Psych 215 Instructors

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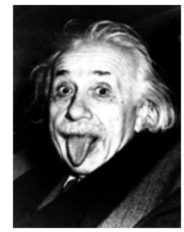
SMELL & TASTE

Psychology 215
Spring 2002
Jody Culham



Final Exam

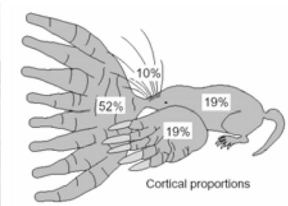
Psychology 215B-002

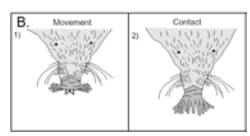
- Wednesday April 17
- 7:00 p.m.
- SSC2028

Format

- same as previous two tests
- 50 multiple choice = 50 points
- 3 short answers (each instructor writes two questions, you must answer one from each of the 3 instructors): 3 x 10 points = 50 points
- non-cumulative

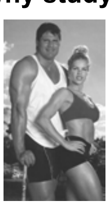
Star-nosed Mole Homunculus

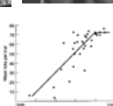




Nose ~ “Somatosensory fovea”

Why study smell and taste?





Evolutionary significance
Safety and survival

Hedonism
(Enjoyment)

Emotion & Memory
(Marcel Proust’s madeleines)

Anosmia

“I always thought I would sacrifice smell to taste if I had to choose between the two, but I suddenly realized how much I had misseed. We take it for granted and are unaware that everything smells: people the air, my house, my skin”

--anosmic patient (Birnberg,1988, in Ackerman, 1990)

=“without smell”

- complete inability to smell
- “odor blindness”
- damage by chemicals or drugs or brain damage or illness
- often temporary (e.g., during a cold)
- can cause a loss of appetite and libido

Smell and Taste

Chemical senses
- Smell = olfaction
- Taste = gustatation

(and by the way Touch = somatosensation = tactile sensation)

- chemosensation
- rely on chemoreceptors

- Interdependence between smell and taste

Olfaction

- volatile: substances must give off vapors
  - Weber's experiment
- fat-soluble

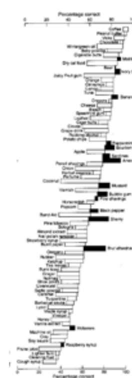
Humans vs. Other Species

Bloodhounds can pick up a 24hr old trail.
Dogs have 1,000,000,000,000 receptors and we have about 10,000,000 (i.e., They have 10,000X more receptors than humans).

Sniffer rats have been used to detect explosives.
Rats are 8-50X more sensitive than humans.

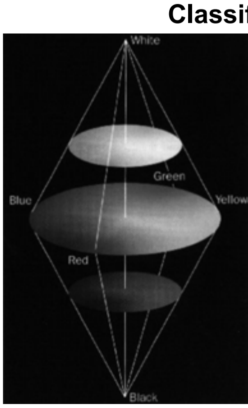
Humans' <u>receptors</u> are as sensitive. We just have fewer of them. Human olfactory receptors can be excited by the action of just one molecule of odorant

Identification vs. Discrimination



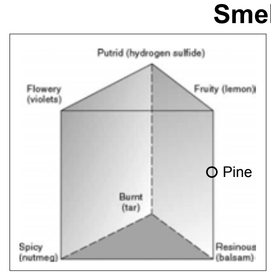
- Odor Identification: Most people can identify fewer than half the odors presented to them in a laboratory experiment.
- "tip of the nose phenomenon": inability to name a familiar odor
- Odor discrimination: Although identification is poor, people can tell the difference between approximately 10,000 odors
- With training and additional clues, people can reach 98% correct odor identification
- Varies from person to person
  - Females are typically better than males
  - Declines with age
  - Worse for smokers than non-smokers

Classifying Smells



- In vision we can classify colors into color space (e.g., hue, saturation, brightness)
- Is there a "smell space"?

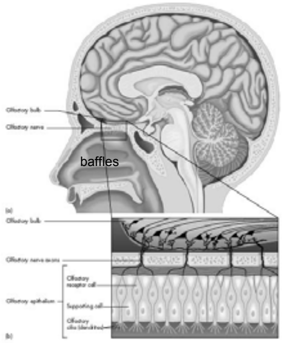
Smell Space



Hennig's smell prism
- subjects rated similarities of 400 different odors
- a particular odor falls on one part of the surface of the prism
- odors near each other on the surface are perceived as similar
- newer statistical techniques (multidimensional scaling) can map out odor space with fewer assumptions

