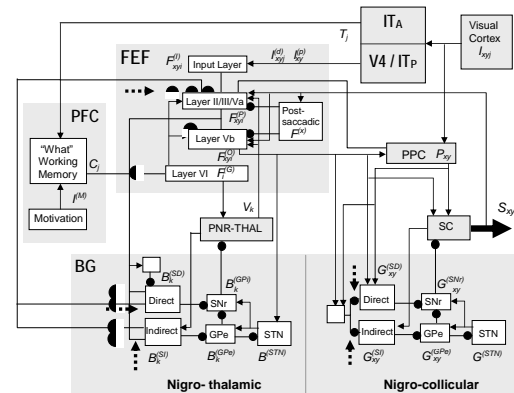


CELEST NUGGET FOR NSF

LEARNING TO BALANCE BETWEEN PLANNED AND REACTIVE BEHAVIORS

How does the brain learn to balance between reactive and planned behaviors? Impulsive behaviors that are not appropriate to a given environmental context, such as a classroom, can prevent learning of more task-appropriate, planned behaviors. Although rapid reactive movements are needed to ensure survival in response to unexpected dangers, planned movements are needed to achieve more sophisticated and intelligent performance. However, planned movements often take longer to elaborate than reactive movements. How does the brain prevent reactive movements from being triggered in situations

where more slowly occurring planned movements would be more adaptive? How does the brain know that a plan is being elaborated even before the final plan is selected? Key features of both reactive and planned movements are learned, but by different brain systems, ranging from the basal ganglia, superior colliculus, and cerebellum to the temporal, parietal, and prefrontal cortices. Thus, to fully understand how to balance reactive and planned movements, one needs to study a brain system that includes many different brain regions. The basal ganglia and frontal cortex, working together with these other brain regions, allow animals to learn planned behaviors that acquire rewards when prepotent reactive behaviors are insufficient. Recent work in CELEST, led by Professors Daniel Bullock and Stephen Grossberg, is further developing a model, called TELOS, to explain how laminar circuitry of the frontal cortex, exemplified by the frontal eye fields, interacts with the basal ganglia, thalamus, superior colliculus, and inferotemporal and parietal cortices to learn and perform reactive and planned movements. Eye movements have first been studied for several reasons: Eye movements are a crucial system whereby the brain efficiently acquires visual information; eye movement control requires a study of how visual information is converted into motor movements; eye movements typically precede arm movements towards the same goal objects, and are important during visual cognition and navigation; eye movement planning uses brain regions that are also used for other sorts of sensory-motor and cognitive planning; eye movement experiments can probe brain systems that are involved in reactive movements, memory-guided movements, and planned movements in an easily controllable way; as a result, there are large quantitative behavioral and neurobiological data bases about eye movements. TELOS model simulations show how dopaminergic reward and non-reward signals guide monkeys to learn and perform different sorts of saccadic (ballistic) eye movements in the fixation, single saccade, overlap, gap, and delay (memory-guided) saccade tasks. Model cell activities through time quantitatively simulate the neurophysiologically recorded dynamics of more than twenty different types of cells, and provide testable functional explanations of why so many different cell types are needed for the learning and control of reactive and planned movements. Ongoing work with CELEST colleagues is further developing this model system to better understand how rule-like plans are learned for the control of more complex movements and cognitive plans, and to use the model to explain new experimental results by CELEST members.



TELOS model circuit. The large arrows denote brain areas where dopaminergic signals modulate learning.