Irritating smells alert special cells, study finds

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If you cook, you know. Chop an onion and you risk crying over your cutting board as a burning sensation overwhelms your eyes and nose. Scientists do not know why certain chemical odors, like onion, ammonia and paint thinner, are so highly irritating, but new research in mice has uncovered an unexpected role for specific nasal cavity cells. Researchers funded by the National Institute on Deafness and Other Communication Disorders (NIDCD), part of the National Institutes of Health, describe this work in the March issue of the *Journal of Neurophysiology*.

Weihong Lin, Ph.D., of the University of Colorado Denver School of Medicine and University of Maryland, Baltimore County, led the study which discovered that a particular cell, abundant near the entry of many animal noses, plays a crucial and previously unknown role in transmitting irritating and potentially dangerous odors. Dr. Lin and colleagues from both universities plus the Mount Sinai School of Medicine identified the role of this solitary chemosensory cell in transmitting irritating chemical odors in the noses of mice.

Scientists have found similar solitary chemosensory cells in the nasal cavities, airways and gastrointestinal tracts of many mammals as well as fish, frogs and alligators; they think it is likely that they are also present in humans, explains Thomas Finger, Ph.D., one of the senior co-authors at the University of Colorado Denver.

Prior to this work, scientists who study smell and taste thought that irritating odors directly stimulated the trigeminal nerve, which senses

touch, temperature and pain throughout the head region, including the delicate membranes that line the inside of the nose. The research team, under the guidance of Diego Restrepo, Ph.D., found that solitary chemosensory cells scattered in the epithelium inside the front of the nose respond to high levels of irritating odors and relay signals to trigeminal nerve fibers.

“This elegant research corrects an erroneous assumption about how irritating odors are perceived and expands our understanding of olfaction,” says James F. Battey, M.D., Ph.D., director of NIDCD. “With further investigation, it also might lead to a better understanding of why some people are exceptionally sensitive to irritating odors.”

Solitary chemosensory cells on the surface of the nasal cavity are in close contact with trigeminal nerve fibers which end just below the surface. Earlier research revealed that these cells contain bitter taste receptors and that bitter substances applied to the surface of the nasal cavity trigger a trigeminal nerve response.

Intrigued, Drs. Restrepo and Finger decided to explore whether solitary chemosensory cells respond to irritating odors. Using nasal tissue from mice, the scientists measured a variety of changes in solitary chemosensory cells as they exposed the cells to low and high levels of several irritating, volatile chemical odors.

Among their observations were changes in electrical activity in the cells—which indicates a response to an outside stimulus—and changes in intracellular calcium ion concentration—which indicates signaling to other cells. Their measurements demonstrated that the solitary chemosensory cells responded to the odors and relayed sensory information to trigeminal nerve fibers.

Once stimulated, the trigeminal nerve will convey pain and burning

sensations and can trigger protective reflexes such as gagging and coughing. The architecture of nasal tissue with solitary chemosensory cells on the surface and trigeminal nerve fibers just below allows the nose to detect a greater number of irritating odors, the scientists explain.

Fortunately, the threshold for triggering a response is high, so exposure to a small amount of an irritating chemical, as might naturally emanate from some kinds of fresh fruit, will not bring on gagging and coughing. For example, lemons contain the volatile chemicals citral and geraniol but at levels too low to trigger a trigeminal response. Only high, potentially dangerous levels of odors will trigger the protective gagging-and-coughing response.

The researchers point out that their findings provide an example of the Law of Specific Nerve Energies, conceived by Johannes Peter Muller in 1826. Muller said that the way we perceive a stimulus depends on the nerve or sensory system that conveys it rather than the physical nature of the stimulus itself. In the case of irritating odors, we perceive them as irritating because they are transmitted via the trigeminal nerve, leading the brain to interpret the message as pain rather than as a smell.

The researchers say their findings raise new questions about how irritating odors are detected. They say more research is needed to explore whether solitary chemosensory cells are programmed to recognize specific irritants, which receptors are involved, and what steps a solitary chemosensory cell uses to convert a chemical stimulus to a signal it relays to the trigeminal nerve.

Source: NIH