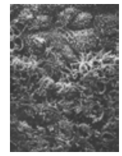
Are odors additive (like color, e.g., red + green = yellow) or superimposable (like piano keys $\rightarrow$ chords)?
- lemon + balsam $\neq$ pine
- more like superimposition

Olfactory system

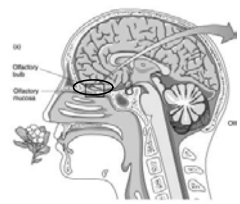


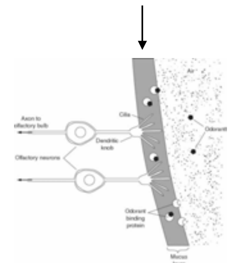
- nose
  - baffles
- olfactory epithelium
  - olfactory mucosa
  - olfactory sensory neurons
    - olfactory receptors
- olfactory nerve
- olfactory bulb
- olfactory cortex
- other brain areas
  - limbic system
  - orbitofrontal cortex

Olfactory Mucosa

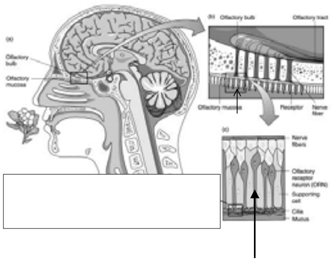


- dime-sized region in nasal cavity
- contains cilia of olfactory receptors





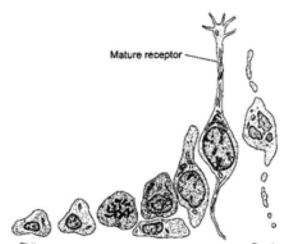
Olfactory Sensory Neurons



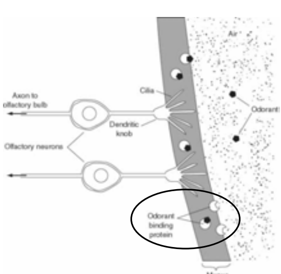
- unlike other senses, receptors are in direct contact with the outside world
- transduce odor molecules into neural signal
- cilia
  - protrude into mucosa
- dendrites
- axons
  - long connections
  - form olfactory nerve

Neuronal growth and death

- Smell and taste receptors only last 5-7 weeks
- How do new receptors get wired up appropriately to replace dead receptors?

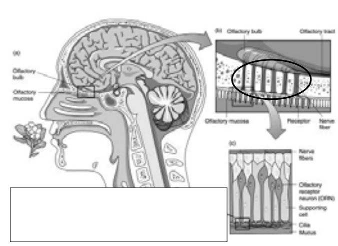


Odorant binding proteins



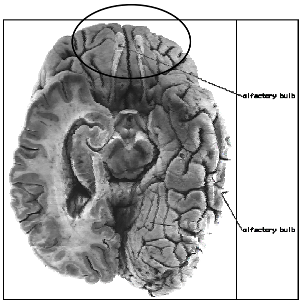
- Odorant binding proteins traps odor molecules and transports them to the mucosa
- Over 100 varieties of olfactory binding proteins
- “lock and key”: some molecules can bind to a particular binding protein, some can’t

Olfactory Nerve



- axons of sensory neurons transmit electrical signals to olfactory bulb

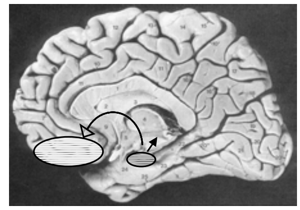
Olfactory bulb

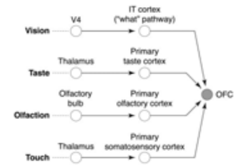


View of bottom of brain

- receives input from olfactory nerve
- no clear “odorotopy”

Olfactory cortex

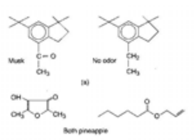




olfactory bulb
- ➔olfactory (piriform) cortex
  - ➔orbitofrontal cortex
    - multisensory integration (smell, taste, vision, touch)
  - ➔limbic system (not shown) including amygdala and hippocampus
    - emotion and memory

How do we code odors then?

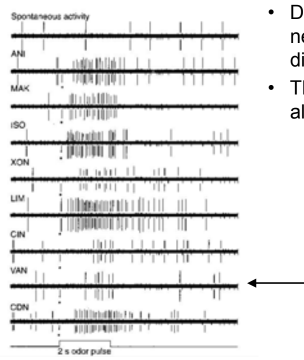
- There’s no clear “odor space”
- There’s no “odorotopy”
- There’s no clear pattern of which molecules activate which receptors



- Molecules with similar structure can smell different
- Molecules with different structures can smell the same

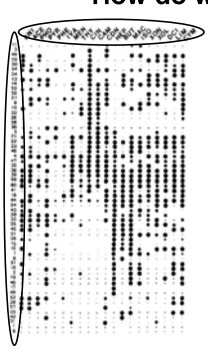
How can we encode different smells?!!!

