New Roles for the Basal Ganglia in Learning and Memory

ROBINSON, RICHARD

The basal ganglia generate patterns not only for movement, but also for learning and memory, according to Ann Graybiel, PhD, professor of neuroscience at the Massachusetts Institute of Technology. The basal ganglia are best known to most neurologists for their involvement in movement disorders, including Parkinson disease and Huntington disease. But as time has gone by, it has become clear that the basal ganglia are also involved in multiple neuropsychiatric disorders, including Tourette syndrome, autism, obsessive-compulsive disorder, and schizophrenia.

Improper pattern generation can lead to both drug addiction and the basal ganglia are deprogrammed in their behavior over many days. In a standard experiment, a naive rat runs a T-shaped maze, and learns to associate a particular tone with a reward, suggesting that the basal ganglia are deprogrammed in the brain as if somehow first, neurons in the striatum fire throughout the task, and as the rathe brain can modulate its own signal-to-noise ratio," Dr. Graybiel said. Dr. Graybiel believes that, together with interconnected cortical areas, the basal ganglia "may act to build higher-order representations of sequential actions and habits."

The basal ganglia are connected to the neocortex through multiple control loops, "which, as they operate, allow us to select what we'll do," she said. Repeated firing leads to the development of a habit. The system is modulated by reward-related dopamine signals from the substantia nigra. The connection between motor control and learning circuits in the basal ganglia is most evident in drug addiction. For a cocaine addict, merely observing another person manipulating drug paraphernalia is enough to strongly activate the basal ganglia, as shown by functional MRI studies. The activation is not only in the limbic part, which has been long associated with addiction reward, but also in the motor part, Dr. Graybiel explained.

LEONSS FROM A SIMPLE MAZE

To study these connections further, Dr. Graybiel's laboratory staff has discovered some clues by examining gene activation changes in"striosomes," patches of tissue that mediate dopaminergic and possibly cholinergic transmission. Across a range of drugs, the amount of drug-induced stereotypy exhibited by experimental animals correlated to the changes were most pronounced in regions implicated in both obsessive-compulsive disorder and drug addiction.

Investigators have also found that the striatum and hippocampus interact during learning. "These two huge circuits fire in synchrony," linking the fact-based memory of the hippocampus with the procedural memory of the basal ganglia.

NEW GENES THAT REGULATE RESPONSES

How do learned habits become the extreme habits characteristic of drug abuse? A different question is: "What are some of the ways in which addiction changes behavior?" For dopamine addiction, the pieces of this puzzle are still coming together, she indicated. "We CalDEG-GEF1 and CalDEG-GEF2, which influence the central signaling pathway in brain areas interested in the possibility that the striatum has within it these two neurons. The two were crucial for development of amphetamine-genetic, and that they are somehow related to dopamine and possibly the..."
induced stereotypy, and for levodopa-induced dyskinesias. The whole process seems to have a 'yin-yang' or 'seesaw' balancing function, in relation to motor output and involuntary movements."

Dr. Graybiel's work in uncovering the importance of the basal ganglia's role in motor learning has been known for longer, in learning has been "spectacular," according to Anne Young, MD, PhD, chief of neurology at Massachusetts General Hospital. The basal ganglia's role in motor learning has been known for longer, she said, and likely explains the difficulty that patients with Huntington or Parkinson disease have in learning new motor tasks. But the new understanding of the basal ganglia's role in cognitive learning has grown only over the past decade. "More and more data are coming out on this aspect," she said, "changing how we think about these diseases, as well."

Dr. Graybiel's work in uncovering the importance of the basal ganglia's role in motor learning has been known for longer, in learning has been "spectacular," according to Anne Young, MD, PhD, chief of neurology at Massachusetts General Hospital. The basal ganglia's role in motor learning has been known for longer, she said, and likely explains the difficulty that patients with Huntington or Parkinson disease have in learning new motor tasks. But the new understanding of the basal ganglia's role in cognitive learning has grown only over the past decade. "More and more data are coming out on this aspect," she said, "changing how we think about these diseases, as well."

Drawing from her three decades of research, Ann Graybiel, PhD, discusses the role of the basal ganglia in cognitive and emotional symptoms associated with movement disorders. ©2008 American Academy of Neurology

ARTICLE IN BRIEF

Drawing from her three decades of research, Ann Graybiel, PhD, discusses the role of the basal ganglia in cognitive and emotional symptoms associated with movement disorders. ©2008 American Academy of Neurology

NEUROLOGY TODAY QUICK LINKS

Home
Neurology News Blog
Neurology Today Conference Reporter
Neurology Today Archive
Neurology in the News Podcast
Video Gallery