Medical Xpress

Researchers identify brain center responsible for responses to rapid temperature change

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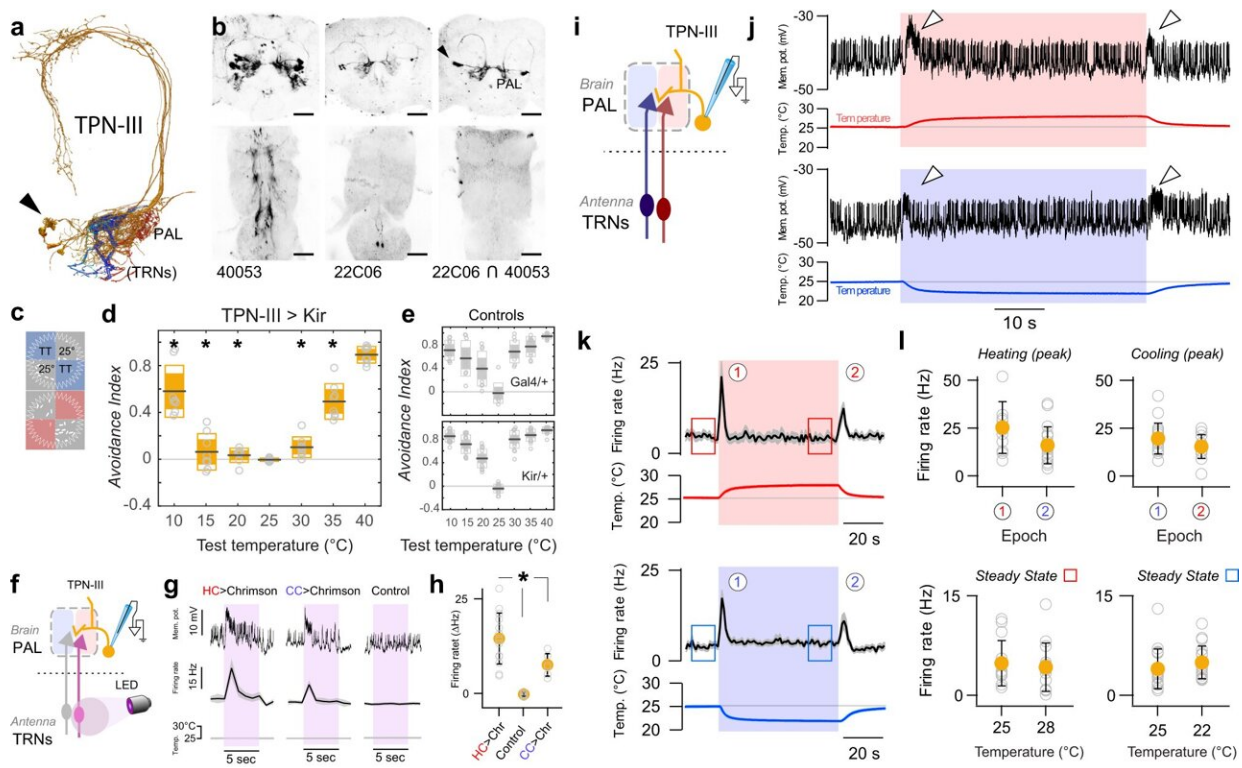

TPN-IIIs display ON responses to temperature change. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-42864-5

We've all heard it: Put a frog in boiling water, and it will jump out. But put the same frog in lukewarm water and heat it gradually, and you'll cook the frog. Often used as a metaphor for the unhurried and stubborn response many have to a slowly rising threat, the mechanisms underlying the urban myth have become a subject of scientific fascination.

This parable seems to have inspired new Northwestern University research, which identified a brain pathway responsible for rapid-threat detection.

"Animals are more likely to react to rapid rather than slow environmental change," said lead author Marco Gallio, associate professor of neurobiology in Northwestern's Weinberg College of Arts and Sciences. "In the present study, we identify a brain circuit in fruit flies that selectively responds to rapid thermal change, priming behavior for escape."

The study is published in the journal *Nature Communications*.

Gallio generally uses fruit flies to understand sensory circuits and the ways they create perceptions of the physical world. Using the fly as a model, the lab studies basic decision-making principles in an animal that has a fraction of the number of neurons (100,000) than humans have (roughly 100 billion). As a well-studied model organism for biological research, flies also are useful subjects because of the pre-existing tools to study fly neurons and behavior.

"There are often two types of responses to external stimuli in the brain: Some neurons respond to a stimulus like light or temperature with very persistent activity," Gallio said. "Other neurons fire just at the beginning, like when a light turns on, and then their activity is gone. We've always wondered what the significance of these short-lived responses is."

In visual stimuli, brains are wired to notice a large contrast between light and dark. Gallio said that the response intuitively also makes sense for the sense of touch: You don't think about pressure when your hand is resting on a surface. Run your hand over something new, however, and you will detect subtle changes in texture. Gallio's team wanted to see if the same was true for the sense of temperature.

To explore how flies respond to rapid change, the team used a high-resolution camera to observe flies navigating different temperature environments. When flies encounter a rapid heat front, they always produce a U-turn away from it.

The lab found flies always responded in cases of rapid temperature change, but not for slow change.

The team also identified a circuit in the fly brain that responds only to rapid temperature change (more than 0.2 degrees Celsius per second). Much like light-ON cells of the visual system, these neurons fired at the beginning of rapid heating and then went quiet.

"Our hypothesis was that these heat-ON responses may indeed correlate with the rate of temperature change," said Jenna Jouandet, the study's first author and a Ph.D. student in the Gallio Lab. "And therefore, may allow flies to anticipate dangerous thermal conditions and prepare to escape."

Indeed, when the researchers experimentally inactivated those neurons, the flies did not escape as promptly.

To better understand how the activity of these neurons may be important for the behavior of the fly, the researchers collaborated with William Kath, applied math professor at Northwestern and deputy director of the new National Institute for Theory and Mathematics in Biology.

Applied math Ph.D. student Richard Suhendra built a small computer model with two antennae and two wheels to demonstrate how adding a neuron that anticipates dangerous heat could improve the flexibility of the vehicle response. (Play with the model through a simple game on the Gallio Lab webpage.)

"The neurons that we initially discovered take input from the thermosensory neurons on the antennae and carry information to the higher brain," Gallio said. "Flies are a great model to map brain circuits in that we were able to reconstruct the full circuit from sensory neurons all the way down to the centers that produce movement."

Gallio explained that rapid changes are nearly always dangerous for a small fly.

"If the temperature is changing by half a degree per second—which is not that much—within 30 or 40 seconds, that fly could be dead," Gallio said. "This system is an alarm bell that rings to prime an animal's behavior for escape. We see the fly escape."

Gallio hypothesizes that the results are broadly generalizable, especially because he sees it play out in humans, whether someone is entering a room that's a different temperature or getting into a hot shower. He said these neurons seem to be able to sense something others do not—they seem to be able to anticipate the future.

More information: Genevieve C. Jouandet et al, Rapid threat assessment in the Drosophila thermosensory system, *Nature Communications* (2023). DOI: 10.1038/s41467-023-42864-5

Provided by Northwestern University