Olfactory System

Date: 03/13/13

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Objectives:

- To demonstrate three aspects of how the human olfactory system makes sense of chemicals encountered in our environment
    1. **Retronasal olfaction**: when we chew food, volatile chemicals are released from the food and travel through the nasopharynx to interact with olfactory sensory neurons in the olfactory epithelium. This sensation constitutes a large part of what we experience as "flavor".
    2. **Synthetic odor processing**: natural odors are often mixtures of scores of unique molecular components, yet the olfactory brain synthesizes the response generated by each of these components into a unified perceptual experience, without conscious awareness of the components themselves.
    3. **Odor detection threshold**: there is a limit to the capability of the human nose to detect very weak chemicals, and this detection threshold changes over the course of life.

Materials and Supplies Needed:

Item	Quantity	Notes (Vendor, price, purpose, etc.)
Plastic squeeze bottles	12	To hold the odor samples
Cotton balls	~12	To absorb liquid odor samples
Isoamyl acetate (banana odor)	1	Odor used in detection threshold samples: Sigma-Aldrich W205508, sample is $40
Isovaleraldehyde	1	Peanut butter odor component: Sigma-Aldrich W269204, sample is $40
Acetic acid	1	Peanut butter odor component: Sigma-Aldrich 320099, 500mL, $48
1-methyl-1H-pyrrole	1	Peanut butter odor component: Sigma-Aldrich W509973, sample is $40
Benzaldehyde	1	Peanut butter odor component: Sigma-Aldrich W212717, sample is $40
3-ethyl-2,5-dimethylpyrazine	1	Peanut butter odor component: Sigma-Aldrich W314900, sample is $40
Jelly Beans	1	1 16 oz. container each of four different flavors purchased from JellyBelly.com: Tangerine, Cherry, Green Apple, Banana. Each container costs approximately $9.00
Jar of natural peanut butter	1	Can be any brand, natural chosen because sample will be taken form the oil layer on top, cost $4-5
Posterboard	1	For recording results of detection threshold test
Stickers	Many	For recording results of detection threshold test (serves as data points to be plotted on the posterboard)

Background Information / Activity Explanation:

The human olfactory system is designed to sense volatile chemicals encountered in the environment. These chemicals interact with olfactory sensory neurons that line the olfactory epithelium in the back of the nasal cavity. Olfactory sensory neurons send electrical impulses to the olfactory bulb, which in turn projects to the primary olfactory cortex at the junction of the frontal and medial temporal lobe of the brain.

There are two primary ways that odorous molecules reach the nasal cavity. The first and most obvious is called **orthonasal olfaction**, where sniffing air through the nose brings the molecules to the olfactory epithelium. The second, less appreciated route is through **retronasal olfaction**, whereby odor molecules travel through the back of the throat (the nasopharynx) up to the nasal cavity. When we eat, retronasal olfaction provides much of the multisensory experience we know as "flavor", which also includes gustatory sensation from the tongue and somatosensory sensation from the mouth. An easy way to demonstrate the importance of retronasal olfaction for flavor is to simply pinch your nose the next time you take a bite.

A primary goal of sensory systems in general is to combine the brain signals generated by "low level" stimulus features into a single meaningful perceptual object. For example the image of a cup might consist of lines, contours, shading, and colors. Using our visual system we can recognize and describe these low level features, but also recognize the unified object as "cup". Using our olfactory system we can recognize combinations of molecules as distinct odors. For example, the smell of chocolate is a mixture of over 500 distinct molecules, yet we easily recognize this complex mixture as "chocolate". However, unlike the visual system, we do not have perceptual access to the low level features. Humans, in fact, are capable of picking out only 3 or 4 attributes of a smell, no matter how complex it is. The neural processes by which the olfactory brain generates these synthetic perceptual odor objects is an area of active research.

Procedures:

Retronasal Olfaction:

1. Mix jelly beans of different flavors/colors in a bowl.
2. Instruct participant to pinch their nose shut, close their eyes, and choose one jelly bean from the bowl at random
3. With eyes still closed, instruct participant to chew the jelly bean and attempt to guess the flavor
4. After the guess is made, participant can open eyes, un-pinch their nose and guess again
5. Should be very difficult to guess flavor with nose pinched because retronasal olfaction has been blocked

Synthetic Odor Processing:

1. Prepare diluted samples of each of the 5 peanut butter odor components. Pure (~98%) samples purchased from Sigma-Aldrich will be diluted in either mineral oil or diethyl phthalate.
2. Only 1mL of the diluted sample is needed. First make a 1% solution of each odor sample
3. Put one cotton ball into each squeeze bottle.
4. Pipette approximately 0.5mL of each diluted solution onto the cotton ball in each squeeze bottle and label them "C1-C5"

5. Pipette approximately 0.5mL of the oil on top of the peanut butter jar onto the cotton ball of a separate squeeze bottle and label it “?????”
6. At the demonstration table, instruct participants to smell each of the 5 odor samples in turn, and try to guess which common food odor these components are found in.
7. After a guess is made, allow the participants to smell the actual peanut butter sample
8. Small discussion on how most odors are mixtures, but our brain combines these component signals to a unified perceptual experience: e.g. peanut butter

Odor Detection Threshold

1. Prepare a dilution series of odor samples using isoamyl acetate (banana odor, but could be anything safe/pleasant) diluted in mineral oil
2. Dilution series should include one sample each of 0.0001%, 0.001%, 0.01%, 0.1%, and 1.0%
3. Pipette ~0.5mL of each dilution sample onto a cotton ball in a plastic squeeze bottle, as above
4. Prepare an odor “blank” bottle that contains a cotton ball but no odor sample
5. Label bottles in such a way that you will know their concentration but that cannot be seen by the participant.
6. During demonstration, start with weakest odor and the blank. Present them one at a time to the participant and ask them to guess which sample has the banana odor.
7. If they get it wrong, increase the concentration and try again
8. Proceed until participant gets it right twice in a row (or three times if you have enough time)
9. Have participants record their detection threshold on a histogram prepared on the posterboard – use stickers as data points
10. Prepare one histogram for kids and one for adults, plotting each separately as you determine them
11. Demonstrate who has a “better nose”, kids or adults