Somatosensation

Objectives: Discuss the sense of touch and its components. Determine the relative sizes of fine touch sensitive receptive fields by completing 2 pt touch discrimination testing on different parts of your body. Discuss how hot and cold are, at their root, chemical phenomena.

Concepts

- There are many types of different touch receptors that respond to different types of tactile stimulation
- Perception is relative, and sensory input can be perceived differently based on the environment.
- Different parts of the body have larger or smaller receptive fields- areas of the body that are more “important” in the sense of touch, like face and fingers, have small distances of 2pt touch discrimination and take up a relatively large part of the brain area devoted to touch (somatosensory cortex and homonculus). Less important parts of the body, like back and legs, have relatively larger receptive fields, fewer receptors, and take up less space in the brain

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Setup:

Materials: Calipers (6), Ice, hot water, lukewarm water, plastic cups, pen, skin receptor handouts, JND handouts, water heater

Teacher Preparation: Print and bring various handouts, bring supplies

Classroom Preparation: Distribute calipers, dilute hot water to make sure hot water will not burn students, distribute ice water, hot water, and lukewarm water to cups and hand out to the different groups.

Introduction

Cutaneous rabbit illusion demonstration

Jon will demonstrate the cutaneous rabbit illusion on a few lucky volunteers at the front of the class.

The cutaneous rabbit is a tactile illusion evoked by tapping two or more separate regions of the skin in rapid succession. The illusion is most readily evoked on regions of the body surface that have relatively poor spatial acuity, such as the forearm. A rapid sequence of taps delivered first near the wrist and then near the elbow creates the sensation of sequential taps hopping up the arm from the wrist towards the elbow, although no physical stimulus was applied between the two actual stimulus locations. Similarly, stimuli delivered first near the elbow then near the wrist

evoke the illusory perception of taps hopping from elbow towards wrist. While the rabbit illusion has been most extensively studied in the tactile domain, analogous sensory saltation illusions have been observed in audition and vision.

From Wikipedia, the free encyclopedia https://en.wikipedia.org/wiki/Cutaneous_rabbit_illusion

Video demonstrating: https://www.youtube.com/watch?v=Mith4TPLrb4 Best reaction at around 3:40

Group Work (40 minutes):

To reduce wasted time, every group will be doing both experiments. We will not transfer between groups for this lesson.

Group Introductions

1. How do you think your sense of touch works? Have you learned anything previously in or out of school?

Get them to discuss the sense of touch, see if they have any interesting experiences (e.g., rubbing your nails on a file or chalk can be unpleasant without hurting). Try to get them to answer that nerves send signals to the brain, and clarify the idea of a touch receptor from there.

2. We've talked a little bit about the different receptors for seeing and hearing- do you think there's one type of touch receptor? Many? What are some different types of touch that would be useful to sense?

See if you can get the students to divide into different viewpoints - have them use intuitive guesses to try to decide if it makes sense for there to be one type of touch receptor, or many.

Show printout of receptors in the skin

Below is a list of just some of the mechanical receptors, and what they sense. There are additional receptors not shown here or on the diagram.

Characteristics of sensory receptors in the skin			
Receptor	Stimulus	Sensation	Adaptation
Merkel's disk	Steady indentation	Pressure	Slow
Meissner's corpuscle	Low frequency vibration	Gentle fluttering	Rapid
Ruffini's corpuscle	Rapid indentation	Stretch	Slow
Pacinian corpuscle	Vibration	Vibration	Rapid

Hair receptor	Hair deflection	Brushing	Rapid or Slow

3. How do you think your sense of touch organizes itself in the brain?

Once again, start with a discussion on the matter. While we haven't talked about any brain mapping previously, there might be some people who know that specific areas of the brain respond to different regions.

After a decent discussion, show the somatosensory homunculus (it will be the Safe For Work edition). Get a few giggles, then point out the corresponding pictures about how the cortex maps to the body. Points to cover:

- Discuss how electrical/chemical stimulation in these regions will result in the feeling of something being there.
- These regions remain even when the limb is gone. Discuss phantom limb syndrome and the idea of using a mirror box to cure it (https://en.wikipedia.org/wiki/Mirror_box)
- This region can also screw up - it's possible that you can damage your brain in a way to get various *agnosias*. You can have an arm, and then not be able to locate it. If you see your arm, you would recognize an arm, but not recognize it as your own arm
- Region coverage is proportional to sensitivity of the limb (e.g., hands take up a huge amount of the brain compared to the torso)
- This region is 'right across the street' from the motor region.

