Biology 13A Lab #8: Nervous System II — The Senses

Lab #8 Table of Contents:

Expected Learning Outcomes

At the end of this lab, you will be able to

- locate and identify structures in the sheep eyeball;
- explain the functions of parts of the eye;
- assess visual acuity using a Snellen eye chart;
- perform tests of the human somatosensory system; and
- explain receptive fields and sensory adaptation.

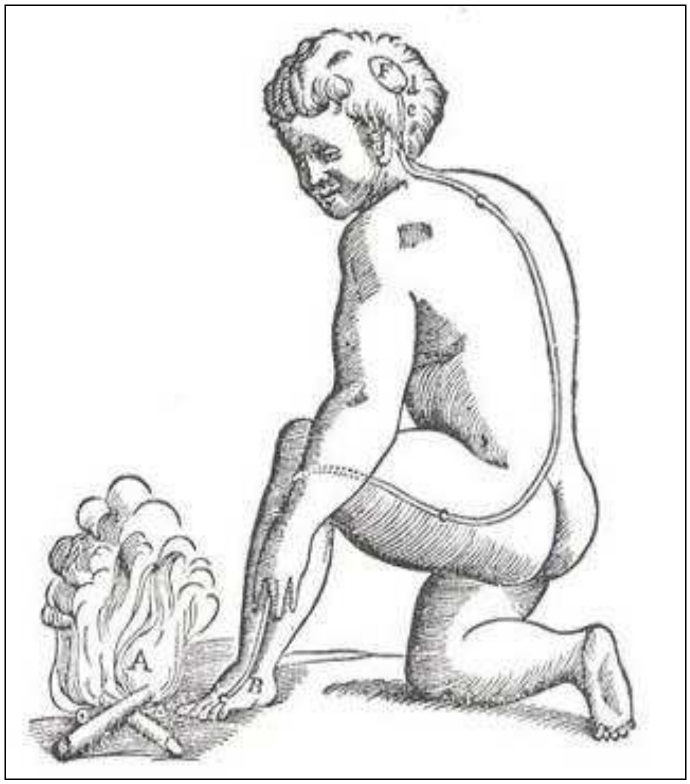


Figure 8.1 Descarte's concept of the pain reflex, from his *L'Homme de Rene Descartes*. 1664.

Introduction

A major job of the nervous system is to gather information about the internal and external environment and to integrate and process it so that we respond appropriately. When you are hungry, you eat, when you are cold, you are motivated to put on a jacket. This ability to “read” the environment and respond is obviously essential for survival.

Information-gathering structures in the body called **receptors** respond to a variety of stimuli; receptors in the eye react to light, those in skin sense touch, pressure, and temperature. Other receptors respond to pain or visceral stretch.

A huge amount of sensory information is constantly sent to the spinal cord and brain. **Sensation** is the physical act of responding to stimuli and converting it to an electrical signal to be sent to the central nervous system. **Perception** occurs primarily in the brain and is the process of organizing and interpreting sensory information. One aspect of this is screening information so that you can focus on what’s important. For example, during lecture, a student focuses on what the professor is saying and the powerpoint presentation, and ignores the sensation of clothing, the noise from a fan, the sunshine outside the window, the text messaging activity of a neighbor, etc.

The senses are organized into two groups. **General senses** include touch, pain, and temperature, and receptors are widely distributed throughout the body. **Special senses** are associated with complex structures in the head such as the eye and ear. Special senses are smell, sight, taste, smell, hearing, and equilibrium (balance).

Check Your Understanding: Answer the following questions based on your reading of the introduction.

1. Describe the general path of a signal for touch from the fingertip to the brain.
2. Define receptor, sensation, and perception.
3. Distinguish between general and special senses.
4. What is the difference between sensation and perception? Why do you think the distinction is important?

Activity 1: Sheep Eye Dissection

Part 1: Anatomy of the Eye

First, examine the eye model and identify the structures in bold letters. The eye is composed of external structures that are seen on the surface of the eyeball and internal structures visible only when the eye is cut open during dissection.

