Researchers find two brain circuits involved with habitual learning

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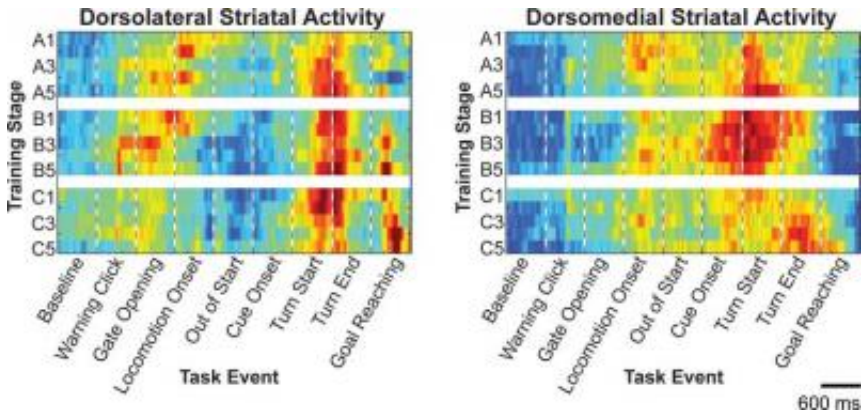

Rats exhibit different patterns of neural activity in the dorsolateral and dorsomedial parts of the striatum while learning to navigate a maze. Dorsolateral striatal neurons are most active (red) when the rat performs specific actions like starting, turning, and stopping. Dorsomedial striatal neurons are most active when the rat is deciding which way to turn, but this activity declines over time as the rat masters the task. Image: Catherine Thorn/MIT

Driving to and from work is a habit for most commuters - we do it without really thinking. But before our commutes became routine, we had to learn our way through trial-and-error exploration. A new study out of MIT has found that there are two brain circuits involved with this kind of learning and that the patterns of activity in these circuits evolve as our behaviors become more habitual.

The researchers focused on the basal ganglia, brain structures that are

best known for their role in movement control, but which are also involved in emotion, cognition and reward-based learning.

These different functions are thought to reside in different parts of basal ganglia. The dorsolateral part of the striatum (the input side of the basal ganglia) controls movement and is connected to the sensorimotor cortex, while the dorsomedial striatum controls flexible behavior and is connected to higher areas known as association cortex. But it has not been clear how these distinct circuits contribute to the learning of new behaviors.

Now for first time, researchers at MIT have recorded the activity of these two circuits in rats as they learned to navigate a maze, and found that the circuits have distinct patterns of activity that evolve during the course of learning.

The team led by Ann Graybiel, a MIT Institute Professor and member of the McGovern Institute for Brain Research, recorded the activity of thousands of neurons in the striatum as rats learned to find a cache of chocolate sprinkles at the end of a maze. As they approached a T-junction in the maze, the rats had to decide whether to turn right or left. The correct direction was indicated by a sound or a touch cue, the meaning of which the rats had to discover through trial-and-error. And just like human commuters, the rats performed this over and over again until the correct choice became routine.

As the rats' performance improved with repetition, the two different striatal circuits showed distinct patterns of activity. The dorsolateral striatal neurons were most active at the specific action points within the maze (start, stop, turn etc) and this pattern became steadily stronger with practice. The dorsomedial neurons, by contrast, showed highest activity around the decision period -- when the rat experienced the cue and had

to decide which way to turn. These neurons were also most active as the rats were learning, and their activity declined in later trials once the rats had mastered the task.

"We think the two basal ganglionic circuits must work in parallel," said Catherine Thorn, first author of the study. "We see what looks like competition between the two circuits until the learned behavior becomes ingrained as a habit."

"These brain circuits are affected in Parkinson's disease, substance abuse and many psychiatric disorders," says Graybiel. "If we can learn how to tilt the competition in one direction or the other, we might help bring new focus to existing therapies, and possibly aid in the development of new therapies." But in terms of every day life, Graybiel adds, "it is good to know that we can train our brains to develop good habits and avoid bad ones."

More information: "Differential dynamics of activity changes in dorsolateral and dorsomedial striatal loops during learning." Thorn CA, Atallah H, Howe M, Graybiel AM. Neuron. 10 June 2010.

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