Your genes affect your betting behavior

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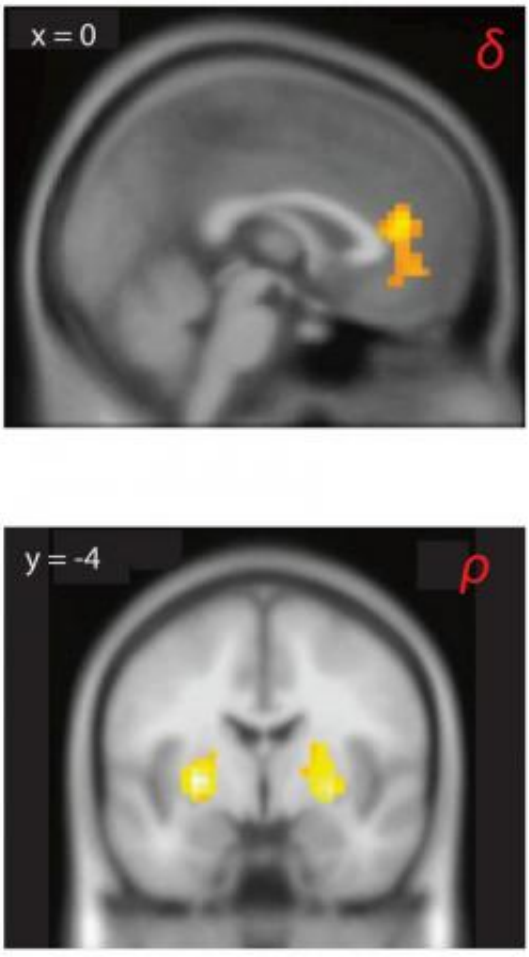

Brain scans show high activity in the medial prefrontal cortex (top) and striatum (bottom) while playing a competitive game. UC Berkeley and UIUC researchers have now found genetic variations in dopamine-regulating genes in the prefrontal cortex and striatum associated with differences in belief learning and reinforcement learning, respectively. Credit: Ming Hsu, UC Berkeley

Investors and gamblers take note: your betting decisions and strategy are determined, in part, by your genes. University of California, Berkeley, and University of Illinois at Urbana-Champaign (UIUC) researchers have shown that betting decisions in a simple competitive game are influenced by the specific variants of dopamine-regulating genes in a person's brain.

Dopamine is a neurotransmitter – a chemical released by brain cells to signal other brain cells – that is a key part of the brain's reward and pleasure-seeking system. Dopamine deficiency leads to Parkinson's disease, while disruption of the dopamine network is linked to numerous psychiatric and neurodegenerative disorders, including schizophrenia, depression and dementia.

While previous studies have shown the important role of the neurotransmitter dopamine in social interactions, this is the first study tying these interactions to specific genes that govern dopamine functioning.

"This study shows that genes influence complex social behavior, in this case strategic behavior," said study leader Ming Hsu, an assistant professor of marketing in UC Berkeley's Haas School of Business and a member of the Helen Wills Neuroscience Institute. "We now have some clues about the neural mechanisms through which our genes affect behavior."

The implications for business are potentially vast but unclear, Hsu said, though one possibility is training workforces to be more strategic. But the findings could significantly affect our understanding of diseases involving dopamine, such as schizophrenia, as well as disorders of social interaction, such as autism.

"When people talk about dopamine dysfunction, schizophrenia is one of

the first diseases that come to mind," Hsu said, noting that the disease involves a very complex pattern of social and decision making deficits. "To the degree that we can better understand ubiquitous social interactions in strategic settings, it may help us understand how to characterize and eventually treat the social deficits that are symptoms of diseases like schizophrenia."

Hsu, UIUC graduate student Eric Set and their colleagues, including Richard P. Ebstein and Soo Hong Chew from the National University of Singapore, will publish their findings the week of June 16 in the online early edition of the *Proceedings of the National Academy of Sciences*.

Two brain areas involved in competition

Hsu established two years ago that when people engage in competitive social interactions, such as betting games, they primarily call upon two areas of the brain: the medial prefrontal cortex, which is the executive part of the brain, and the striatum, which deals with motivation and is crucial for learning to acquire rewards. Functional magnetic resonance imaging (fMRI) scans showed that people playing these games displayed intense activity in these areas.

"If you think of the brain as a computing machine, these are areas that take inputs, crank them through an algorithm, and translate them into behavioral outputs," Hsu said. "What is really interesting about these areas is that both are innervated by neurons that use dopamine."

Hsu and Set of UIUC's Department of Economics wanted to determine which genes involved in regulating dopamine concentrations in these brain areas were associated with strategic thinking, so they enlisted as subjects a group of 217 undergraduates at the National University of Singapore, all of whom had had their genomes scanned for some 700,000 genetic variants. The researchers focused on only 143 variants

within 12 genes involved in regulating dopamine. Some of the 12 are primarily involved in regulating dopamine in the prefrontal cortex, while others primarily regulate dopamine in the striatum.

The competition was a game called patent race, commonly used by social scientists to study social interactions. It involves one person betting, via computer, with an anonymous opponent.

"We know from brain imaging studies that when people compete against one another, they actually engage in two distinct types of learning processes," Set said, referring to Hsu's 2012 study. "One type involves learning purely from the consequences of your own actions, called reinforcement learning. The other is a bit more sophisticated, called belief learning, where people try to make a mental model of the other players, in order to anticipate and respond to their actions."

Trial-and-error learning vs belief learning

Using a mathematical model of brain function during competitive social interactions, Hsu and Set correlated performance in reinforcement learning and belief learning with different variants or mutations of the 12 dopamine-related genes, and discovered a distinct difference.

They found that differences in belief learning – the degree to which players were able to anticipate and respond to the actions of others, or to imagine what their competitor is thinking and respond strategically – was associated with variation in three genes which primarily affect dopamine functioning in the medial prefrontal cortex.

In contrast, differences in trial-and-error reinforcement learning – how quickly they forget past experiences and how quickly they change strategy – was associated with variation in two genes that primarily affect striatal dopamine.

Hsu said that the findings correlate well with previous brain studies showing that the prefrontal cortex is involved in belief learning, while the striatum is involved in reinforcement learning.

"We were surprised by the degree of overlap, but it hints at the power of studying the neural and genetic levels under a single mathematical framework, which is only beginning in this area," he said.

Hsu is currently collaborating with other scientists to correlate career achievements in older adults with genes and performance on competitive games, to see which brain regions and types of learning are most important for different kinds of success in life.

More information: Dissociable contribution of prefrontal and striatal dopaminergic genes to learning in economic games, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1316259111

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