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Lecture Notes - 7/27/99

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Taste, Smell, and Touch: Lecture Notes

O. Introduction

- Taste and smell are chemical senses. They give us information about the chemical composition of our surroundings. Taste is an immediate sense - a final checkpoint for the acceptability of food before it enters the body. Smell is a more distant sense allowing us to detect small concentrations of airborne substances.
 - Taste and smell only separated when animals moved to land. Since in the sea, all chemicals are dissolved in the same medium (water) there is no need for two separate senses. Fish and other sea creatures have one general chemical sense.
 - Taste is not just in the mouth. Catfish have chemoreceptors all along their body (a catfish is like a giant tongue), and flies have receptors on their feet so that they can tell immediately upon landing whether an object is good to eat.
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I. Taste

- Why do we need taste?
 - Taste is a gate-keeper sensory mechanism designed to test food and other substances before they enter the body.
 - Things that are potentially useful for the body tend to taste good, and things that are potentially harmful taste bad.
- Anatomy of Taste
 - The tongue contains many ridges and valleys called **papillae**. There are four types of papillae (shown in this [Figure](#)):
 - Filiform papillae: cone shaped & found all over the tongue (which is why tongues look rough)
 - Fungiform papillae: mushroom shaped & found at the tip and sides of the tongue
 - Foliate papillae: a series of folds along the sides of the tongue
 - Circumvallate papillae: shaped like flat mounds surrounded by a trench & found at the back of the tongue

- All papillae except filiform contain **taste buds** (so the very center of your tongue which only has filiform papillae is "taste-blind")
- Each **taste bud** contains a number of **taste cells** which have tips that protrude into the **taste pore**. [\[Figure\]](#)
- The Taste Pathway
 - Transduction occurs when different taste substances cause a change in the flow of ions across the membrane of a taste cell.
 - Different substances affect the membrane in different ways. [\[Figure\]](#)
 - Bitter and sweet substances bind into receptor sites which release other substances into the cell.
 - Sour substances contain H⁺ ions that block channels in the membrane.
 - Salty substances break up into Na⁺ ions which flow through the membrane directly into the cell.
 - [\[Figure\]](#) Electrical signals generated in the taste cells are transmitted in three pathways:
 - The **chorda tympani nerve** conducts signals from the front and sides of the tongue.
 - The **glosso-pharyngeal nerve** conducts signals from the back of the tongue.
 - The **vagus nerve** conducts taste signals from the mouth and the larynx.
 - These three nerves make connections in the brain stem in the nucleus of the solitary tract (NST) before going on to the thalamus and then to two regions of the frontal lobe (the insula and the frontal operculum cortex).
- The Neural Code for Taste
 - What tastes do we taste? The four basic tastes are sour, sweet, salty, and bitter. All of our taste sensations can be described as a combination of these four basic tastes.
 - Different taste receptors (and therefore different parts of the tongue) are most sensitive to different tastes. [\[Figure\]](#)
 - Specificity vs. Distributed encoding for taste. [\[Figure\]](#) [\[Figure\]](#)
 - Specificity encoding: there are fiber tracts that are responsible for a specific taste sensation (e.g., there is a "salty" tract, or a "sweet" tract.)
 - Distributed encoding: a taste sensation is the result of a pattern of activation of the different taste cells. Substances that cause similar patterns of activation will taste similar.
- Experience of Taste
 - Your experience of taste depends on your internal state (things always taste better when you're hungry), on your past experiences (familiar

- foods generally taste better than unfamiliar foods), and your genes (people have different sensitivities to certain tastes).
 - Taste experience is also subject to effects of adaptation. (Why does orange juice taste gross after you've just brushed your teeth?).
 - Our sensation of taste also depends heavily on smell and texture (touch). Ever notice how food just doesn't taste that good when you have a stuffed up nose? [\[Figure\]](#)
 - [Overview](#)
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II. Smell