Olfactory Coding



- Different olfactory receptor neurons respond differently to different compounds
- This neuron responds well to all compounds except vanilla

How do we code odors then?



The sizes of the spots are proportional to the strengths of the neural responses

- The pattern of responses across all the different receptor types is unique for each odor
- Brain circuits learn to recognize the different patterns

Taste, flavor and heat

Taste
- only four (debatably five) aspects
  - sweet
  - salty
  - bitter
  - sour
  - umami (e.g., monosodium glutamate; tastes ‘meaty’ or ‘savory’)

Flavor
- the complex sensation associated with food, based on the food’s taste, temperature, texture and smell
- flavor = taste + olfaction

“Heat”
- pain receptors on tongue register capsaicin, the substance in hot peppers

Taste without Smell

- Black bars = correct identification with smell
- White bars = correct identification without smell

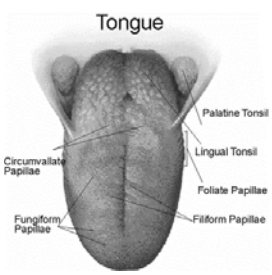
Taste

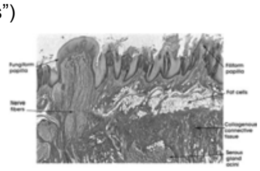
- substance must be soluable
  - you don't taste your fork
- need saliva
  - 25 ounces (1 L) per day!
- mixtures interact in complex ways
  - whole can be more than sum of parts

Tongue Papillae

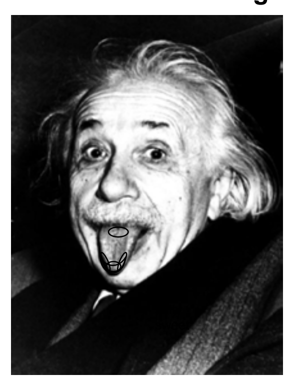
Tongue

- muscle with mucous membrane
- covered in papillae ("pimples")



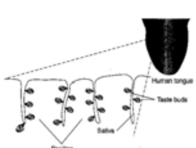


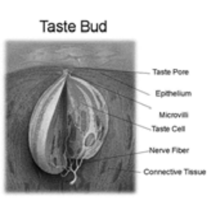
Tongue Map



- Textbooks used to say that you could only taste certain things in different regions of the tongue
- Those maps only apply to weak solutions
- With stronger solutions, you can taste any of the aspects anywhere you have taste buds

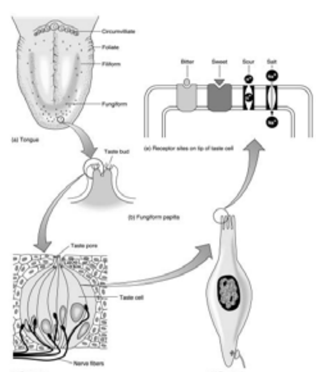
Taste buds





- receptor cells for taste
- in papillae
- none in the centre of your tongue
  - a gustatory "blind spot"
- also in throat, roof of mouth and inside of cheeks
- life expectancy ~10 days
- each bud has ~50 taste receptor cells
- a taste bud looks like a head of garlic and the receptors look like the cloves

Taste receptors



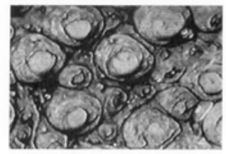
- Villi at the tip of the taste cell contains receptor sites for bitter, sour, salty and sweet substances
- Stimulation of the receptors causes and electrical signal in the receptor

Individual differences

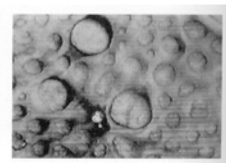
- Different people have different sensitivity to certain substances
- Ability to taste certain substances (PTC, PROP) is genetically determined
  - nontasters
    - report little taste
    - 25% of people
  - tasters
    - report bitter taste
    - 50% of people
  - supertasters
    - report extremely bitter taste
    - 25% of people
- Other substances may taste different to nontasters, tasters and supertasters (e.g., bitterness of coffee)

Nontasters, Tasters and Supertasters

- Dye tongue blue
- Count number of papillae in reinforcement circle at tip
  - <20: nontaster
  - >40: supertaster



supertaster



nontaster

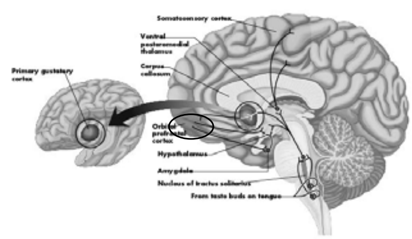
Taste variability

"I do not like broccoli. And I haven't liked it since I was a little kid and my mother made me eat it. And I'm President of the United States and I'm not going to eat any more broccoli."

