LSC 365 – Human Organism

Sensory and Reflex Physiology Lab

Goal

The aim of this session is for students to familiarize themselves with their senses, sensory-related phenomena, and some sensory illusions, and to collect data on certain aspects of the senses for further analysis.

Background

Conventionally, there are five senses: sight, hearing, taste, smell, and touch (visual, auditory, gustatory, olfactory, and tactile senses respectively). This is clearly an oversimplification. Additional sensory modalities include temperature, pain, vibration, joint position, and proprioception.

Many short but informative exercises in sensory physiology, such as those in this experiment, can be performed with simple equipment and everyday items. The materials needed for this experiment include:

- pins, paperclips or a compass
- white paper and a black pen
- a ruler
- a small flashlight
- small buckets or large beakers
- hot, cold, and luke-warm water
- 6 different experimental solutions
- cotton swabs

Sensory Physiology

Visual Receptors

Exercise 1: Accommodation (focusing)

The eye can accommodate (change focus) for far or near vision, by varying the shape of the lens.

1. Cover or close one eye, and hold a pin about 15 cm in front of the other eye, in line with some distant object.
2. Look at the distant object and note that the pin appears blurred and dim: it is out of focus.
3. Now look at the pin. Note that the distant object becomes dim and indistinct. Note also that accommodation for the near object (the pin) is accompanied by a feeling of effort.
4. Cover one eye and hold the pin at arm's length. While looking at the point of the pin, slowly bring it toward the face until it becomes blurred. The shortest distance at which the pin can be kept in focus is your 'near point'. Record this distance.

Exercise 2: The blind spot

The visual field for each eye includes a blind spot, representing the optic disc, a part of the retina with no photoreceptors because it is the location where the optic nerve leaves the eye.

1. Obtain a pen with a black tip and a white barrel. Alternatively, you can wrap some white paper around the barrel of a black pen, leaving only the black writing tip exposed.
2. Mark a small cross on a piece of white paper. Close the left eye and look steadily at the cross, with your eye at a distance of about 25 cm. For the rest of this exercise, keep your head completely still and continue to look at the cross.
3. Move the pen out (to the right) from the cross. At a certain distance the tip will become invisible. Mark this place with a spot on the paper.
4. Carry the pen further to the right, until it becomes visible again. Mark this place with another spot.
5. Similarly, mark the upper and lower limits of the blind spot.

With care and patience, the entire outline of the blind spot can be traced. It is oval in shape with irregular margins. The irregularities represent places where the retinal blood vessels emerge from the optic disc.

Hypothesize why you do not notice your blind spot in your day-to-day activities. Why isn't this an important safety hazard while you're driving?

Exercise 3: Mechanical stimulation of the retina

The eye has properties similar to those of a camera, in that the image formed on the retina is inverted. Light falling on the retina on one side of the eye gives a visual response in the opposite side of the visual field. Mechanical stimulation of the retina, by pressure on the eyeball, also gives a visual response that is inverted.

1. Turn your gaze to the left, and shut both eyes. Keep looking to the left.
2. With a finger-tip, press gently on the right side of your right eyeball, at the corner of the eye. Note the visual effect.
3. Slide your finger up and down, and note the direction of movement of the visual response.
4. Turn your gaze to the right, and similarly press on the left side of your right eyeball, at the corner of the eye. Again note the visual effect.

Describe the visual response to your mechanical stimulation. If you stimulate the right side of the retina, what and where do you see a response?

Why do you think that you can actually <u>see</u> something simply due to mechanical stimulation of your eyeball?

Exercise 4: The negative after-image

The sensitivity of retinal photoreceptors decreases gradually while they are being stimulated by light and increases while they are not. This *adaptation* to light and dark allows visual function

over a very wide range of light intensities. It has the side effect of giving rise to negative after-images.

1. Place a black object on a piece of white paper, or draw a black square on the paper.
2. Look directly at the black object for 30 seconds with your eyes at a comfortable distance from the paper. You may blink, but should take care to keep your gaze fixed.
3. Shift your gaze to a piece of plain white paper, and note the after-image of the black object. The image lasts for many seconds. The image is inverted in contrast (the black object gives a bright after-image), hence the name 'negative after-image'. How long does the after-image last? Does this depend on how long you look at the black object first?
4. Repeat with a colored object, and note the color change in the after-image. What color object produces what colored after-image?

Cutaneous Receptors

Exercise 5: Touch Localization

The density of tactile receptors in the skin differs greatly in different parts of the body.

1. Subject closes eyes. Experimenter touches and marks a point on the skin (gently).
2. With eyes still closed, subject uses a pencil to point to the same spot. Experimenter measures the distance from the subject's pencil tip to the marked point in mm.
3. Perform two trials in each region of the skin that you test, record both and average.

Perform this experiment on five different parts of body (e.g., the finger tip, the back of the hand, the back of the neck, the ankle and the foot). Be specific in your notes about the locations on the body you tested and be sure to note the distance at each location. Explain any differences you find.

Exercise 6: Two-point discrimination

The density of tactile receptors in the skin differs greatly in different parts of the body.

