

'Might have been' key in evaluating behavior

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"What might have been" or fictive learning affects the brain and plays an important role in the choices individuals make – and may play a role in addiction, said Baylor College of Medicine researchers and others in a report that appears online today in the *Proceedings of the National Academy of Sciences*.

These "fictive learning" experiences, governed by what might have happened under different circumstances, "often dominate the evaluation of the choices we make now and will make in the future," said Dr. P. Read Montague, Jr., professor of neuroscience at BCM and director of the BCM Human Neuroimaging Laboratory and the newly formed Computational Psychiatry Unit. "These fictive signals are essential in a person's ability to assess the quality of his or her actions above and beyond simple experiences that have occurred in the immediately proximal time."

Using techniques honed in previous experiments that studied trust, Montague and his colleagues used an investment game to test the effects of these "what if" thoughts on decisions in 54 subjects. Using functional magnetic resonance imaging (fMRI) to measure blood flow changes in specific areas of the brain, they precisely measured responses to economic instincts.

These blood flow changes in the brain reflect alterations in the activity of nerve cells in the vicinity. In this case, they measured the brain's response to "what could have been acquired" and "what was acquired." This newly discovered "fictive learning" signal was measured, localized

and precisely parsed from the brain's standard reward signal that reflects actual experience.

Each subject took part in a sequential gambling task. The player makes a new investment allocation (a bet) and then receives a "snippet" of information about the market – either the market went up and the investment was a good one or the market goes down and the play had a loss. Each subject received \$100 and played 10 markets, making 20 decisions about each.

Montague and his associates found that fictive learning – the "what might have happened" – affected the brains of the subjects and played an important role in their decisions about the game. This effect manifested as a distinct selective activation signal in a part of the brain called the ventral caudate nucleus. The emotion of regret for a path chosen or not taken can be strongly influential on future decision-making. The fictive learning signal discovered by Montague and the team of researchers does not necessarily manifest as such a conscious "feeling" but contributes to the brain's computation and planning operations in a robust way that is now available to rigorous experimental analysis in health and in diseases of the brain/mind.

"We used real world market data – the crash of 1929, the bubble of the late 1990s and so on – to probe each subject's brain response to fictive signals (what could have been) as they navigated their choices. This means we now have a kind of neural catalogue of how famous stock market episodes affect signals in the average human brain," said Montague.

He plans to use the findings from this study to explore the balance of choices between actual and fictive outcomes.

"These results provide a new tool for exploring issues related to

addiction," Montague said. "For example, why does a person choose using a drug even though he or she can imagine the bad consequences that can result" We now have a way to measure quantitatively the balance between reward-seeking (like seeking a drug) and the thoughts that could intervene."

"The brain has a well-defined system for pursuing actual rewards based on actual outcomes. The system is complex, but recent research has begun to dissect them in great detail. The importance of that work is that the reward guidance signals are exactly those hijacked by drugs of abuse," said Dr. Terry Lohrenz, an instructor in the neuroimaging laboratory at BCM and the report's first author. "Identifying real neural signals to fictive outcomes now positions us to understand how our more abstract thoughts – the way we contextualize or frame our experience – guide our behavior."

Source: Baylor College of Medicine

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