How learning influences smell

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The smell of an odor is not merely a result of chemical detection but is also influenced by what the smeller learns about the odor. Now, researchers have discovered how such "perceptual learning" about an odor influences processing of information from the purely olfactory chemical detection system. Wen Li, Jay Gottfried, and colleagues at Northwestern University reported their findings with human subjects in the December 21, 2006, issue of the journal *Neuron*.

"Verbal context strongly influences the perception of odor quality—a rose by any other name would not smell as sweet," explained the researchers. "For example, the same odorant smells entirely different depending on whether it is labeled as fresh cucumber or mildew."

"Learning also changes odor quality. A cherry odor becomes smokier in quality after being experienced together with a smoky odor. Thus, a given set of olfactory receptors activated by an odorant may not map directly onto a given odor percept. Rather, odor perception may rely on more synthetic, or integrative, mechanisms subserved by higher-order brain regions," they wrote.

In a previous study, also published in *Neuron*, Gottfried and colleagues had identified regions of the cortex involved in "coding" odors. In the new study, they sought to explore whether perceptual learning about an odor lead to changes in subjects' ability to differentiate the odors.

In their experiments, the researchers first exposed volunteers to a set of odors and tested their ability to differentiate the odors. They next

habituated the subjects to one of the odorants by exposing them to the odor for several minutes. Finally, they retested the subjects' ability to distinguish the odors. The odors the subjects were asked to distinguish included those that had the same odor quality, for example floral, as well as those that shared characteristic molecular groups, for example being an alcohol.

As the subjects were undergoing the odor differentiation trials, their brains were scanned using functional magnetic resonance imaging (fMRI). This widely used technique for measuring brain activity involves using harmless radio waves and magnetic fields to measure blood flow in brain regions, which reflects brain activity.

Gottfried and his colleagues found the subjects better able to differentiate odors after the period of habituation to a similar odor. What's more, the fMRI scans revealed increases in response in the odor-processing areas of their brains that reflected learning.

The researchers concluded that "prolonged exposure to one odorant resulted in improved differentiation among related odorants (and even among novel related odorants). Thus, with exposure to a floral-smelling alcohol (i.e., phenethyl alcohol), subjects effectively became floral 'experts' and simultaneously became experts for the underlying molecular group," they wrote. The subjects appeared to be "developing more refined, or differentiated, subcategories of these olfactory features," wrote the researchers.

"The current findings, along with recent data from our laboratory, provide further evidence that odor quality coding in olfactory cortex is not a straightforward outcome of odorant structure," they concluded. "In all likelihood, neural representations of odor quality are a dynamic product of lower-level coding from olfactory bulb and higher-level cortical inputs, under the regulation of learning and experience,

attention, sensory context, and language.

"We speculate that the process of odor feature differentiation, via sensory exposure, may underlie much of the way that humans naturally learn to identify odors in the environment, with progressive and ever more refined differentiation, to the point where we are able to recognize thousands, if not hundreds of thousands, of different smells," they wrote.

"This mechanism may underlie the acquisition of fine-grained percepts that distinguish, for example, the smell of Rosa damascena (Bulgarian Rose) from that of Rosa centifolia (Rose Maroc), to the point where we would be able to appreciate the immense richness of aromas in everyday life," they wrote.

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