Smell & Taste

9.35

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Taste & smell are chemical senses

Sensing the chemicals in the environment is essential to all life.

In taste and smell we are in direct contact with the material of interest (unlike vision & audition).

Basic taste sensations

The classic four tastes:

- Sweet (sugars; also sweeteners, lead paint)
- Sour (acids, e.g. vinegar, lemon juice)
- Bitter (poisons)
- Salty (sodium)

(Image removed due to copyright considerations.)

Taste sensations are not strictly localized, but there is variation across the tongue.

The fifth taste: umami.

(Image removed due to copyright considerations.)

Ikeda (1908) proposed a fifth basic taste, called umami. He discovered that glutamate caused it. He introduced MSG as a flavorant.

Only recently has umami been accepted as a basic taste by Western scientists. It is "meaty" or "savory".

Advances in the science of sweeteners

Saccharin - 1879 - Discovered in when a Johns Hopkins worker inadverently licked his fingers.

Cyclamate - 1937 - Michael Sveda, a graduate student at the University of Illinois, was smoking a cigarette. He put it down on the lab bench and when he put it in his mouth he noticed a sweet taste.

Aspartame - 1965 - James Schlatter licked fingers in preparing to pick up a peice of weighing paper. It is a combination of two naturally occurring amino acids (aspartic and phenylalanine).

Sucralose - 1976- A chloride-containing carbohydrate product some 600-times sweeter than sugar. Discovered when a foreign student (Shashikant Phadnis) working in Prof Leslie Hough's lab at King's College, London, misunderstood a request for "testing" as "tasting".

Lessons learned...

Taste, Smell, Flavor

- Much of what we call taste is actually smell.
- Demonstrate by holding your nose while eating an apple or an onion.
- The term “flavor” is used technically to include taste, smell, tactile, and even sound (crunchiness).

Taste buds are tiny.

Those big things you can see are papillae.

(Image removed due to copyright considerations.)

Four kinds of papillae: curcumvallate, fungiform, foliate, filiform. Filiform papillae are non-tasting.

Topography of the tongue

(Image removed due to copyright considerations.)

- *Supporting cells* - contain microvilli, secrete substances into lumen of taste bud.
- *Sensory receptor cell* - has peg-like extensions projecting into lumen. These contain the sites of sensory transduction.
- *Basal cells* - these differentiate into new receptor cells. They are derived from surrounding epithelium. The cells are continuously renewed every 10 days or so.

Non-tasters, supertasters

For most people, *n*-propylthiouracil (PROP) tastes quite bitter.

For some people (supertasters) it tastes unbelievably bitter.

Some people don't taste it at all.

These differences are genetic and correlate with the density of papillae

(Image removed due to copyright considerations.)

Broadly tuned responses

Individual neurons are not very specific. Here are responses for sweet, salty, and sour neurons.

(Bitter not shown here)

(Image removed due to copyright considerations.)

Up close: salty & sour

(Image removed due to copyright considerations.)

Salty: sodium ions (Na+) enter through channels on microvilli and side. Depolarization results in calcium ions (Ca++) entering the cell, leading to neurotransmitter release.

Acids = H+ ions, which act three ways: by directly entering the cell; by blocking potassium ion (K+) channels on the microvilli; and by binding to and opening channels on the microvilli that allow other positive ions to enter the cell -> depolarization -> neurotransmitter release.

Up close: sweet & bitter

(Image removed due to copyright considerations.)

Sweet stimuli (sugar, artificial sweeteners) bind to receptors on cell surface that are coupled G-proteins. This prompts the subunits (α β and γ) of the G-proteins to split into α and $\beta\gamma$ which activate a nearby enzyme -> second messenger -> closing potassium channels indirectly.

Bitter (e.g., quinine, coffee): stimuli act through G-protein-coupled receptors and second messengers -> release of calcium ions -> depolarization -> neurotransmitter release.

Up close: Umami

Umami: Amino acids such as glutamate, bind to G-protein-coupled receptors and activate second messengers. The intermediate steps between the second messengers and the release of packets of neurotransmitters are unknown.

(Image removed due to copyright considerations.)

Smell (olfaction)

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Smell is important to humans, although not as important as to some animals.

Smell is evocative of memories & emotions

(Image removed due to copyright considerations.)

Marcel Proust:
Remembrance of Things Past.

"... And suddenly the memory returns. The taste was that of the little crumb of madeleine which on Sunday mornings at Combray when I went to say good day to her in her bedroom, my aunt Léonie used to give me, dipping it first in her own cup of real or of lime-flower tea..."

Some smells you can buy in cans

New car smell (used car dealers)

Cake in the oven (realtors)

Leather (plastic handbags)

Pig scents (artificial insemination of pigs)

(Image removed due to copyright considerations.)

Smell goes straight to the brain: cortex, limbic system, thalamus

(Image removed due to copyright considerations.)

Anosmia can result from head trauma: nerves get sheared off by cribriform plate.

Olfactory system

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Olfactory epithelium contains 6 million receptors (dogs have more). Cells are renewed about every two weeks

Some random smell chemicals

- benzaldehyde: almonds/marzipan; cherries, peaches. Also pesticide, solvent.
- d-limonene: from citrus peel; orange smell; chief ingredient of Goo-Gone, Citra-Solve, etc.
- methyl mercaptan: potent sulfur compound in skunk odor, natural gas additive, post-asparagus urine (individual differences here).

Smell classification & scaling

Henning's smell prism.
Inspired by Newton's color wheel.
But it doesn't really work.

Multidimensional scaling (Schiffman) leads to two dimensions, but not much insight.

There are perhaps 1000 receptor types. So need 1000 dimensions?

(Image removed due to copyright considerations.)

Human smells

- Apocrine glands in armpits secrete stuff that breaks down to form distinctive odors.
- Dogs can distinguish individuals (including non-identical twins) based on HLA-type (immune system markers for self/not-self).
- Moms & babies can recognize each other's smell.

Lock & key model

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Smell experiences are based on multiple receptors.

Pattern of responses across receptors is critical.

Two meanings for smell?

Some stuff smells bad but tastes good.

You can teach new smells (presented to nose); then mix them in substance to be tasted (presented to olfactory nerves via tongue). Subjects don't recognize them.

Paul Rozin argues: "outside" smell has different uses from "inside" smell.

Pheromones

Bombykol: produced by the female silkworm moth (*Bombyx mori*) to attract potential mates. Receptors on the antennae of males can sense single molecules!

In vertebrates: vomeronasal organ

(Image removed due to copyright considerations.)

Do humans have a VNO, and do they use it? Still controversial.