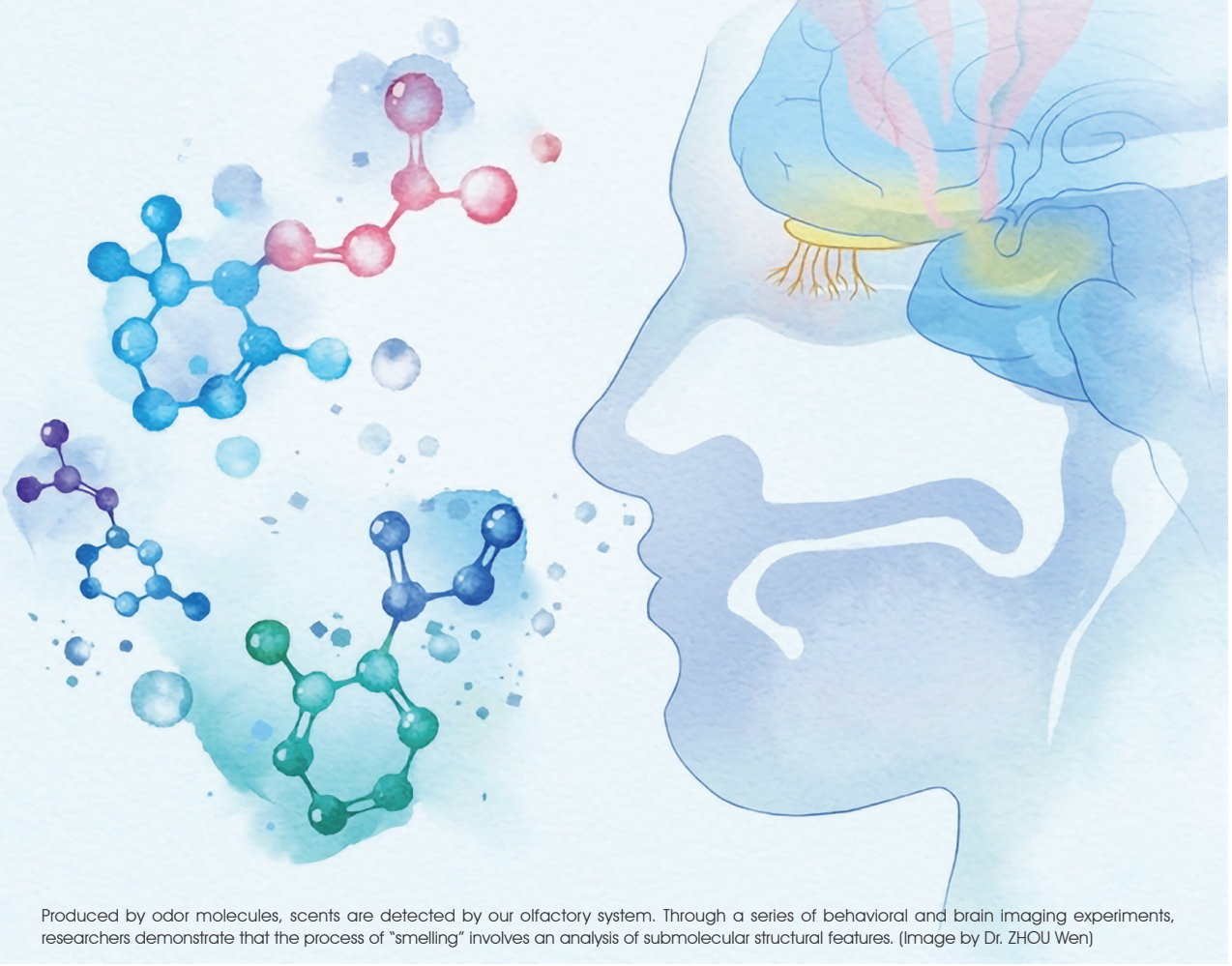
Smells Are Built from Chemical Substructures in the Brain

By YAN Fusheng

You may think the scent of coffee or roses hits your nose as one seamless sensation. A new study shatters that notion, revealing our brain doesn't perceive smells as whole molecules. Instead, it deconstructs odor molecules into substructures before reassembling them into unified scents we recognize. This counterintuitive finding flips our understanding of how we process the invisible world of smells around us.



Produced by odor molecules, scents are detected by our olfactory system. Through a series of behavioral and brain imaging experiments, researchers demonstrate that the process of "smelling" involves an analysis of submolecular structural features. (Image by Dr. ZHOU Wen)

What we think of as a single, unified smell like freshly brewed coffee or a rose in bloom is actually built from an analysis of smaller chemical substructures, according to a new study published in *Nature Human Behaviour* on March 18, 2024.

The study was conducted by a research team led by Dr. ZHOU Wen from the Institute of Psychology of the Chinese Academy of Sciences (IPCAS).

For decades, scientists believed odor molecules were processed as undifferentiated wholes by the olfactory system. However, this new research shows the brain deconstructs odorant molecules into their submolecular components before reassembling them into a unified perception we recognize as a particular smell.

The smells we experience are manifestations of continuous analysis and synthesis of the volatile compounds around us, breath by breath. Our olfactory system dynamically computes smell perceptions based on the structural features of odor molecules and how they relate to our recent sniffs.

In the study, ZHOU's team used adaptation techniques to selectively alter how over 400 participants perceived the smells of odor compounds with overlapping molecular structures. After being adapted to part of a molecule's structure, people reported that the whole odor compound was smelled more similar to its non-adapted portion.

Brain imaging data showed that as odor molecules enter the nose, adaptation to part of their structure dampened responses in areas like the piriform cortex related to processing that substructure. This shifted the overall neural response pattern toward representing the non-adapted portion of the molecule.

The findings overturn the previous theory that smells are processed as pre-defined wholes. Instead, the study suggests smells are actively constructed and can morph based on recent olfactory experience. The malleability may help explain why smells can seem so fickle and subjective compared to other senses.

The research team next plans to explore whether this molecule subdivision happens at the very first olfactory receptors or later in neural processing. Understanding smell's foundations could eventually aid endeavors like designing artificial noses or malodor management.

Reference

Ye, Y., Wang, Y., Zhuang, Y., Tan, H., Zuo, Z., Yun, H., . . . Zhou, W. (2024). Decomposition of an odorant in olfactory perception and neural representation. *Nature Human Behaviour*. doi:10.1038/s41562-024-01849-0