UC SANTA BARBARA
THE Current

April 23, 2020
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Not So Sweet

Have you ever noticed how a bite of warm cherry pie fills your mouth with sweetness, but that same slice right out of the refrigerator isn't nearly as tempting? Scientists know this phenomenon to be true, but the mechanism behind it has been poorly understood.

Now, using fruit flies as his subjects, UC Santa Barbara Distinguished Professor Craig Montell has discovered one process responsible for this occurrence. Montell's team, which includes Qiaoran Li, Nicolas DeBeaubien and Takaaki Sokabe, found that cool temperatures suppress the appeal of sweetness. However, these conditions did not affect the sugar neurons themselves. Rather, they acted via other sensory cells by way of a protein originally discovered to sense light in the eye. Despite this, the perception of coolness in sugary food is not altered by light. The results appear in the journal Current Biology.

"The appeal of food is influenced by more than just chemical composition," said Montell, the Duggan professor in the Department of Molecular, Cellular, and Developmental Biology. "We already know that cool temperatures reduce the delectability of sweetness in humans." He and his colleagues wondered whether this was also true in fruit flies, and if so, what were the underlying mechanisms?

The team found a significant difference in fruit flies' interest in feeding between 23 degrees Celsius (73.4° Fahrenheit) and 19° C (66.2° F). That said, they measured no difference in the activity of the flies' sweet-sensing taste neurons, despite the change in behavior.

“Since the temperature is not directly affecting the sugar neurons, it must be affecting some other types of cells, which then indirectly affect the propensity to consume sugar,” Montell noted.

Fruit flies detect sugar with one type of taste neuron. Bitter is sensed by another type of neuron, and mechanosensory neurons detect the texture of food, such as hardness. However, temperature sensation is not quite as simple. Both bitter and mechanosensory neurons are also involved in detecting coolness. Only if both are activated does the brain interpret that as a cool signal.

All of these stimuli seem to reduce the animal’s desire to feed, explained Montell. Bitter compounds trigger bitter neurons, which tell the fly to stop feeding. Hard foods trigger the mechanosensory neurons, which also tell the fly to stop feeding. And cool temperatures trigger both, to the same effect.

Critical to this response is a protein called rhodopsin 6. Rhodopsins are most commonly associated with vision, but over the past few years the Montell group has connected rhodopsins to a variety of other senses. Indeed, just a couple weeks prior, Montell’s lab published the first study connecting different members of this class of protein to chemical taste.

“The bitter neurons express this rhodopsin called Rh6, and if you get rid of it, then cool temperatures no longer suppress the appeal of sugar,” he said.

Without Rh6, the bitter-and-cool-detecting neurons are no longer turned on by low temperatures. And since cool-sensation requires activating multiple, different types of neurons, loss of Rh6 prevents the fly from recognizing the lower temperature, thereby eliminating the decreased attraction to sugary food.

“The surprise was finding that it was really the other neurons, not the sugar neurons, whose activity went up,” Montell said, “and that the cool activation of other neurons was indirectly suppressing the sugar neurons.”

The sweet-sensing neurons are still activated by sugars at low temperatures; however, the activation of these other neurons by decreased temperature suppresses the communication between the sweet-detecting neurons and the animal’s brain. This is likely achieved by an inhibitory neurotransmitter released by the bitter/cool-activated neurons.

As for why fruit flies avoid food when it’s chilly, Montell suspects it’s due to their metabolism. Fruit flies’ metabolism, and thus food requirements, are affected by temperature. Lower temperatures mean slower metabolisms, and less need for food. And generally, if the food is cold, so is the fly.

In fact, the fly generation time — the time it takes an egg to turn into an adult fly — doubles from 10 days to 20 when the temperature is lowered from 25 to 18 degrees Celsius. “Everything is just slowed down,” Montell said, “and that’s why feeding is reduced. You don’t want to eat the same amount when your metabolism is slowed down.” This explanation doesn’t hold true for warm-blooded animals like humans, even if we show a similar behavior.

In the future, Montell and first author Qiaoran Li plan to further investigate the mechanosensory side of food appeal by looking at how particle size influences feeding behavior. As an example, he offers the distinct difference between fresh and refrozen ice cream. Despite having the same chemical composition and temperature, most people prefer ice cream that hasn’t melted and refrozen into a block.

Reflecting on the surprising finding, Montell remarked, “It’s great for your expectations to be wrong, as long as you can then figure out what’s right.”

About UC Santa Barbara

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