Flies process attractive and deterrent odors in different brain areas

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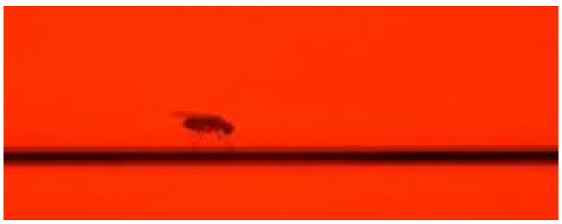
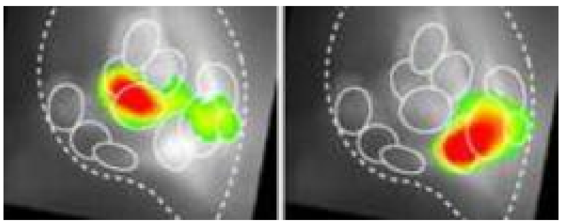


Drosophila fly in a glass tube of the "Flywalk" apparatus. Credit: Max Planck Institute for Chemical Ecology/Knaden

In collaboration with colleagues from Portugal and Spain, researchers at the Max Planck Institute for Chemical Ecology in Jena, Germany, have developed an apparatus that automatically applies odors to an airstream, while filming and analyzing the behavior of insects simultaneously. The system is called Flywalk and consists of glass tubes, airstream regulators, and a video camera. The reactions of 15 flies to up to eight different odorant signals can be tested at the same time. A first series of tests revealed that male and female fruit flies responded differently to attractant substances. The tests confirmed that male flies were no longer attracted to females that had already mated with another male because of the particular odor, cis-vaccenyl acetate, surrounding these females.

Flywalk can exactly measure the responses of insects to odor signals. If insects run upwind, i.e. against the direction of the airstream, the odor is rated as attractive; if they stop or run downwind, the odor is deterrent.

The system allows the use of not only single odorants but also odor mixtures. In addition, odor pulses of varying length and concentration can be given. The high throughput and the long automated measurement periods – the insects can stay in the Flywalk tubes for up to eight hours – facilitate the statistical analysis of the results.



This shows two views inside the brain of a fruit fly while it is smelling; left: active glomeruli (represented by bright colors) after stimulation with a deterrent odor (linalool); right: active glomeruli after application of an attractant (3-methylthio-1-propanol). This shows that deterrent responses are generated in lateral areas of the brain, whereas attractant responses are generated in medial areas. Credit: Max Planck Institute for Chemical Ecology/Strutz

Experiments with fruit flies demonstrated that females – in contrast to males – were more attracted by typical food odors, such as ethyl acetate. This behavior seems to reflect the search for the best oviposition place in order to make sure that the larval offspring will find sufficient food after hatching. The response to deterrent odors, such as benzaldehyde, was identical in both males and females. Males, on the other hand, responded positively to the odor of unmated females: If the odor surrounding virgin females was introduced into the Flywalk tubes, the males moved upwind. "This way, we demonstrated for the first time that females, as observed in other insect species, attract their mates with odors. The chemistry of these odorant substances is currently being analyzed," says Kathrin Steck, who carried out the experiments. The substance that renders mated females unattractive to males willing to mate is already known: cis-vaccenyl acetate. With this odor a male marks the female during copulation. Thus a male fruit fly prevents further fertilization by other males and makes sure that his genes are spread.

For a recently published study in Cell Reports, scientists scrutinized the tiny brains of fruit flies. Using specific activity markers, they measured certain nerve cells, the so-called projection neurons, which are located in the antennal lobe, the olfactory center of flies. Experiments performed with six highly attractive and six highly deterrent odors, selected out of 110 different and tested compounds, revealed that attractive and deterrent odors are processed in specific brain regions of the flies (see picture), as has already been shown in mice and humans. "The function of an insect brain thus resembles that of a mammalian brain more than previously thought," the researchers write. Because the activity of projection neurons already reflects a kind of "interpretation" of incoming odorant signals, the assessments "good" or "bad" which ultimately regulate the flies' behavior seem to be represented early in the insects' brains.

Activity measurements in the antennal lobes of Lepidopteran species Spodoptera littoralis (Egyptian cotton leafworm) and Spodoptera exigua (beet armyworm), dreaded agricultural pests, showed that neurons responded very specifically to individual plant odors. These results correspond to the feeding habits of these insects: Both moths infest more than 100 different plant genera, among them many crop plants, and must therefore be able to accurately associate an odor with a particular plant species. Because of their broad host range, these insects are known as host generalists. In comparison, three specialist species, namely *Acherontia atropos* (death's-head hawkmoth), *Smerinthus ocellata* (eyed hawkmoth), and *Manduca sexta* (tobacco hornworm), seem to have specialized in the recognition of only a few host plants: different odors often generated similar or even identical excitation patterns in the brains of the moths.

More information: Kathrin Steck, Daniel Veit, Ronald Grandy, Sergi Bermúdez i Badia, Zenon Mathews, Paul Verschure, Bill S. Hansson, Markus Knaden. A high-throughput behavioral paradigm for Drosophila olfaction - the Flywalk. Nature Scientific Reports 2, 361; doi: 10.1038/srep00361 (2012)

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