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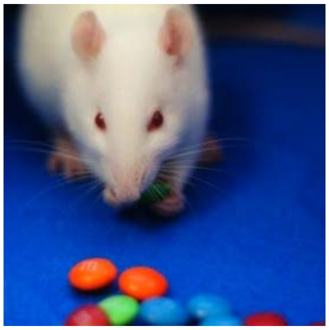
Simply Irresistible: Scientists Trace Gluttony's Path in the Brain

By Daisy Yuhas


"Enkephalin surges in dorsal neostriatum as a signal to eat."

How much is too much chocolate? Desperately devouring 5 percent of one's body weight might sound extreme, but scientists tinkering with the brain chemistry of rodents have found it's certainly possible.

Scientists at the University of Michigan (U.M.) have identified how a brain region plays a role in our pursuit of sweet temptations. As they describe in the September 20 issue of *Current Biology*, a surge of chemical compounds resembling opium in this area can trigger the impulse to gorge on a treat without restraint.

The region in question is the neostriatum. In humans this area is split into two parts, behind the eyes and below the folds of the cortex near the front of the head. It's just above the brain's well-studied reward circuitry, which includes the ventral striatum and nucleus accumbens. Traditionally, the neostriatum has been studied in movement and habitual motor behaviors. Although no previous research had found a clear causal link between the region and motivation to eat, some human studies with functional magnetic resonance imaging have suggested that the neostriatum is active when an overweight subject looks at food or an addict views a drug of choice.

To investigate the brain region further, the researchers studied changes in the neostriatum chemistry of lab rats when at rest, hungry, offered food, feeding and after eating. The proffered food was chocolate, specifically M&Ms. Author and biopsychologist Alexandra DiFeliceantonio at U.M. says, "Chocolate offers sweetness and fattiness—the perfect storm of a stimulus to get the effect we wanted."

Using a catheter, the researchers sampled fluid from the neostriatum during these stages to discern neurotransmitter activity. They observed a pronounced spike in one neurotransmitter in particular—enkephalin—when rats began feeding. Enkephalin, like the neurotransmitter endorphin, is an opioid that sends out pleasurable signals. The scientists observed that the stronger the enkephalin rise, the faster the rats raced to eat M&Ms.

Eventually—after having wolfed down about 10 M&Ms each in 20 minutes—normal rats became sated and ceased eating. With this change, the enkephalin rush abated while other circuitry presumably kicked in to tell the brain to stop the compulsion.

In the hopes of finding a directional link between the neostriatum's opioid receptors and feasting, the researchers injected an artificial opioid straight into the neostriatum. When they proffered the rats M&Ms, a feeding frenzy began again, but this time most of the animals gobbled more than 17 of the candies each. Given their slight sizes, this is comparable to a 68-kilogram human eating three kilograms of chocolate within an hour.

The ravenous episode was so intense that the rats showed no signs of stopping and had to be forcibly removed from the feast. In addition, opioid-injected rats gobbled chocolate faster, as though the drugged subjects were more desperate to begin with. Opioid injections to neighboring brain regions, or injections with other chemicals, produced a much weaker response. This led the researchers to believe that the neostriatum's opioid receptors activate an intense motivational system, driving the rats to pursue rewards.

In a final test, the researchers decided to evaluate whether the neostriatum's neurotransmitter spike actually enhanced the way rats were attracted to their food—somehow magnifying the experience of a rich, chocolatey taste. To do this, they offered rats injected with or without the opioid a taste of chocolate or sweet oral infusion. They then measured how much a rat liked the taste by counting lip-licking, a common behavioral test of taste preference in babies and nonhuman primates. They found that the opioid-dosed rats did not appear particularly enthused about chocolate's sweet flavor—they did not lick their lips more when exposed to a sweet after the injection. The researchers concluded that their overindulgence was based purely on compulsion and not the candy's intensified deliciousness.

The finding suggests that flooding the neostriatum's receptors with opioids—natural or not—can drive extreme overeating. The region's proximity to the brain's pleasure network means the work can have implications for other enjoyable activities and vices. "These areas work together in concert and create these seas of wanting in the brain," DiFeliceantonio says.

"This study is adding another piece to the puzzle of how the reward system works," says neuroscientist Gary Wenk at The Ohio State University. Wenk, who was not involved in the study, explains that evolutionary reasons can help us understand why our brain pushes us to overeat: "We evolved so that when we found food, we would eat as much as we could." Not only would this ensure that we received necessary nutrients, it kept competitors from stealing our meals—we'd leave nothing for them to take. The brain helps by activating the opiate system as a euphoric reward, counteracting the discomfort of a swelling waist and encouraging us to have one more bite.