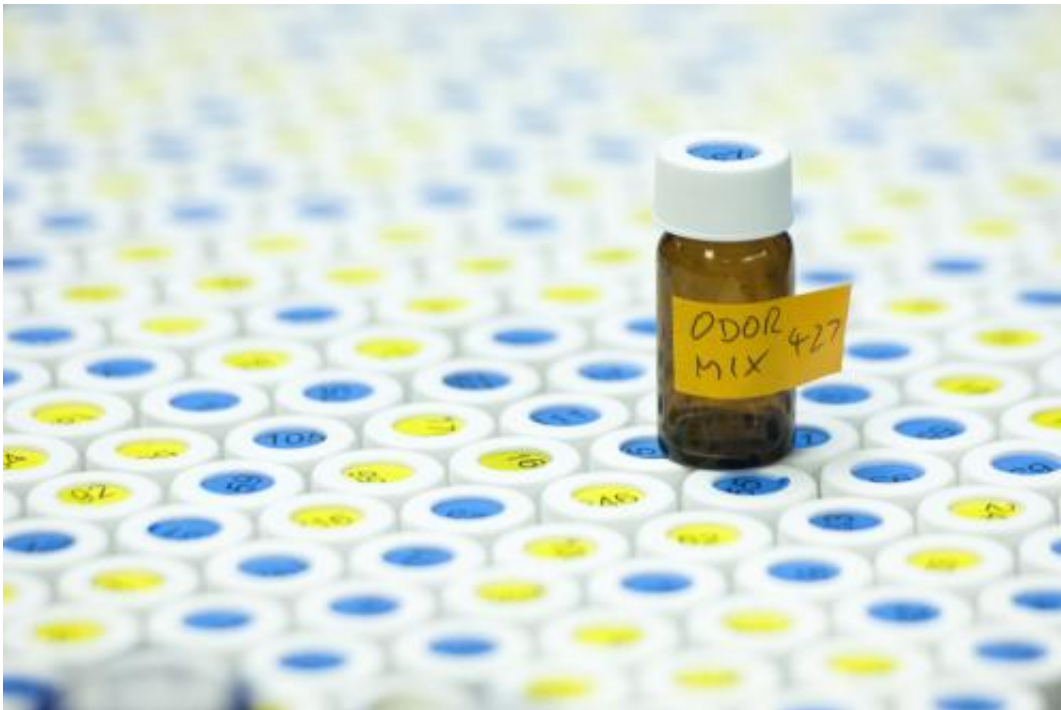


Humans can distinguish at least one trillion different odors, study shows

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Vials of odors are among hundreds that Rockefeller University researchers used to measure volunteers' ability to distinguish between scents. Credit: Zach Veilleux / The Rockefeller University

In a world perfumed by freshly popped popcorn and exhaust fumes, where sea breezes can mingle with the scents of sweet flowers or wet paint, new research has found that humans are capable of discriminating at least one trillion different odors. Howard Hughes Medical Institute (HHMI) scientists determined that our sense of smell is prepared to

recognize this vast olfactory palette after testing individuals' ability to recognize differences between complex odors mixed in the laboratory.

It has been said for decades that humans are capable of discriminating between 10,000 different odors. The number is cited in scientific literature and appears in popular magazines. "It's the generally accepted number," says HHMI investigator Leslie Vosshall, who studies olfaction at the Rockefeller University. "Our analysis shows that the human capacity for discriminating smells is much larger than anyone anticipated."

Vosshall and her colleagues published their findings March 21, 2014, in the journal *Science*. "I hope our paper will overturn this terrible reputation that humans have for not being good smellers," she says.

Vosshall had long been bothered by the idea that humans were limited to smelling 10,000 odors – an estimate that was made in the 1920s, and not backed by any data. "Objectively, everybody should have known that that 10,000 number had to be wrong," she says. For one thing, it didn't make sense that humans should sense far fewer smells than colors. In the human eye, Vosshall explains, three light receptors work together to see up to 10 million colors. In contrast, the typical person's nose has 400 olfactory receptors.

But no one had tested humans' olfactory capacity. "We know exactly the range of sound frequencies that people can hear, not because someone made it up, but because it was tested. We didn't just make up the fact that humans can't see infrared or ultraviolet light. Somebody took the time to test it," Vosshall says. "For smell, nobody ever took the time to test."

Vosshall and Andreas Keller, a senior scientist in her lab at Rockefeller University, knew they couldn't test people's reactions to 10,000 or more

odors, but they knew they could come up with a better estimate. They devised a strategy to present their research subjects with complex mixtures of different odors, and then ask whether their subjects could tell them apart.

They used 128 different odorant molecules to concoct their mixtures. The collection included diverse molecules that individually might evoke grass, or citrus, or various chemicals. But when combined into random mixtures of 10, 20, or 30, Vosshall says, they became largely unfamiliar. "We didn't want them to be explicitly recognizable, so most of our mixtures were pretty nasty and weird," she says. "We wanted people to pay attention to 'here's this really complex thing – can I pick another complex thing as being different?'"



Andreas Keller in the lab surrounded by vials of odors he and his colleagues used to measure volunteers' ability to distinguish between scents. Credit: Zach Veilleux / The Rockefeller University

The scientists presented their volunteers with three vials of scents at a time: two matched, and one different. Volunteers were asked to identify the one scent that was different from the others. Each volunteer made 264 such comparisons.

Vosshall and her colleagues tallied how often their 26 subjects were able to correctly identify the correct outlier. From there, they extrapolated how many different scents the average person would be able to discriminate if they were presented with all the possible mixtures that could be made from their 128 odorants. "It's like the way the census works: to count the number of people who live in the United States, you don't knock on every single door, you sample and then extrapolate," she explains. "That's how I like to think of this study. We knocked on a few doors."

In this way, they estimated that the average person can discriminate between at least one trillion different odors. "I think we were all surprised at how ridiculously high even the most conservative lower estimate is," Vosshall says. "But in fact, there are many more than 128 odorants, and so the actual number will be much, much bigger."

Vosshall says she doubts individuals are exposed to a trillion smells on a daily basis. "But I like to think that it's incredibly useful to have that capacity, because the world is always changing," she says. Plants are evolving new smells. Perfume companies are making new scents. You might move to some part of the world where you've never encountered the fruits and vegetables and flowers that grow there. But your nose is ready. With a sensory system that is that complex, we are fully ready for anything," she says.

More information: "Humans Can Discriminate More than 1 Trillion Olfactory Stimuli," by C. Bushdid et al. *Science*, 2014.

Provided by Howard Hughes Medical Institute

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