Medical Xpress

Study explains why mistakes slow us down, but not necessarily for the better

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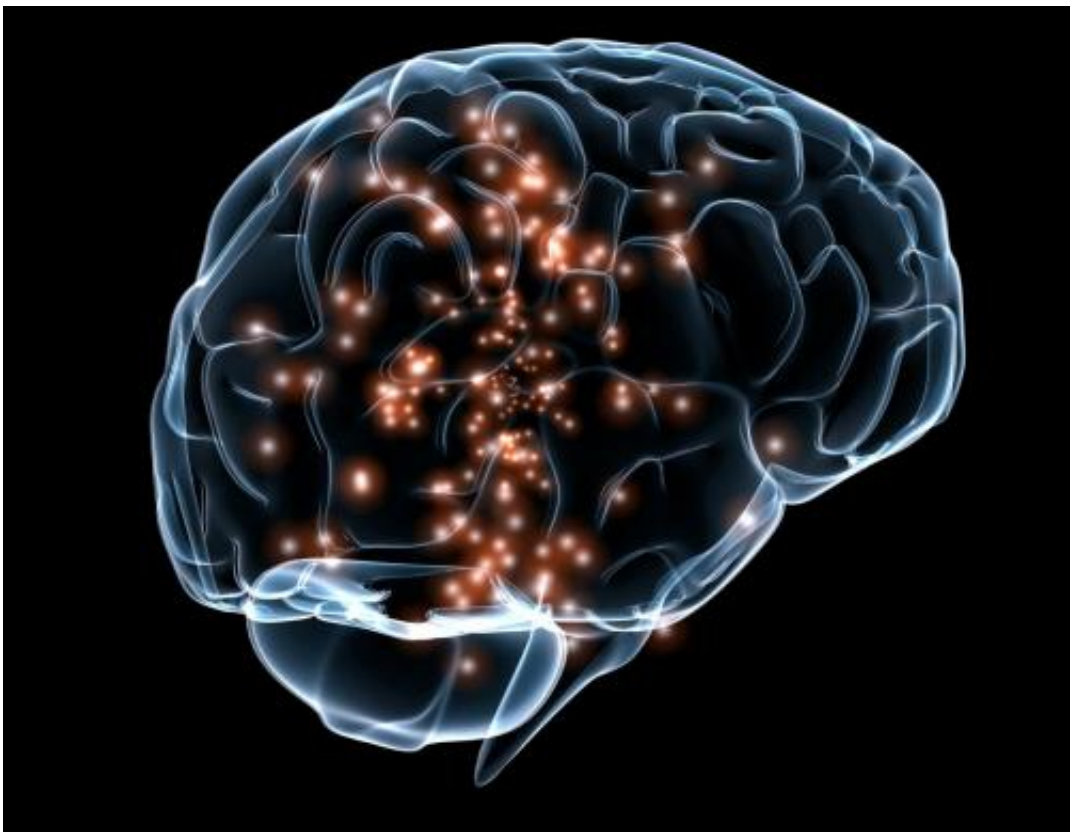

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Taking more time to make decisions after a mistake arises from a mixture of adaptive neural mechanisms that improve the accuracy and maladaptive mechanisms that reduce it, neuroscientists at New York University have found. Their study, which addresses a long-standing

debate on the value of deliberation after errors in decision-making, also potentially offer insights into afflictions that impair judgments, such as Alzheimer's Disease and Attention Deficit Hyperactivity Disorder (ADHD).

"Our research reveals that a combination of changes in the brain slow us down after mistakes," explains Braden Purcell, an NYU post-doctoral fellow and a co-author of the study, which appears in the journal *Neuron*. "One gathers more information for the decision to prevent repeating the same mistake again. A second change reduces the quality of evidence we obtain, which decreases the likelihood we will make an accurate choice."

"In the end, these two processes cancel each other out, meaning that the deliberative approach we take to avoid repeating a mistake neither enhances nor diminishes the likelihood we'll repeat it," adds Roozbeh Kiani, an assistant professor in NYU's Center for Neural Science and the study's other co-author.

It's been long established that humans often slow down after mistakes, a phenomenon called post-error slowing—or PES. Less clear, however, are the neurological processes that occur under PES.

The NYU researchers sought to address this question through a series of experiments involving monkeys and humans. Both watched a field of noisy moving dots on a computer screen and reported their decision about the net direction of motion with their gaze. The experimenters controlled the difficulty of each decision with the proportion of dots that moved together in a single direction—for instance, a large proportion of dots moving to the right provided very strong evidence for a rightward choice, but a small proportion provided only weak evidence.

Humans and monkeys showed strikingly similar behavior. After errors,

both slowed down the decision-making process, but the pattern of slowing depended on the difficulty of the decision. Slowing was maximum for more difficult decisions, suggesting longer accumulation of information. However, the overall accuracy of their choices did not change, indicating the quality of accumulated sensory information was lower.

Brain activity observed from the monkeys while they performed the task shed light on what was happening in the brain. Specifically, the researchers analyzed neural responses from a region of parietal cortex involved in accumulating information in their task. During decision making, these neurons represent evidence accumulation by increasing their activity over time at a rate that depends on the quality of evidence. Specifically, stronger motion leads to faster ramping and weaker motion leads to slower ramping.

After mistakes, the exact same motion stimulus produced neural activity that ramped more slowly—consistent with impaired quality of sensory evidence. Critically, however, the neurons showed significant increase in how much evidence was accumulated before a decision, preventing a reduction in the overall accuracy.

"Patients with ADHD or schizophrenia often do not slow down after errors and this has been interpreted as an impaired ability to monitor one's own behavior," explains Purcell. "Our results suggest that this absence of slowing may reflect much more fundamental changes in the underlying decision making brain networks. By better understanding the neural mechanisms at work after we make a mistake, we can begin to see how these afflictions impair this process."

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