Researchers Find Where Brain Learns to Make Decisions

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Researchers at The Johns Hopkins University have pinpointed a circuit in the brain responsible for encoding decision-making behavior, a circuit that — if damaged — appears to prevent a person from altering that behavior when circumstances change.

The discovery promises to enhance understanding of why some brain-damaged people have learning issues, an insight that could eventually lead to the development of more effective treatments for those with brain injury and trauma.

"There's a gap between current neurological treatment, which is typically focused on treating symptoms, and neuroscientific research, which is elucidating how the brain works," said Michael Saddoris, a graduate student in the Department of Psychological and Brain Sciences at Johns Hopkins' Krieger School of Arts and Sciences and a co-author of a paper on the topic that appeared in a recent issue of the journal Neuron. "Our work attempts to bridge that gap by providing a mechanism for how the brain operates both under damaged and normal conditions, which could provide a framework for future treatments."

The circuit in question is located in a region of the brain called the orbital frontal cortex, located right behind the eyes. It encodes the visual and other cues that people and animals use when making decisions about behavior or during the learning process, said co-author Michela Gallagher, a professor of psychological and brain sciences.

"People with lesions in this part of the brain — from strokes or other injury — seem to learn in a normal way, but are then unable to adapt their behavior when new situations arise, which is perplexing to us," Saddoris said. "Though we still don't know precisely what it is about damage to that area of the brain that causes this, we now know where it is happening, which is an important first step"

The researchers used laboratory rats to delve into how the OFC might encode information about decision-making, as well as to examine how other parts of the brain are affected when the OFC is damaged.

Electrodes were planted into the region of the rats' brains that are involved with decision-making and communicate with the OFC. Half the rats' OFC regions were damaged on one side of their brains. The rats — both those with damaged and undamaged OFC regions — then were given a task. They had to learn which odor led to a sugar reward and which led to a bitter and unpleasant outcome: a salty treat.

"The task we gave the rats was similar to what a human being would experience if he was buying a soda at a machine in a foreign country," Saddoris said. "Pushing one button resulted in a strange-tasting salty soda, while another resulted in a pleasant, sugary soda. After a few trials and errors, the person would likely learn to push the button that got him the sugary soda." Through the electrodes, the research team was looking for whether neurons fired more often in the presence of one odor cue or another — the firing being a signal that the rodent was thinking about one outcome or another, Saddoris said.

"In the animals with lesions on their OFCs, the firing activity developed much more slowly than it did in the normal animals, suggesting that the OFC is critical in helping animals learn to form associations quickly," he said.

The researchers then challenged the rats' ability to adapt and learn by reversing the cues, so that the odor that formerly had led to a sweet treat now resulted in a bitter tidbit and vice versa. Continuing the soda machine analogy, Saddoris said: "The person comes back and the button he always pushed to get his favorite soda caused a bitter, salty soda to come out. He'd then have to change his strategy and figure out, all over again, how to get the soda he wanted."

The researchers wanted to observe whether the rats with and without damage to their OFC region were able to track to the new outcome — a Pine Sol scent now led to a desired sweet treat, for instance — and whether the neuron firing was similarly affected, signaling its impact on the decision-making process.

They found that the neural responses of the OFC- damaged rats remained "locked in;" that is, the damaged rats' brains were unable to adjust to the switch in clues.

"It was as if everything was very slowed down for the damaged rats, as if the neural system for their decision- making was moving at a fraction of its normal pace," Saddoris said. "It seems that OFC-lesioned animals are at the mercy of old, irrelevant information with which to make decisions. This is likely the reason people with damage to that area of their brains persist in behaving in certain ways, even when it is obvious that is it not in their best interest to do so."

According to Saddoris, these findings demonstrate that the brain is fundamentally altered by damage to the OFC.

"It helps explain why people with damage to the OFC behave the way they do," he said. "They have the ability to learn normally about their world, but they have an area of their brains that is sluggish and inflexible in guiding their behavior, trapping them in a prison of habit, so to speak.

These findings give us insight into how the brain is organized." The study was supported through grants from the National Institute on Aging, the National Institute on Drug Abuse, and the National Institute of Mental Health. Materials also were provided by Stephen Warrenburg at International Flavors and Fragrances.

The article, "Rapid Associative Encoding in Basolateral Amygdala," appeared in Volume 46, Issue 2 of the journal Neuron, published April 21, 2005.

Source: Johns Hopkins University