On the model, find the following:

- **Sclera**, the outer layer of tough, white connective tissue. The anterior portion of the sclera is modified to form a window, the **Cornea**, through which light can pass.
- **Conjunctiva**, the thin layer covering the inside of the eyelids and the anterior, exposed part of the eye. It attaches to the cornea anteriorly. It occasionally becomes infected and results in “pink-eye”, or conjunctivitis.
- **Pupil**, the circle that can be constricted to control the amount of light that reaches the center of the eye. The pupil is surrounded by the **Iris**, which has smooth muscles that can control the pupil size.
- **Choroid**, the layer under the sclera that consists of pigmented tissue that appears black.
- **Ciliary Body**, the black, anterior part of the choroid that looks like the underside of a mushroom top. It contains smooth muscle that changes the shape of the lens so that the eye can focus on objects in the near distance.
- **Lens**, a clear, marblelike ball that attaches by tiny threads to the ciliary body. In the sheep eye it is opaque because of the preservative, but in life it is crystal clear because of a unique arrangement of proteins.
- **Retina**, the filmy, beige layer that lines the inside of the back of the eyeball. It houses the photoreceptors, specialized cells (rods and cones) that are stimulated by light.
- **Optic Nerve**, a whitish, ropy structure that exits the back of the eyeball. It carries nerve impulses from the photoreceptors to the brain for interpretation.
- **Aqueous humor**, clear watery fluid between the cornea and the lens in the anterior section of the eyeball.
- **Vitreous humor**, jelly-like filling in the posterior section of the eyeball.

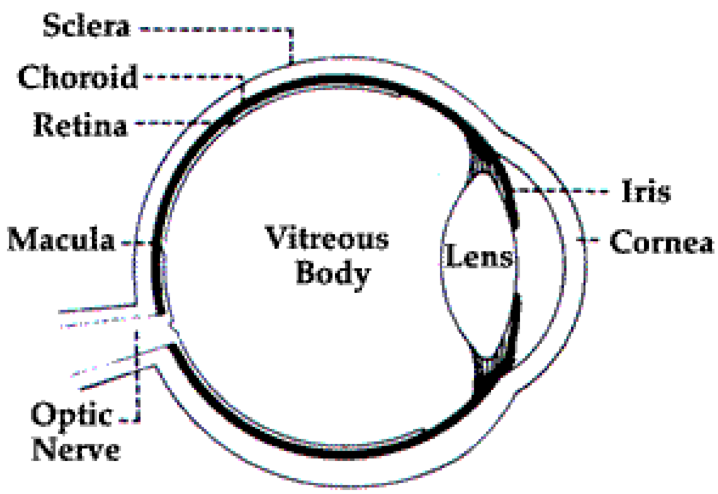


Figure 8.2 Anatomy of the Eye

Part 2: Dissecting the Sheep Eye

1. Each pair of students should obtain a sheep eye, dissection tray, and a bamboo stick to point out structures.
2. Identify the structures listed in bold in the paragraphs above. Identify the external structures first, then cut the eye in half in a coronal or frontal section so that the eyeball is divided into anterior and posterior portions. Note the iridescent structure at the back of the eyeball. It is called the *tapetum lucidum* ("carpet of light"). This feature is not found in the human eye, but is in animals that are adapted for living at night such as cats and deer.

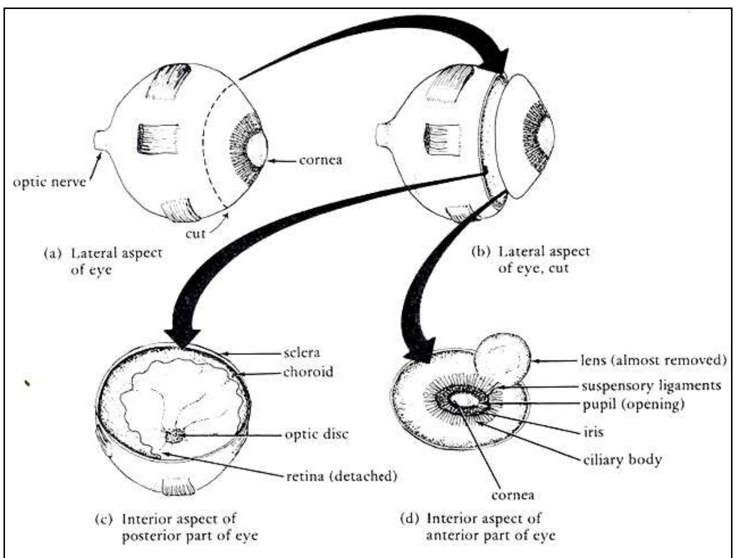


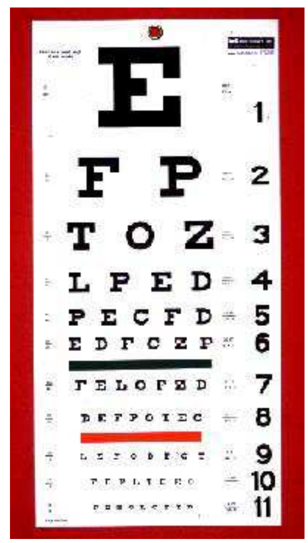
Figure 8-3. Dissection of the eye

Figure 8.3 Dissection of Sheep Eye

Check Your Understanding: Answer the following questions.

