Neuroscientists now can read the mind of a fly

December 4 2015

Drosophila sp fly. Credit: Muhammad Mahdi Karim / Wikipedia. GNU Free Documentation License, Version 1.2

Northwestern University neuroscientists now can read the mind of a fly. They have developed a clever new tool that lights up active conversations between neurons during a behavior or sensory experience, such as smelling a banana. Mapping the pattern of individual neural connections could provide insights into the computational processes that underlie the workings of the human brain.

In a study focused on three of the fruit fly's sensory systems, the researchers used fluorescent molecules of different colors to tag neurons in the brain to see which connections were active during a sensory experience that happened hours earlier.

Synapses are points of communication where neurons exchange information. The fluorescent labeling technique is the first to allow scientists to identify individual synapses that are active during a complex behavior, such as avoiding heat. Better yet, the fluorescent signal persists for hours after the communication event, allowing researchers to study the brain's activity after the fact, under a microscope.

"Much of the brain's computation happens at the level of synapses, where neurons are talking to each other," said Marco Gallio, who led the study. "Our technique gives us a window of opportunity to see which synapses were engaged in communication during a particular behavior or sensory experience. It is a unique retrospective label."

Gallio is an assistant professor of neurobiology in Northwestern's Weinberg College of Arts and Sciences.

By reading the fluorescent signals, the researchers could tell if a fly had been in either heat or cold for 10 minutes an entire hour after the sensory event had happened, for example. They also could see that exposure to the scent of a banana activated neural connections in the olfactory system that were different from those activated when the fly smelled jasmine.

Details of the versatile technique, which could be used with other model systems for neuroscience study, will be published Dec. 4 in the journal *Nature Communications.*

Gallio and his team wanted to study the brain activity of a fruit fly while it performed a complex behavior, but this is not easily achieved under a microscope. The scientists figured out a different approach using genetic engineering. Starting with the gene for a green fluorescent protein found in jellyfish, the authors derived three different colored markers that light up at the point of contact between neurons that are active and talking to each other (the synapse). The fluorescent signals can be read one to three hours after the action is over.

"Different synapses are active during different behaviors, and we can see that in the same animal with our three distinct labels," said Gallio, the paper's corresponding author.

The fluorescent green, yellow and blue signals enabled the researchers to label different synapses activated by the sensory experience in different colors in the same animal. The fluorescent signals persisted and could later be viewed under a relatively simple microscope.

The researchers studied the fruit fly Drosophila melanogaster, a model animal for learning about the brain and its communication channels. They tested their newly engineered fluorescent molecules by applying them to the neural connections of the most prominent sensory systems in the fly: its sense of smell, sophisticated visual system and highly tuned thermosensory system.

They exposed the animals to different sensory experiences, such as heat or light exposure and smelling bananas or jasmine, to see what was happening in the brain during the experience.

To create the labels, the scientists split a fluorescent molecule in half, one half for the talking neuron and one half for the listening neuron. If those neurons talked to each other when a fly was exposed to the banana smell or heat, the two halves came together and lit up. This only happened at the site of active synaptic transmission.

"Our results show we can detect a specific pattern of activity between neurons in the brain, recording instantaneous exchanges between them as persistent signals that can later be visualized under a microscope," Gallio said.

This is the kind of new technology scientists discuss in the context of President Obama's BRAIN (Brain Research Through Advancing Innovative Neurotechnologies) Initiative, Gallio said. Such a tool will help researchers better understand how brain circuits process information, and this knowledge then can be applied to humans.

More information: The paper is titled 'Dynamic labelling of neural connections in multiple colours by trans-synaptic fluorescence complementation.'

Provided by Northwestern University