Sensory Physiology Lab

These labs are designed to help you understand how the special senses work. You do not need to do them in any particular order (there aren't enough materials for all groups to do all the experiments at the same time anyway). Record your results in your lab notebook.

Exercise 1. Cutaneous Receptors:

Materials:
Thin bristles, cold and warm metal rods
Calipers, cold and warm water baths and thermometers
Grid stamp and stamp pads

Sensory receptors in the skin transduce mechanical or chemical stimuli into nerve impulses, but it is the brain's interpretation of the action potentials that creates the sensory perception.

A. Mapping the temperature and touch receptors of the skin (warmth, cold, touch and pain).

Procedure:
1. With a ballpoint pen, draw a square (2cm per side) on the ventral surface of the subject's forearm.

2. With the subject's eyes closed, gently touch a dry, ice-cold, metal rod to different points in the square. Mark the points of cold sensation with a dark dot.

3. With the subject's eyes closed, gently touch a dry, warm metal rod (heated to about 45° C in a water bath) to different points in the square. Mark the points of warm sensation with an open circle.

4. Gently touch a thin bristle to different areas of the square and indicate the points of touch sensation with a small x's.

5. Reproduce this map in your lab report.

B. The Two-Point Threshold in Touch Perception. The density of touch receptors is measured by the two-point threshold test.

Procedure:
1. Starting with the calipers wide apart and the subject's eyes closed, determine the two-point threshold on the back of the hand. (Randomly alternate the two-point touch with one-point contacts, so that the subject cannot anticipate you.)

2. Repeat this procedure with a palm of the hand, fingertip, and back of the neck, arm and leg.

3. Write the minimum distance (in mm) in a data table.
Describe your results.

C. Adaptation of Temperature Receptors. Sense receptors respond strongly to acute changes in our environment and then stop responding when the stimuli become constant. This phenomenon is known as sensory adaptation.

Procedure:
1. Place one hand in warm water (about 40° C) and the other in cold water, and leave them in the water for a minute or two (remove them if the water becomes too uncomfortable).

2. Now, place both hands in lukewarm water (about 22° C) and record your observations and conclusions regarding your sensations.
Describe your results.

D. Referred Pain. Amputees frequently report feelings of pain in their missing limbs as if they were still there; this is part of the phantom limb phenomenon. The source of nerve stimulation is trauma to the cut nerve fibers, yet the brain perceives the pain as coming from the amputated region of the body that had originally produced the action potentials along these nerves.

Procedure:
1. Gently tap the ulnar nerve where it crosses the median epicondyle of the elbow.

2. Describe the locations where you perceive tingling or pain. Was this feeling perceived to be in a different location than where the mallet struck? If so, where? Describe the importance of referred pain in the diagnosis of deep visceral pain and give examples.

E. Reflex Arc
Materials:
Rubber mallets
Blunt probes

In a reflex, specific sensory stimuli evoke characteristic motor responses very rapidly because few synapses are involved. Because specific simple reflexes occur at a specific spinal cord segment and involves particular nerves, tests for simple reflex arcs are very useful in diagnosing neurological disorders. Muscles have stretch receptors called muscle spindles responsible for monosynaptic arc reflexes.

Knee-jerk or Patellar reflex : Muscles stimulated (quadriceps femoris) are extensors - they increase the angle of a joint. The flexor muscles are the hamstrings. Striking patellar ligament stretches tendon and quadriceps femoris muscle. Other reflexes: Bicpes jerk, triceps jerk, ankle jerk

Report your results:

Exercise 2: Ears: Cochlea and Hearing

Materials:
Tuning forks and rubber mallets

A. Conduction of Sound Waves Through Bone: Rinne's and Weber's Tests. Hearing is normally produced by the vibration of the oval window in response to sound waves conducted through the movements of the middle-ear ossicles; the endolymph fluid of the cochlea can also be made to vibrate in response to sound waves conducted through the skull bones directly, thereby bypassing the middle ear. This makes it possible to differentiate between deafness resulting from middle-ear damage (conduction deafness-otosclerosis) and deafness resulting from damage to the cochlea or vestibulocochlear nerve (sensory deafness-loud noises).

Procedure:
Rinne's Test:
1. Strike tuning fork with a rubber mallet to produce vibrations.

