Researchers Show How Brain Decodes Complex Smells

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Duke University Medical Center researchers have discovered how the brain creates a scent symphony from signals sent by the nose.

In studies in mice, the researchers found that nerve cells in the brain's olfactory bulb -- the first stop for information from the nose -- do not perceive complex scent mixtures as single objects, such as the fragrance of a blooming rose. Instead, these nerve cells, or neurons, detect the host of chemical compounds that comprise a rose's perfume. Smarter sections of the brain's olfactory system then categorize and combine these compounds into a recognizable scent. According to the researchers, it's as if the brain has to listen to each musician's melody to hear a symphony.

Humans may rely on the same smell decoding system, because mice and men have similar brain structures for scent, including an olfactory bulb, the researchers said.

"We wanted to understand how the brain puts together scent signals to make an odor picture. We discovered the whole is the sum of its parts," said Da Yu Lin, Ph.D., who conducted the research as a graduate student studying with neurobiologist Lawrence Katz, Ph.D., a Howard Hughes Medical Institute investigator at Duke. Katz died in November 2005.

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Foundation.

Scientists have long debated how the brain makes order out of the hundreds of volatile chemical compounds that assault the nose. Is the brain's odor code redundant, with single cells responding to multiple components in the smell of a freshly baked cookie? Or does the brain process each scent component like a jigsaw puzzle piece, assembling the signals until it recognizes the picture is a cookie?

To find answers, the Duke researchers exposed mice to different odors and measured response of neurons across the olfactory bulb with intrinsic signal imaging. The imaging technique maps brain activity by detecting changes in reflected light from the brain with a sensitive camera.

To start, the researchers separated and identified the volatile compounds in each odor with gas chromatography. "A complex mixture like urine has at least a hundred separate compounds in it," Lin said. They analyzed scents as diverse as peanut butter, coffee and fresh bobcat urine shipped to the laboratory on dry ice.

The researchers then exposed the mice to the original odor and its individual compounds. "We found that glomeruli, the functional units of the olfactory bulb, act as detectors for individual compounds," Lin said. "There are no single detectors for complete smells."

Thus, to distinguish different scents, the brain must integrate the signals of multiple chemical components into an odor "picture." The researchers suspect that this integration doesn't happen in the olfactory bulb. Instead, the bulb likely passes the data to more advanced brain structures where it is assembled and recognized as a specific scent.

Understanding how the olfactory system works in mice may also provide

broader insights into human perception, said Stephen Shea, Ph.D., a Duke University Medical Center research associate who participated in the study. Perception relies on combining multiple components, whether the input is smell, sight or sound. Shea suggested that probing the olfactory system could help scientists better understand, for example, how the various biological and neurological components underlying perception formed and evolved.

Source: Duke University Medical Center