Can humans really tell apart a trillion smells?

It's been reported that our noses were a 100 million times more sensitive than had been previously believed and that humans could apparently discriminate 1 trillion different smells.

Finally we could hold our collective noses up high and know that we could walk into any duty-free perfumery and tell the difference between a cheap eau-de-cologne and the expensive scent of Clive Christian's Imperial Majesty [selling at a mere $215,000 for 16 ounces].

But wait, not so fast. A study published on arxiv by Markus Meister, a professor of Molecular and Cellular Biology at Harvard University, disputes the logic of the original paper and argues that the original Science paper's claims are wrong by "astronomical factors."

> The authors were misled by failures in a mathematical method they designed. As a result, their claims have no basis. The paper's extravagant claims are based on errors of mathematical logic.

Ten as opposed to one trillion—that is some logical error. Now it is important to note here that Meister isn't saying we can only discriminate between 10 different smells, merely that the logic of the original paper could just as easily support that we could only tell the difference between 10 smells.

So our sense of smell isn't as superior as we thought?

Meister doesn't address this in his paper, but in his dismissal of the original paper he does point the way to answering this question in the future. So it is worth a look at the original experiment to see exactly how the researchers came up with their 1 trillion different smells, and how Meister believes their logic was flawed:

The researchers gathered up 128 odorant molecules including citrus, tobacco, mint and garlic and combined them in varying quantities into mixtures of 10, 20 and 30 smells and put them in glass vials. The scientists gave the test subjects three vials at a time: two with the same concoction, and a third that was different. Based on how often the test subjects were able to correctly identify which of the vials smelled different, the scientists extrapolated that humans could differentiate among at least 1 trillion different smells.

Meister gave three arguments against the logic used in the paper and the second of these Adam J. Coulhon, blogger at neuroecology covers in his blog:

> The second criticism concerns the *dimensionality* of the sensory data. How many ways does it vary? In vision, we know that people are trichromats (for the most part). Red, blue, green: these are the three fundamental dimensions color vision varies across. How many are

dimensions are there in olfaction? There are at least 400 odorant receptor genes in humans, which suggest that there are at least 400 different odorant molecules that we could detect – though the exact number depends on the wiring of the olfactory system. This suggests that smells exist in 400 *orthogonal* directions in humans.

Markus Meister shows that if odors are represented along *one* dimension then the same analysis used in the initial paper yields *ten* discriminable odors. On the other hand, if you have more (non-orthogonal) dimensions, you could potential discriminate an *infinite* number odors. Therefore, he claims, this analysis is just plain wrong. We'll call this the "choose your own dimension" criticism and probably has an empirical answer (which happens to be ~400

This argument hints at how Meister thinks scientists might progress in investigating how many smells humans can actually discriminate. If scientists can identify the primary color equivalent in smells, what he calls the "dimensionality of odor precepts" they can stand a chance of finding how many smells we can discriminate, rather than just specifying the number of smells out there that we could possibly discriminate between. He states it, in more rigorous terms, in his paper:

Regardless of approach, determining the dimensionality of the space of odor percepts is a precondition to estimating the number of distinct percepts. The recognition that color space is three-dimensional has had enormous impact in science, art, and technology, as anyone reading this on a color monitor will confirm. By comparison, knowing that there are >1 million distinct color percepts is a minor advance. Similarly, finding a low-dimensional basis set for odors would be truly profound.

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Additional Resources:

- [Your genes give you a unique world of smells–1.7 trillion scents](#), Genetic Literacy Project
- [Can we inherit fear of a smell? The latest on transgenerational epigenetics](#), Genetic Literacy Project
- [Mapping evolutionary history with genes for smell](#), National Geographic