- Why do we need smell?
 - Smell is our distant chemical sense. We can discern information about the chemical composition of substances before coming into more direct contact with them.
 - For many animals, smell is the most important sense.
 - Although for humans smell is not as important as say vision or hearing, we do use smell more than we think to guide behavior.
 - Smell is an important part of taste. Many qualities of foods that we think we taste, are actually a function of smell. [\[Figure\]](#)
- Anatomy of Smell
 - [\[Figure\]](#)
 - The **Olfactory Mucosa** is a dime-sized region located high inside the nasal cavity and is the site of olfactory transduction.
 - The olfactory mucosa contains **olfactory receptor neurons**. [\[Figure\]](#)
 - Olfactory receptor neurons have **cilia** (little hair-like projections) which contain the **olfactory receptor proteins**. [\[Figure\]](#)
- The Smell Pathway
 - Olfactory transduction occurs when odorant molecules reach the olfactory mucosa and bind to the olfactory receptor proteins on the cilia of the olfactory receptor neurons.
 - When odorants bind to the receptor site, the receptor protein changes shape which in turn triggers the flow of ions across the receptor-cell membrane and an electrical response is triggered in the cilium.
 - Electrical responses in the cilia spread to the rest of the receptor cell, and from there are passed onto the **olfactory bulb** of the brain in the olfactory nerve.
 - There are about 1,000 different types of receptor proteins each sensitive to different odorants.

- We have a total of about 10 million receptor neurons. Each receptor neuron has about 1,000 similar receptor proteins. Because there are 1,000 different receptor proteins, there are also 1,000 different receptor neurons.
- Inputs from similar receptor neurons go to similar **glomeruli** (collections of cells within the olfactory bulb). Because there are 1,000 different types of receptor neurons, there are 1,000 different types of glomeruli.
- From the olfactory bulb, mitral cells and tufted cells carry olfactory information to the olfactory cortex, and to the orbitofrontal cortex.
- The Neural Code for Smell
 - because odorants are such complicated stimuli, we don't yet have a complete picture of how smell is encoded by the brain
 - different areas of the mucosa are sensitive to different types of odorants
 - smells appear to be organized spatially in the olfactory bulb (similar smells are grouped together)
 - an **odotope** is a group of odorants that share some chemical feature and cause similar patterns of neural firing. Neurons that fire to the same odotope are usually located near each other.
- Experience of Smell
 - Humans can tell the difference between 10,000 different odors. But often it is difficult to name the odors. People who are trained to recognize odors (wine experts or perfume experts) are not necessarily any more sensitive with their nose - just better at retrieving names of smells from memory.
 - Dogs can be 10,000 times more sensitive to odors than humans. Yet, a individual human olfactory receptor is no less sensitive than a dog's. What makes dogs so sensitive? Although their receptors aren't any better, they have many many more of them (1 billion receptors in dogs compared to only 10 million in humans).
 - Pleasant smells (like fresh-baked bread or coffee) are used in supermarkets to encourage customers.
- Pheromones
 - Pheromones (often odorless airborne molecules play a crucial role in the behavior of many animals. For example, a pregnant mouse will spontaneously abort if she is presented with the smell of a non-parent male mouse within a certain critical time period. Do pheromones affect humans too?
 - Although for a long time scientists were skeptical about the possible effects of pheromones on humans, a recent flood of research has established that humans do indeed use an accessory olfactory system

(comprised of a vomeronasal organ & projections) just like many other animals.

- Pheromones have an effect on human attraction to potential mates. Women prefer the smell of those men whose genetically coded immunities are different from their own.
- Pheromones play a role in synchronizing menstrual cycles.
- Pheromones can affect moods.
- We can smell fear.

III. Touch

- Homunculi: different amounts of brain real estate are devoted to different parts of the body. Face, mouth, hands, feet, and genitals get the most sensory representation, while the back gets the least. The amount of cortex devoted to a body part is related to the sensitivity of that body part to touch & pain.