Sugar can be addictive, scientist says

December 10 2008

A Princeton University scientist will present new evidence today demonstrating that sugar can be an addictive substance, wielding its power over the brains of lab animals in a manner similar to many drugs of abuse.

Professor Bart Hoebel and his team in the Department of Psychology and the Princeton Neuroscience Institute have been studying signs of sugar addiction in rats for years. Until now, the rats under study have met two of the three elements of addiction. They have demonstrated a behavioral pattern of increased intake and then showed signs of withdrawal. His current experiments captured craving and relapse to complete the picture.

"If bingeing on sugar is really a form of addiction, there should be long-lasting effects in the brains of sugar addicts," Hoebel said. "Craving and relapse are critical components of addiction, and we have been able to demonstrate these behaviors in sugar-bingeing rats in a number of ways."

At the annual meeting of the American College of Neuropsychopharmacology in Scottsdale, Ariz., Hoebel will report on profound behavioral changes in rats that, through experimental conditions, have been trained to become dependent on high doses of sugar.

"We have the first set of comprehensive studies showing the strong suggestion of sugar addiction in rats and a mechanism that might underlie it," Hoebel said. The findings eventually could have

implications for the treatment of humans with eating disorders, he said.

Lab animals, in Hoebel's experiments, that were denied sugar for a prolonged period after learning to binge worked harder to get it when it was reintroduced to them. They consumed more sugar than they ever had before, suggesting craving and relapse behavior. Their motivation for sugar had grown. "In this case, abstinence makes the heart grow fonder," Hoebel said.

The rats drank more alcohol than normal after their sugar supply was cut off, showing that the bingeing behavior had forged changes in brain function. These functions served as "gateways" to other paths of destructive behavior, such as increased alcohol intake. And, after receiving a dose of amphetamine normally so minimal it has no effect, they became significantly hyperactive. The increased sensitivity to the psychostimulant is a long-lasting brain effect that can be a component of addiction, Hoebel said.

The data to be presented by Hoebel is contained in a research paper that has been submitted to The Journal of Nutrition. Visiting researchers Nicole Avena, who earned her Ph.D. from Princeton in 2006, and Pedro Rada from the University of Los Andes in Venezuela wrote the paper with Hoebel.

Hoebel has been interested in the brain mechanisms that control appetite and body weight since he was an undergraduate at Harvard University studying with the renowned behaviorist B.F. Skinner. On the Princeton faculty since 1963, he has pioneered studies into the mental rewards of eating. Over the past decade, Hoebel has led work that has now completed an animal model of sugar addiction.

Hoebel has shown that rats eating large amounts of sugar when hungry, a phenomenon he describes as sugar-bingeing, undergo neurochemical

changes in the brain that appear to mimic those produced by substances of abuse, including cocaine, morphine and nicotine. Sugar induces behavioral changes, too. "In certain models, sugar-bingeing causes long-lasting effects in the brain and increases the inclination to take other drugs of abuse, such as alcohol," Hoebel said.

Hoebel and his team also have found that a chemical known as dopamine is released in a region of the brain known as the nucleus accumbens when hungry rats drink a sugar solution. This chemical signal is thought to trigger motivation and, eventually with repetition, addiction.

The researchers conducted the studies by restricting rats of their food while the rats slept and for four hours after waking. "It's a little bit like missing breakfast," Hoebel said. "As a result, they quickly eat some chow and drink a lot of sugar water." And, he added, "That's what is called binge eating -- when you eat a lot all at once -- in this case they are bingeing on a 10 percent sucrose solution, which is like a soft drink."

Hungry rats that binge on sugar provoke a surge of dopamine in their brains. After a month, the structure of the brains of these rats adapts to increased dopamine levels, showing fewer of a certain type of dopamine receptor than they used to have and more opioid receptors. These dopamine and opioid systems are involved in motivation and reward, systems that control wanting and liking something. Similar changes also are seen in the brains of rats on cocaine and heroin.

In experiments, the researchers have been able to induce signs of withdrawal in the lab animals by taking away their sugar supply. The rats' brain levels of dopamine dropped and, as a result, they exhibited anxiety as a sign of withdrawal. The rats' teeth chattered, and the creatures were unwilling to venture forth into the open arm of their maze, preferring to stay in a tunnel area. Normally rats like to explore their environment, but the rats in sugar withdrawal were too anxious to

explore.

The findings are exciting, Hoebel said, but more research is needed to understand the implications for people. The most obvious application for humans would be in the field of eating disorders.

"It seems possible that the brain adaptations and behavioral signs seen in rats may occur in some individuals with binge-eating disorder or bulimia," Hoebel said. "Our work provides links between the traditionally defined substance-use disorders, such as drug addiction, and the development of abnormal desires for natural substances. This knowledge might help us to devise new ways of diagnosing and treating addictions in people."

Source: Princeton University