Fruit flies show surprising sophistication in locating food source

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To a fruit fly, a piece of rotting fruit or the food in your picnic basket is a little slice of heaven. It's where the tiny animal—not much more than a speck on your fingertip can find food and a mate, the two passions of its short, two-month lifespan.

But the odor plume of a food source can be very slight, subject to the vagaries of wind and other weather, in a world that looms large to this tiny bug. Yet the fly is uncanny in finding a meal. How? By using more than just its sense of smell.

Reporting in the current edition of the journal *Current Biology*, now online, UCLA researchers show that tiny Drosophila, with a brain smaller than a poppy seed, combines massive amounts of information from its sense of smell and vision, then transforms these sensory signals into stable and flexible flight behavior that leads them to a food source. Understanding the integration of these sensory cues could be relevant to developing smarter robotic drones.

"Essentially we show how vision allows flies to navigate odors," said Mark Frye, an assistant professor in the Department of Physiological Science, and a member of the UCLA Brain Research Institute. He is coauthor of the paper, along with Brian Duistermars, a Ph.D. candidate and member of Frye's lab.

The conundrum is this: fruit flies have 700 times lower visual spatial resolution than humans, and five times fewer olfactory receptor types.

Yet their ability to find smelly things in visual landscapes as diverse as forests, deserts, and backyard patios would suggest a behavioral performance greater than might be predicted by the sum of its sensory inputs.

Frye and Duistermars found that flies stay the odor course by combining sensory information. They designed a “virtual plume simulator” in which a fly is tethered, but free to steer into and out of a plume of vinegar odor (nectar to a fruit fly). At the same time, a cylinder around the fly displayed a variety of background images, meant to roughly mimic the images the flies might encounter in the real world—blades of grass, say, or twigs on a tree.

Normally in free flight, a fly’s path is characterized by segments of straight flight interspersed with transient “spikes” called saccades where they veer left and right.

On the cylinder, the researchers displayed a visual backdrop of equally spaced, high-contrast vertical stripes, and then periodically switched the vinegar plume between 0 and 180 degrees within the circular arena. Then they tracked the fly’s heading. Under these conditions, the animal periodically encounters the plume by steering into it. Upon plume contact, the fly performed fewer saccades, presumably because it is honing in and following the plume. Yet the saccades were not altogether absent, Frye notes, an apparent attempt on the fly’s part to “constantly seek the sweet spot—the strongest scent—of the plume.”

To examine the visual influence on odor-tracking accuracy, the researchers changed the visual backdrop. They alternated a sequence of three visual treatments including high-contrast stripes, uniform grayscale, and a second high-contrast treatment. Each fly started within the vinegar plume and was exposed to the three visual stimuli at 20 second intervals. When the striped and high-contrast panoramas appeared, the flies were able to maintain their heading into the plume. But when the flat, featureless grayscale was displayed, the flies steered out of the plume and began generating saccades. Even though they occasionally would reencounter the plume within the grayscale visual panorama, they were unable to remain there until the high-contrast pattern reappeared, at which point accurate plume tracking resumed.

Frye said this shows the flies are using the backdrop as physical markers to keep track, along with their olfactory sense, of where the plume is. Such “crossmodal integration” at the behavioral and cellular level, said Frye, represents a functional adaptation for distinguishing and responding to critically important features of a complex sensory environment.

Frye noted that a fruit fly’s brain only has approximately 200,000 neurons, compared to the billions of neurons in a human brain. “Yet a fruit fly casually outperforms the most sophisticated robots that humans can engineer,” he said. “The research in our lab seeks to understand the mechanisms with which a tiny nervous system controls the vastly complex biomechanics of flying. In doing so, we hope to advance our understanding of sensory neurobiology and also help to develop smarter robots.”

Source: University of California - Los Angeles

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