Neural mapping paints a haphazard picture of odor receptors

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Despite the striking aromatic differences between coffee, peppermint, and pine, a new mapping of the nose's neural circuitry suggests a haphazard patchwork where the receptors for such disparate scents are as likely as not to be neighbors.

Inexplicably, this seemingly random arrangement is faithfully preserved across individuals and even species, with cells that process the same scent located in precisely the same location on the olfactory bulb, the brain's first processing station for odors.

The crazy-quilt map of odor-processing neurons on the front lines of the olfactory system is described by Harvard University neuroscientists in the February issue of the journal *Nature Neuroscience*.

"It had been thought that the layout of the olfactory bulb was variable from individual to individual, but followed a chemotopic order where cells handling similar odor responses are near each other," says Markus Meister, the Jeff C. Tarr Professor of Molecular and Cellular Biology in Harvard's Faculty of Arts and Sciences. "Here we show that the layout is actually very precise -- the same from animal to animal -- but doesn't appear to follow any chemotopic order whatsoever."

Working with mice and rats, Meister and colleague Venkatesh N. Murthy recorded neural responses to several hundred distinct odors, including anise, beer, cloves, coffee, ginger, lemon, orange, peppermint, pine, rose, and even fox pheromones. The neuroscientists found that across individuals and even across the two species, bundles of neurons from a given type of odor receptor -- known as glomeruli -- were found in almost exactly the same spot on the olfactory bulb, a sensory structure measuring some four to five millimeters across and located at the very front of the brain.

"Glomeruli from different receptors line the surface of the olfactory bulb like an array of close-packed marbles," says Murthy, professor of molecular and cellular biology at Harvard. "Across individuals the location of a given glomerulus varies by only one array position. Compared to the size of the map, this represents a remarkable developmental precision of one part in 1,000."

Meister and Murthy then analyzed whether nearby glomeruli detect similar odors, such as those with similar chemical structures. Neuroscientists have previously hypothesized axes of similarities along which odors might be classified.

"One might expect that nearby glomeruli should have similar odor sensitivities," Meister says, "but we were surprised to find this was not the case. The odor response spectra of two neighboring glomeruli were as dissimilar as those of distant glomeruli."

This seemingly haphazard layout of sensory properties stands in marked contrast to other brain maps, such as those governing vision, touch, and hearing. In these three cases, our brains represent the outside world using ordered maps -- such as when neighboring points in visual space activate neighboring points on the retina.

"That sort of arrangement makes sense, since most brain computation is local, relying on short connections between nearby cells," Murthy says. "This is necessary because the connections between neurons occupy most of the volume available to the brain, and long-distance connections require more of this volume."

Meister and Murthy suspect that the deliberate randomness in rodents' odor maps is likely also found in humans, which have only one-third as many receptors but are capable, in some extreme cases, of discerning tens of thousands of distinct smells.

Source: Harvard University

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