Monkeys can play Monday morning quarterback too

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Yale researchers show that monkeys can make the same sort of "what if" mental notes that humans do, such as in this game of rock paper scissors. Credit: Courtesy of Yale University

Regret has long been viewed as an exclusively human thought, one which helps prevent us from repeating bad choices but becomes debilitating when it triggers obsessive thoughts about past actions.

Now a new study by Yale University researchers shows that monkeys also can be Monday morning quarterbacks and visualize alternative, hypothetical outcomes. The findings, reported in the May 26 issue of the journal *Neuron*, pinpoint areas of the brain where this process takes place and may give scientists new clues into how to treat diseases such as depression and schizophrenia.

"Regret serves us well most of the time, by helping us recognize choices that lead to bad outcomes," said Daeyeol Lee, professor of neurobiology at Yale School of Medicine and the Kavli Institute for Neuroscience and co-author of the study. "But sometimes regret can be very damaging."

Regret essentially is the ability to recognize that alternate courses of action could have led to more favorable outcome. For instance, someone who bought a home at the height of the housing market envisions a better outcome if she or he had rented a home or moved to a healthier market. We don't only learn by being rewarded or punished for specific actions, the way many psychologists once believed, Lee noted.

"Our brain is wired to run these hypothetical simulations all the time," Lee said. "If you try to learn only from the actual outcomes of your own experience, this represents only a tiny fraction of information you can get from your world."

Lee and co-author Hiroshi Abe, in the Department of Neurobiology, recorded neuronal activity in rhesus monkeys as they played a modified game of rock-paper-scissors, receiving large juice rewards for winning games, smaller rewards for tying and nothing for losing. Monkeys were more likely in the subsequent round to pick the winning symbol in the previous game – for instance selecting paper if a rock smashed scissors. In other words, they were able to imagine a different outcome.

The Yale team also found that neural activity in the brain area known as the prefrontal cortex reflects both rational and emotional aspects of regret. One of its subdivisions is the dorsolateral prefrontal cortex, an area previously implicated for other complex cognitive functions, such as working memory, and the neurons in this area signal what action would have led to a better outcome. By contrast, the orbitofrontal cortex, another region in the prefrontal cortex, focuses more on the emotional aspects of regret. Knowing the neural home of regret may help

researchers find drugs to treat mental illnesses in which patients obsess over past decisions that have led to poor outcomes, Lee said. He also notes that hallucination common in the patients of schizophrenia – sometimes losing the ability to discriminate the sources of voices – may be caused by the loss of ability to learn from both actual and hypothetical outcomes simultaneously.

Provided by Yale University