1. What structure of the outer part of the eyeball helps to provide protection and support for the inner part?
2. What structure in the eye has specialized nerve cells that receive information about light?
3. What is the shiny structure on the choroid at the back of the sheep eyeball? What is its function?
4. Compare and contrast structure and function of the ciliary body and iris.

Activity 2: Visual Acuity



Visual acuity is usually measured with a Snellen chart. The Snellen chart displays letters of progressively smaller size. "Normal" vision is 20/20. This means that the test subject sees the same line of letters at 20 feet that a typical person sees at 20 feet. 20/40 vision means that the test subject sees at 20 feet what an average person sees at 40 feet. Another way of saying this is that a person with 20/40 vision has vision that is only half as good as the average, or, objects must be at half the normal distance for her/him to see them. A person with 20/20 vision is able to see letters 1/10th as large as someone with 20/200 vision. However, 20/15 vision is better than 20/20. A person with 20/15 vision can see objects at 20 feet that a person with 20/20 vision can only see at 15 feet.

Levels of Vision

- 20/20 - Normal vision. Fighter pilot minimum.
  Required to read the stock quotes in the newspaper or numbers in the telephone book.
- 20/40 - Able to pass Driver's License Test in all 50 States. Most printed material is at this level.
- 20/80 - Able to read alarm clock at 10 feet. News Headlines are this size.
- 20/200 - Legal blindness. Able to see STOP sign letters.

1. Stand 20 ft. away from the Snellen chart, cover one eye, and read the letters out loud. Have a partner stand next to the chart to verify your reading. The numbers to the left of the last line you read correctly pertain to the vision rating for that eye. If you wear glasses, perform the test both with and without glasses.

2. Repeat for the other eye. Note that the set of numbers to the side of the row of letters always starts with 20. This number simply corresponds to the number of feet you are standing from the chart. The second number refers to the distance that a person with “normal” vision would be standing from the chart if that were the person’s last correct line.

3. Record visual acuity for each eye.

Left: ______

Right: ______

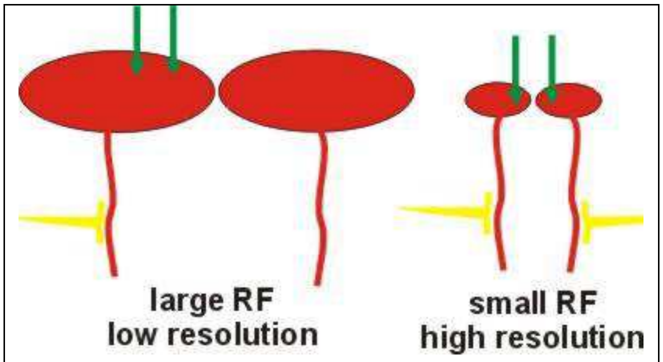
Activity 3: Somatosensory System Tests

The skin has numerous **mechanoreceptors** that respond to pressure and vibration and **thermoreceptors** that respond to temperature. When adquately stimulated, the receptors convert the mechanical or heat stimuli into electrical signals that travel along axons to the brain or spinal cord for interpretation.

Some areas of the skin are more sensitive to touch than others. The level of sensitivity depends on **receptor density** and the size of the **receptive field**. The receptive field is the area where a stimulus will cause a neuron to fire. For example, the receptive field of a mechanoreceptor in the skin is the patch of skin that particular neuron responds to. Large receptive fields allow a neuron (receptor) to sense changes over a large area but without much precision. In the most sensitive areas of the body, there is a high density of mechanoreceptors with small receptive fields.

