Medical Xpress

Smell experience during critical period alters brain

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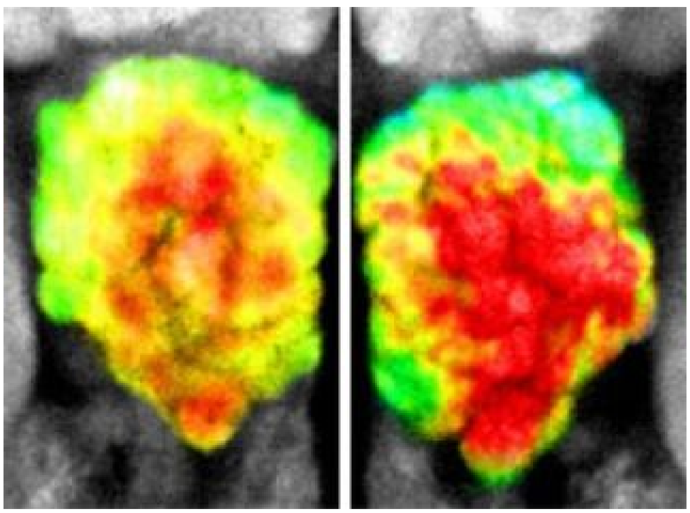

During the first few days of life, chronic exposure to carbon dioxide (right) rather than air (left) alters the activity of projection neurons and interneurons in the fly brain -- research that is first to show that the olfactory system is plastic. Credit: Rockefeller University

Unlike the circuitry of the visual system, that of the olfactory system was thought to be hardwired: Once the neurons had formed, no amount of sensory input could change their arrangement. Now researchers at Rockefeller University and their collaborators have upturned this scientific dogma by showing that there is a sensitive period during which the external environment can alter a circuit in the fly brain that detects carbon dioxide, a gas that alerts flies to food and mates.

This research, to be published in the December 6 issue of Neuron, may suggest that this brain plasticity isn't limited to the carbon dioxide detection circuit. Rather, it may be a general feature of the olfactory system itself.

"The circuit has a genetic plan, but that genetic plan can adjust to real world conditions," says Leslie Vosshall, head of the Laboratory of Neurogenetics and Behavior. "This paper is the first compelling case that the olfactory system is plastic."

Using several imaging techniques, Vosshall and her colleagues traced the carbon dioxide circuit, a well-described pathway that consists of three different types of neurons, the axons and dendrites of which form an entangled ball called a glomerulus. The researchers exposed flies to elevated levels of carbon dioxide to see whether it would alter the shape of this circuit or how it functioned. The glomerulus's volume was already increased after two days of exposure (from birth) and kept on increasing for five days, at which point it stopped. The increase in this specific glomerulus could only be induced by elevated levels of carbon dioxide and was also reversible.

After those initial few days, however, the researchers saw a different story unfold. If they didn't expose the flies to carbon dioxide within the first five days, genetics locked in the glomerulus's size such that no matter how long the flies were exposed to the gas, the glomerulus's volume didn't increase. These findings suggest that the fly's external environment can rewire the carbon dioxide detection circuit only during a five-day window of development.

"During this critical period, the olfactory system is flexible enough to calibrate its genetic map to its local environment," says first author Silke Sachse, a former postdoc in the Vosshall lab who is now a group leader in optical imaging at the Max Planck Institute for Chemical Ecology in

Jena, Germany. "But once that window closes, the circuit is no longer plastic."

To figure out the mechanism by which the glomerulus increases its volume, the Vosshall group imaged the three types of neurons that make up the glomerulus -- olfactory sensory neurons, projection neurons and interneurons -- to see whether their structure or function had changed. The olfactory sensory neurons, which report sensory information to glomeruli, did not show any sign of structural or functional changes.

However, the projection neurons, which send information from the glomeruli to the brain, and the interneurons, which communicate with the two types of neurons as well as the glomeruli, showed significant functional changes. "Usually the sensory neurons collect information and send it to the brain and it is the job of the brain to interpret what the information means," says Vosshall. "For plasticity to be useful, it probably makes sense to delegate that job to the brain rather than to the external sensory neurons."

Source: Rockefeller University