Experiment 1: Thermosensation

Part 1

1. Place one hand/finger into each of two water baths (one hot, one cold) simultaneously for 1 minute.
2. Afterwards, place both hands simultaneously into a bath containing lukewarm water. What sensation do you feel in each hand?

Explanation: In this experiment, different groups of cutaneous thermoreceptors (which tend to be phasic) will undergo sensory adaptation. The result of differential adaptation of thermoreceptors, in turn, will illustrate how the same environmental conditions can be perceived in different ways based on the sensitivity of different sensors.

Part 2

Give diluted capsaicin and menthol oils for people to test on the backs of their hands - NOT THE FINGERS! The solutions shouldn't be too spicy, but someone will rub their eyes with their fingers at some point, and that would be bad. Explain that these chemicals are interacting with

the cold and heat receptors in their body - to your brain, there is no difference between these chemicals and actual temperature changes.

Experiment 2: 2 point touch discrimination

Start this group by immediately separating people into pairs. Hand out sharpies to each pair

Part 1

1. You will take measurements from different body part locations: Fingertip, palm of hand, forearm, forehead.
2. The worksheet will have the following table for each section:

	2P	2P	1P	2P	1P	1P	2P	1P	2P	1P	%
5mm											
10mm											
20mm											
35mm											

4. Students will adjust the calipers to the proper length, then place either 2 points or 1 point on the region of the body in question. The subject will respond whether they feel 1 point or 2, and the experimenter will right down if they were correct (check mark) or incorrect (X-mark) Once the pattern is established, this should progress quickly.

5. Students should shift between experimenter and subject each body part.

6. After everyone is done, calculate the percentage correct (there are 10 trials, so this should be easy) as a proxy for sensitivity.

Expected receptive field: These data (rounded) are from a 2-pt discrimination threshold experiment (published in *The Skin Senses*, edited by D. R. Kenshalo, Springfield, IL, 1968).

Site	Threshold Distance		
Fingers	2-3 mm	Forearm	35 mm
Upper Lip	5 mm	Upper arm	39 mm
Cheek	6 mm	Back	39 mm
Nose	7 mm	Shoulder	41 mm

Palm	10 mm	Thigh	42 mm
Forehead	15 mm	Calf	45 mm

Part 2 - Pen task

Present this as something they can show their friends.

Either use a co-mentor, or a volunteer student to demonstrate. Using a sharpie, mark your partner on the finger while he/she are looking away. Hand them the sharpie (while they are still looking away), and have them mark where they thought you poked. Repeat on different parts of the body. This is a fast and dirty method of measuring 2 point touch discrimination and the sensitivity of various region on the body.

Students will keep doing this until the end of the class. Use this as question/answer time for students who are still interested.

Fun Facts

Below are some interesting and horrifying conditions you can discuss about pain and feeling.

Hypoalgesia: Hereditary sensory and autonomic neuropathies (HSAN), are hereditary disorders that are characterized by malfunctioning or nonfunctioning pain receptors. Most of these diseases are also associated with decreased temperature sensation as well. Diseases like this can be very dangerous for the patients, because they are not able to judge what hurts, and therefore when they should stop doing something. A child with the disease might bite their finger clean off before they realized that what they were doing might harm them, or they might leave their hand on a hot stove without ever realizing it was on. These examples support the theory that pain is essential for life, more specifically, survival.

Hyperalgesia: an increased sensitivity to pain, which may be caused by damage to nociceptors or peripheral nerves.

Allodynia: a pain resulting from a stimulus that does not normally provoke pain. An abnormal increase in sensitivity to stimuli of the sense.

Paresthesia: a sensation of tingling, tickling, pricking, or burning of a person's skin with no apparent physical cause. The most familiar kind of paresthesia is the sensation known as "pins and needles" or of a limb "falling asleep". A less well-known and uncommon but important paresthesia is formication, the sensation of bugs crawling underneath the skin