A. Two Point Discrimination

The two-point discrimination test reveals the ability of the somatosensory system to determine if the skin is being touched in one or two points. If the two points are in an area of skin that has a low touch receptor density and large receptive fields, only one point may be perceived. If the two points are in an area of skin that has a high touch receptor density and small receptive fields, the subject may perceive those two points. That is, two stimuli are perceived as separate if they are stimulating the receptive fields of two different mechanoreceptors.



Receptive field size determines spatial resolution (the number of points that can be detected in a given skin area).

www.pc.rhul.ac.uk/.../ PS1061/L6/PS1061_6.htm

Figure 8.4 Receptor Fields

In this exercise you will test your partner's ability to perceive the stimulation of two different sensory receptors. This test provides an indirect measure of the density and receptive field size of touch receptors in different parts of the body. The individual being tested should close his or her eyes for the duration of the test! You should do the two-point discrimination test at six different locations: the five listed below and another of your own choosing. Record your data (results) on the chart below.

Materials:

- caliper, pins or toothpicks
- alcohol pads to clean tips
- short, metric ruler

Procedure:

1. Your partner, the subject of the experiment, should be seated comfortably, eyes closed.
2. Begin with the two points together. Gently (lightly touch the skin, do not poke the subject), place the tips of the pins to the skin at the same time.
3. Your partner, the subject, should report feeling one or two points.
4. Move the points 1 mm further apart and gently touch the tips of the pins to the skin.
5. Repeat steps 3-4 until the subject reports feeling two points.
6. Record the smallest separation distance (between the two points) that the subject reports feeling two points.
7. Repeat this procedure on at least five different skin regions.
8. Compare your results with the results of other students in the lab. Are the results consistent from subject to subject?

Results:

Location	Smallest separation (distance) at which two points are detected (mm)
Fingertip (of index finger)	
Hand (Palm)	
Hand (Dorsal, back, surface)	
Back of Neck	
Lips	
Other Location:	

Think about it:
How can this test provide an indirect measure of the density (number per square cm) of receptors in different locations in the skin? How can this test provide information about the size of receptive field of touch receptors in different parts of the body?

B. Temperature Adaptation

Adaptation is the decline in frequency of nerve impulses (in a sensory neuron) even when a receptor is stimulated continuously and without a change in stimulus strength. That is, adaptation is occuring when a sensory signal decreases in the presence of an above-threshold, persistent stimulus. Adaptation is part of many sensory systems. For example, when we walk into a house before a holiday feast, the smell of the food is immediate and intense. After a few minutes we no longer sense these odors at the same intensity. Adaptation allows the nervous system to disregard continuous sensory information and be prepared for changing or new incoming sensory stimuli. In this exercise you will demonstrate the phenomenon of temperature adaptation.

Materials:

- room-temperature water bath
- ice water bath
- hot water bath
- paper towels

Procedure:

1. Have your partner (his/her eyes can be open for this experiment) place one hand in the ice water bath and one hand in the hot water bath.
2. Record your partner's immediate perceptions.
3. Wait two minutes. Record your partner's perceptions at this time. Did one hand adapt more quickly than the other? (If this is too painful, do not keep your hand in the cold water for 2 minutes!)

4. Have your partner remove both hands from the water at the same time and place both hands in the same room temperature water bath. Did one hand adapt more quickly than the other? Record your partner's immediate perceptions for each hand.

Results:

Perceptions immediately after putting hands in hot and cold water:

Cold water hand: ______________________________

Hot water hand: ______________________________

Perceptions after 2 minutes in hot and cold water:

Cold water hand: ______________________________

Hot water hand: ______________________________

Perceptions immediately after putting hands in room temperature water:

Cold water hand: ______________________________

Hot water hand: ______________________________

Think about it:
Did the two hands feel the same when placed in room temperature water? Why or why not? Why do we feel cold at 60° F in the summer and warm at the same temperature in the winter? What is the advantage of temperature adaptation? (or is it a disadvantage?)

Check Your Understanding: Answer the following questions.

1. What does 20/20 vision mean?
2. Which location in the body had the smallest separation (distance) at which two points are detected? What can you conclude about the density and size of receptive fields in the areas with the largest and smallest separations?
3. Explain the functional, adaptive reason that receptive fields and density would differ from place to place in the body? What is the area of greatest sensitivity and why is it so sensitive? What is the area of least sensitivity and why isn't it more sensitive?
4. Describe the advantages and disadvantages of temperature adaptation.

Thanks to Dr. Jenny McFarland for the somatosensory exercises for this lab.