1. Take a metal paperclip and unfold it. Bend it into a U shape, with the wire points about 10 mm apart, or use a compass with tips 10mm apart.
2. Touch the two points gently on the palm of a subject's outstretched hand, and ask if one point or two is felt. With a separation of 10 mm, the double stimulus from the two points can be easily felt. Be careful to make sure that both points touch the skin at the same time.
3. Ask the subject to close both eyes. Bend the paperclip so as to bring the points closer together. By repeated trials with different point separations, find the smallest separation that the volunteer can distinguish as two points. You can test the truthfulness of the subject's responses, from time to time, by pressing only one of the points down.
4. Measure the separation of the points.
5. Repeat steps 3 and 4 with trials on five different parts of the body (e.g., the finger tip, the back of the hand, and the back of the arm, the ankle and the foot). Write down the distance between the points for each area of the body

Exercise 7: A thermal illusion

Many sensory systems show *adaptation*: a declining response to a continued steady stimulus. Temperature sensors in the skin adapt in this way, and so thermal sensations of warmth or cold are determined more by *changes* in temperature than by the temperature itself.

1. Obtain three containers (small buckets or large beakers). Fill one container with hot, but not painfully hot, water. Fill another with cold water, and fill the third with luke-warm water.
2. Place one hand in hot water, and the other hand in cold water. Leave them there for 30 seconds.
3. Now place both hands in luke-warm water. The water feels warm to one hand and cold to the other.

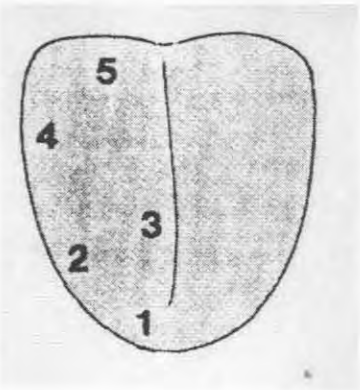
Hypothesize how and why this sensation occurs.

Chemoreceptors

Exercise 8: Taste bud distribution

Taste receptors ('taste buds') are found principally on the tongue, but also on the palate and pharynx. Four kinds of taste bud are recognized: sweet, sour, salt, and bitter. Each kind of taste bud has a characteristic spatial distribution on the tongue.

1. Get small cups of the experimental solutions. These solutions include the following but will only be numbered so that this is a "blind blind" test, where the subject and experimenter are unaware of which solution is being used. Map where each solution can be tested, and what it tastes like. At the end of the lab, your instructor will tell you what solution was composed of. You will have 6 different solutions to map on the tongue.
2. Dip a cotton swab into solution #1 and shake off excess solution- do not allow any drips to land on the tongue, the cotton swab should be damp but not soaked. Apply this to the back of the subject's tongue (region 5 in figure below), and ask the subject to report the sensation. Repeat at each of the other numbered regions on the tongue. Write down where the most intense taste was observed.
3. Repeat step 2, but with each of the other experimental solutions.
4. Map the locations on the tongue that are most sensitive to each of these solutions.



Are the two sides of the tongue symmetrically sensitive?

Reflex Physiology

The essentials of a reflex mechanism are a receptor organ, an effector organ, and some type of communications network connecting the two. Reflex action is initiated by an input stimulus and results in an output response. Reflex activity ranges from the simple axon reflex to complex reflexes in which the brain participates.

Many reflexes might be regarded as being programmed- that is, the appropriate response to the stimulus has been built into the nervous system. The spinal reflexes that require transmission form the periphery to the spinal cord and then back to the appropriate effector organ are examples of this kind of programming. For instance, if one experiences a painful stimulus such as burning a finger on a hot object, the spinal reflex immediately causes withdrawal of the finger from the offending object. No thought is required, and the reflex functions equally as well in an animal whose spinal cord has been divided above the location of the cell bodies of the participating nerves.

Other reflexes, such as eye reflexes, require action of centers in the brain. In these instances the appropriate response may need to be determined after several different inputs have been evaluated; hence, integrative function of the central nervous system is required.

In the next series of experiments you will investigate several types of human reflexes to demonstrate their integrative function at several levels of integration in the body.

A. The Patellar Reflex

1. Instruct the subject to sit on the lab bench with legs hanging over the edge. Tap the patellar ligament (just below the kneecap) with the reflex hammer.
2. Repeat this test under the following conditions:
   - Have the subject add a column of three three-digit numbers in their head.
   - Have the subject hold on to the lab bench and pull upwards as hard as possible.

   Record the results of each of these tests and note any differences between the reactions. Does the reflex occur when the muscles in the leg are already flexed?

B. The Achilles Reflex

Have the subject remove his or her shoes and socks and kneel on the lab bench with the feet extending over the edge. Lightly flex the subject's foot with your hand. Tap the Achilles tendon just above the heel (tap lightly). Record your results, noting any difference between the two legs.

E. The Pupillary Light Reflex

1. In a very dimly lit area (allow a few minutes for the eyes to adjust), measure the diameter of the subject's pupils and record theses values.
2. Now, stand to the right of the subject and have him or her place the shield against the side of the nose and next to the inside corner of the left eye. Shine a beam of light into the right eye and measure the diameter of <u>each</u> pupil in response to this stimulus.

F. The Ciliospinal Reflex

In the same dimly lit location, observe the reaction of both the left and right pupils in response to the *very light* touch of a clean dissecting needle on the back of the neck. Record your results.

Sensory & Reflex Physiology Post-lab Questions

1. **Describe the different types of sensory receptors and what each helps you to sense.**

2. **Draw the structure of a neuron and label its parts.**

3. **Explain what an action potential is and how it occurs.**

4. **What are the two main divisions of the nervous system?**

5. **What is the fight-or-flight response?**

6. **What is a reflex?**