Study suggests that belief is as important as biochemistry in addiction

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(Medical Xpress)—Are there more than biophysical factors at play in addiction? A new study by Xiaosi Gu and Terry Lohrenz from Virginia Tech Carilion Research Institute in Roanoke shows that cognitive beliefs play a significant role in a person's neurological response to an addictive substance and that belief can diminish the neurological effects of an addictive drug. Their research is reported in The *Proceedings of the*

National Academy of Sciences.

While addictive substances target certain neurological pathways, addiction seems to be more than a mere biochemical response to a drug. Different people respond to addictive substances in different ways, indicating that there must be other mechanisms to account for these differences.

Addiction is a complex phenomenon because, while addictive substances all target the mesolimbic dopaminergic pathway, some people seem to have a stronger neurological response to addictive substances than others. Furthermore, addiction appears to be more complex in humans than rodents. Rodents respond with less interest in the addictive substance when their dopaminergic pathway is suppressed, while humans tend to have mixed results with biochemical suppression, indicating that both cognitive and biochemical factors are likely at play in addictive behavior.

Gu and Lohrenz tested the impact of subject beliefs regarding an addictive substance by investigating computational and neural learning signals using computational modeling and model-based functional magnetic resonance imaging (fMRI) in 24 chronic smokers in a within-subject balanced placebo experiment.

The test subjects were given a cigarette either with or without nicotine. Half of the subjects were told that the cigarettes contained nicotine even though some did not; the other subjects were told that the cigarettes did not have nicotine even though some did. Subjects were tested on four separate occasions. Each smoked a cigarette immediately before an fMRI session. Each time, the test subjects were given a sequential market task based on a quantitative model that tests both non-choice dependent behavior and choice-dependent behavior. The task involved betting, and then experiencing a change in the market price to obtain a

gain or loss.

Gu and Lohrenz's team found that when test subjects believed that there was no nicotine in the cigarette, the neurological response to choice behavior questions was similar to those who did have nicotine. Those who knew that they smoked a nicotine-containing cigarette had a different neurological response. In other words, the belief that they were not smoking nicotine diminished the neurological effects of nicotine. Additional tests showed that subjects who believed they had ingested nicotine demonstrated different reward prediction signals whether the person had smoked a nicotine-containing cigarette or not.

In order to see whether this effect was specific to learning pathways, Gu and Lohrenz's team investigated whether cognitive belief affected visual attention signals. They found no significant changes in visual attention signals whether or not a subject was told that they were smoking nicotine, thus confirming that the effects are specific to value signal and reward prediction error signal, or to the learning pathways.

This study provides quantitative evidence that belief in nicotine's efficacy plays a much larger role in its effects on neurological systems than was previously thought and supplements prior studies with alcohol and cocaine addiction. This evidence implies that our understanding and treatment of addiction may need to be modified to account for the effects of cognitive belief.

While activating the mesolimbic dopaminergic pathway plays a role in physical dependence, it cannot be the only cause of addiction. The authors conclude that "cognitive beliefs could be as potent as pharmacological interventions in terms of modifying biophysical processes in the brain and changing behavior in addicted individuals." They contend that manipulating a person's beliefs about an addictive substance may be one avenue for treating addiction .

More information: Belief about nicotine selectively modulates value and reward prediction error signals in smokers, Xiaosi Gu, *PNAS*, DOI: 10.1073/pnas.1416639112

Abstract

Little is known about how prior beliefs impact biophysically described processes in the presence of neuroactive drugs, which presents a profound challenge to the understanding of the mechanisms and treatments of addiction. We engineered smokers' prior beliefs about the presence of nicotine in a cigarette smoked before a functional magnetic resonance imaging session where subjects carried out a sequential choice task. Using a model-based approach, we show that smokers' beliefs about nicotine specifically modulated learning signals (value and reward prediction error) defined by a computational model of mesolimbic dopamine systems. Belief of "no nicotine in cigarette" (compared with "nicotine in cigarette") strongly diminished neural responses in the striatum to value and reward prediction errors and reduced the impact of both on smokers' choices. These effects of belief could not be explained by global changes in visual attention and were specific to value and reward prediction errors. Thus, by modulating the expression of computationally explicit signals important for valuation and choice, beliefs can override the physical presence of a potent neuroactive compound like nicotine. These selective effects of belief demonstrate that belief can modulate model-based parameters important for learning. The implications of these findings may be far ranging because belief-dependent effects on learning signals could impact a host of other behaviors in addiction as well as in other mental health problems.

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