.

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Abstract

The existence of multiple parallel cortico-basal ganglia-thalamic loops and their important role for decision-making is widely accepted. The striatum is the largest input nucleus of the basal ganglia and gives rise to the direct and indirect pathways, through which it exerts a strong modulatory influence over its frontocortical target areas. Despite considerable progress in understanding the functional role of the striatum in these loops, the different contributions of striatal regions to decision-making and skill learning are still controversial. Recently, a division of the dorsal striatum into a medial region for task acquisition (associative striatum) and a lateral area (putamen) for task performance and habits has gained considerable popularity. Here, we describe one computational model that is implemented in the existing prefrontal cortex – basal ganglia working memory model (PBWM) framework and the biologically plausible primary value and learned value (PVLV) algorithm of reinforcement learning. Four parallel frontostriatal loops were included in this model: (1) The 'orbitofrontal circuit' calculates the incentive value of an outcome that is associated with conditioned stimuli. (2) The 'prefrontal circuit' is in charge of guiding goal-directed behavior. (3) 'Oculomotor circuit': control of eye movements. (4) 'Motor circuit': simple stimulus-response associations. This architecture allows us to simulate a wide range of data from studies on pavlovian and instrumental conditioning, e.g. conditioned orienting, different forms of pavlovian instrumental transfer, and outcome devaluation. Selective lesions of different parts of the model demonstrate the unique contributions of each area in different tasks. The results of our simulations suggest an alternative division of labor among striatal subregions that simply emerges from the connectivity of these subregions within a neural network.