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A COMPUTATIONAL MODEL OF BASAL GANGLIA FUNCTION WITH OUTPUT SELECTION AND REINFORCEMENT LEARNING.

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We propose a computational model of the basal ganglia based closely on known anatomy and physiology. First, we assume that thalamic output targets of the basal ganglia, which relay ascending information to cortical action and planning areas, including motor, supplementary motor, and prefrontal cortices, are tonically inhibited. Second, we assume that the output stage of the basal ganglia, the internal segment of the globus pallidus (GPi), selects a winner from several potential actions. The potential actions are represented as parallel streams of information, each competing for access to the cortical areas that implement them. The requirement for both tonic inhibition of thalamic nuclei and winner-selection leads to a circuit, that in the simplest possible form, has neurons in exactly the configuration found in the basal ganglia. In our model, striatal GABAergic neurons project in a parallel fashion to the GPi. The striatal neurons also converge on the external segment of the globus pallidus (GPe), which in turn inhibits the subthalamic nucleus (STN). STN neurons project in a divergent fashion to the GPi targets. The winner neurons in the GPi are the first to be inhibited, which in turn releases the inhibition of the corresponding thalamic target neurons. Simultaneously, the striatal neurons also inhibit targets in the GPe, which disinhibit the STN and excite all the GPi neurons within a localized region. This prevents further release of GPi neurons within a certain time period. Thus only one action is selected at a time. We combine this mechanism with reinforcement learning through dopaminergic neurons in the substantia nigra and the ventral tegmental area to modify the cortico-striatal synapse efficacy. The model successfully mimics behaviors such as risk aversion as well as the Wisconsin Card Sorting Test. Realistic lesions and transmitter imbalances can be performed to test specific disease hypotheses.