It's not solitaire: Brain activity differs when one plays against others

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Rock, paper or scissors? Learning while playing a strategic game against others involves a different pattern of brain activity than learning from the consequences of one's own actions, researchers found. Credit: L. Brian Stauffer

Researchers have found a way to study how our brains assess the behavior – and likely future actions – of others during competitive social interactions. Their study, described in a paper in the *Proceedings of the National Academy of Sciences*, is the first to use a computational approach to tease out differing patterns of brain activity during these interactions, the researchers report.

"When players compete against each other in a game, they try to make a mental model of the other person's intentions, what they're going to do and how they're going to play, so they can play strategically against them," said University of Illinois postdoctoral researcher Kyle Mathewson, who conducted the study as a doctoral student in the Beckman Institute with graduate student Lusha Zhu and economics professor and Beckman affiliate Ming Hsu, who now is at the University of California, Berkeley. "We were interested in how this process happens in the brain."

Previous studies have tended to consider only how one learns from the consequences of one's own actions, called reinforcement learning, Mathewson said. These studies have found heightened activity in the basal ganglia, a set of brain structures known to be involved in the control of muscle movements, goals and learning. Many of these structures signal via the neurotransmitter dopamine.

"That's been pretty well studied and it's been figured out that dopamine seems to carry the signal for learning about the outcome of our own actions," Mathewson said. "But how we learn from the actions of other people wasn't very well characterized."

Researchers call this type of learning "belief learning."

To better understand how the brain processes information in a competitive setting, the researchers used functional magnetic resonance imaging (fMRI) to track activity in the brains of participants while they played a competitive game, called a Patent Race, against other players. The goal of the game was to invest more than one's opponent in each round to win a prize (a patent worth considerably more than the amount wagered), while minimizing one's own losses (the amount wagered in each trial was lost). The fMRI tracked activity at the moment the player learned the outcome of the trial and how much his or her opponent had wagered.

A computational model evaluated the players' strategies and the outcomes of the trials to map the brain regions involved in each type of learning.

"Both types of learning were tracked by activity in the ventral striatum, which is part of the basal ganglia," Mathewson said. "That's traditionally known to be involved in reinforcement learning, so we were a little bit surprised to see that belief learning also was represented in that area."

Belief learning also spurred activity in the rostral anterior cingulate, a structure deep in the front of the brain. This region is known to be involved in error processing, regret and "learning with a more social and emotional flavor," Mathewson said.

The findings offer new insight into the workings of the brain as it is engaged in strategic thinking, Hsu said, and may aid the understanding of neuropsychiatric illnesses that undermine those processes.

"There are a number of mental disorders that affect the brain circuits implicated in our study," Hsu said. "These include schizophrenia, depression and Parkinson's disease. They all affect these dopaminergic regions in the frontal and striatal brain areas. So to the degree that we can better understand these ubiquitous social functions in strategic settings, it may help us understand how to characterize and, eventually, treat the social deficits that are symptoms of these diseases."

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