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Genes May Hold Keys to How Humans Learn

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New research is giving scientists fresh insights into how genetics are a prime factor in how we learn.

Michael Frank, an assistant professor of psychology and director of the Laboratory for Neural Computation and Cognition at The University of Arizona, headed a team whose results are reported in the Oct. 1 issue of Early Edition, a Web site hosted by the *Proceedings of the National Academy of Sciences.*

Frank and his colleagues found links to learning behaviors in three separate genes associated with dopamine. Dopamine is a neurotransmitter, a chemical in the brain that is often associated with pleasure, learning and other behaviors. Several neurological disorders, such as Parkinson's disease, are also linked to abnormal levels of dopamine.

Frank's study points to fundamental genetic differences between "positive" and "negative" learners.

"All three genes affect brain dopamine functioning, but in different ways, and in different parts of the brain," Frank said. "The genes predicted people's ability to learn from both the positive and negative outcomes of their decisions."

Two of the genes – DARPP-32 and DRD2 – predicted learning about the average, long-term probability of rewards and punishments, not unlike your personal preference for why, for example, you might choose steak over salmon.

"When making these kinds of choices, you do not explicitly recall each individual positive and negative outcome of all of your previous such choices. Instead, you often go with your gut, which may involve a more implicit representation of the probability of rewarding outcomes based on past experience," Frank said.

The DARPP-32 and DRD2 genes control dopamine function in a region of the brain called the striatum, thought to be necessary for this kind of implicit reward learning. A third gene, COMT, did not predict long-term reward or punishment learning, but instead predicted a person's tendencies to change choice strategies after a single instance of negative feedback. Frank said this gene affects dopamine function in the prefrontal cortex of the brain, the area associated with conscious processing and working memory. This would be akin to switching from steak to salmon upon remembering your last experience with overdone steak.

The overall research program was designed to test a computer model that simulates the key roles of dopamine in reinforcement learning in different parts of the brain, as motivated by a body of biological research.

"The reason we looked at these three individual genes in the first place, out of a huge number of possible genes, is that we have a computer model that examines how dopamine mediates these kinds of reinforcement processes in the striatum and prefrontal cortex," Frank said. "The model makes specific predictions on how subtle changes in different aspects of dopamine function can affect behavior, and one way to get at this question is to test individual genes."

Among the evidence incorporated in the model and motivating the genetic study is research showing that bursts of dopamine production follow in the wake of unexpected rewards. Conversely, dopamine production declines when rewards are expected but not received.

To test their hypothesis, the researchers collected DNA from 69 healthy people who were asked to perform a computerized learning program. The volunteers were asked to pick one of two Japanese characters that appeared on a screen and were "rewarded" for a "correct" response, and "punished" for an "incorrect" one.

Frank said more research is needed to confirm that genetic effects are accompanied by brain-related changes in behavior. But, he said, the research offers insights into the genetic basis for learning differences and insights into improving human cognition and learning, both normal and abnormal.

"Understanding how dopaminergic variations affects learning and decision-making processes may have substantial implications for patient populations, such as (those with) Parkinson's disease, attention-deficit hyperactivity disorder and schizophrenia," Frank said. "The genetics might also help us identify individuals who might gain from different types of learning environments in the classroom."

Source: University of Arizona

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