-- George Bush (Sr., "the elected")

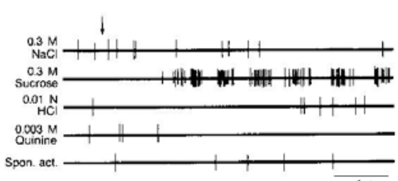
- Individual differences in taste ability may account for people's taste preferences
- Does cilantro taste like soap to you?
- (People also differ in their ability to smell certain substances too… "asparagus pee")
- Conditioned taste aversion: can easily develop an aversion to tastes (Garcia effect)
- Sensory-specific satiety: changes in enjoyablility with fullness

Taste system



taste buds ➔ 3 nerves ➔ nucleus (NST) ➔ thalamus ➔ insula (primary gustatory cortex) ➔ orbital prefrontal cortex

Taste coding

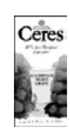


salty
sweet
sour
bitter

- Single neurons in taste-related nerves fire to different taste properties (e.g., neuron above is active for sweet tastes)

Applied Chemosensation: Wine Tasting

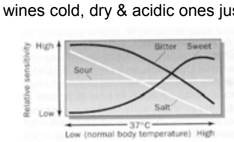
1. Chill the wine
   - Whites ~10°C
   - Reds ~15 °C



Don't drink wine? Try good quality grape juice.

Why?

- Wine odors are more abundant around room temperature
- Substances taste very different depending on temperature
  - cold ➔ less sweet, more acidic
  - serve fruity wines cold, dry & acidic ones just below room temperature



Wine Tasting

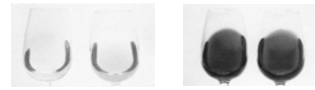

2. Check the label
3. Remove the cork

Why?
• People do much better at identifying flavors if they know what to expect
• Different cultures prefer different tastes (for Coca-Cola, Germans like spicy, Mexicans like citric, Italians like a little bitterness)
• People's expectations are higher in wine with corks (even though plastic stoppers yield better wine, it doesn't sell)

Photos from Oz Clarke's *The Essential Wine Book*

Wine Tasting

4. Look at the wine (browner = older)



young old young old

Why?
• Other properties affect the enjoyment of flavor
  • all the senses come together in orbitofrontal cortex
  • St. Patrick's day: green food tastes weird
  • achromatopsics (patients with lesions to the "color area" of the brain who see the world in shades of gray) lose their appetites

Wine Tasting

5. For rich-tasting wines, use a glass that's narrowed at the top. Don't fill the glass too full (~1/3). Swirl the wine in the glass.

Why?
• Flavor is largely related to smell.
• The swirling releases the volatile aromas.
• The narrowed top captures the aromas.

Wine Tasting

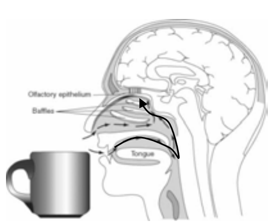
6. Give it a gentle swirl and take a good steady sniff. Characterize the scent. What does it remind you of (honey, chocolate, apples, black current)?

Why?
• Smelling is an active process – you must sniff
• Sniffing activates olfactory (piriform) cortex
• More isn't always better
  • odor constancy: perceived strength of an odor remains constant despite variations in the flow rate
• People's odor identification abilities are so poor (~50% for simple smells), your friends won't be able to tell you you're wrong (even if they're wine snobs)

Wine Tasting


7. Take a mouthful.
8. Draw in a little air through your mouth and suck it through the wine. "Chew" the wine.

Why?
• back door flavor: some argue that odors arriving in the nostrils from the mouth are processed differently than those arriving through the nose
• this may explain why some foods smell bad but taste good or vice versa
• slurping and chewing help cover the whole tongue and make the wine more volatile



Wine Tasting


9. Assess the wine's taste
   • acidity
   • tannin (bitter, astringent)
   • fruit
   • alcohol (burning)

Evaluate the wine with common terms (good, bad, fruity, grapy, spicy, sweet) or more pretentious terms (buttery, earthy, green, honeyed, oaky, petrolly, plummy, steely)

Why?
• While taste is actually quite limited (5 aspects), the flavor and texture add a lot ("full-bodied" = high in alcohol and/or tannin)
• Wine is complex – remember flavors don't add in a straightforward manner, they're a "complex tapestry"
• Have fun! It's all subjective anyway.