2. Perform Rinne's test by placing the handle of the vibrating tuning fork against the mastoid process of the temporal bone with a tuning fork pointed down and behind the ear. When the sound has almost died away, move the tuning fork (by the handle) near the external auditory meatus. If there is no damage to the middle ear, the sound will reappear.

3. Simulate conduction deafness by repeating Rinne's test with a plug of cotton in the ear. Notice that in conductive deafness, conduction by bone (via the mastoid process) is more effective than conduction by air.

Weber's Test:
1. Perform Weber's test by placing the handle of the vibrating tuning fork on the midsagittal line of the head and listen. In conduction deafness, the sound will seem louder in the affected ear (room noise is excluded but bone conduction continues), whereas in sensory deafness, the cochlea is defective and the sound will be louder in the normal ear.

2. Repeat Weber's test with one ear plugged with your finger. The sound will appear louder in the plugged ear because external room noise is excluded.
Report your results.

B. Binaural Localization of Sound. The ability to localize the source of a sound depends partly on the difference in loudness of the sound that reaches the two ears and partly on the difference in the time of arrival of the sound at the two ears. The difference in loudness is more important for high-pitched sounds where the sound waves are blocked by the head. The difference in the time of arrival for low-pitched sounds, which lengths are large enough to bend around the head.

Procedure:
1. With both eyes closed, the subject is asked to locate the source of a sound (e.g., a vibrating tuning fork).

2. The vibrating tuning fork is placed at the various positions (front, back, and sides about a foot from the subject's head), and the subject is asked to describe the location of the tuning fork.

3. Repeat the above procedures with one of the subject's ears plugged.
Report your results.

Exercise 3. Vestibular Apparatus - Balance and Equilibrium

Materials:
Swivel chair

The vestibular apparatus, located in the inner ear above the cochlea, consists of three *semicircular canals* (oriented in three planes), the utricle, and the saccule . The utricle and saccule together called *otolith organs*, and provide a sense of linear acceleration. These structures, like the cochlea are filled with *endolymph* and contain sensory cells activated by bending. These sensory hair cells of the semicircular canals support numerous hair-like extensions, which are embedded in a gelatinous "sail" (the cupula) that projects into the endolymph. Movement of the endolymph fluid, induced by acceleration or deceleration, bends the extensions of the hair cells. The sensory hair cells of the utricle and saccule serve to orient

the head with respect to the gravitational pull of the earth. This exercise will test the effect of vestibular activity on the extrinsic muscles of the eye by producing involuntary eye oscillations vestibular nystagmus.

Procedure:
1. Have the subject sit in a swivel chair with the eyes open and the head flexed 30 degrees forward (chin almost touching the chest). Rotate the chair quickly to the right for 20 sec (about 10 revolutions). After noting the initial nystagmus, have the subject close their eyes.
*** Note**: *Only subjects who are not subject to mention sickness should be used. The exercise should be stopped immediately if the subject feels sick.*

2. Abruptly stop the chair and have the subject open their eyes as wide as possible. Note the direction of nystagmus (left to right or right to left) and document the results in your lab notebook.

3. Repeat this process (using different subjects), alternating with the head resting on the right shoulder and the left shoulder (this stimulates the vertical canals), and note the direction of the post-rotational nystagmus. Report your results.

Exercise 4. Taste & Smell Perception

Materials:
Cotton swabs
Solutions of 5% sucrose, 1% acetic acid, 5% NaCl and 0.5% quinine sulfate
Smell kit

There are five modalities of taste perception: sweet, sour, bitter, salty and umami (which detects the amino acid glutamate). The taste buds consist of specialized epithelial cells arranged in the form of barrel-shaped receptors, associated with sensory (afferent) nerves. Long microvilli extend through a pore at the external surface of the taste bud and are bathed in saliva.

Procedure:
1. Dry the tongue with a paper towel and, using an cotton swab, apply a dab of 5% sucrose solution to the tip, sides and back of the tongue.

2. Repeat this process using 1% acetic acid, 5% NaCl and 0.5% quinine sulfate, being sure to rinse the mouth and dry the tongue between applications.
*** Note**: *Apply quinine sulfate last; the effect is dominant and often lingering.*

3. Sketch your results in the lab notebook (record the location where you tasted each solution).

Smell Kits
Smell kits are available. Work in pairs and try to determine if you can name the odor in each of the vials. Also, report if any of the vials elicits emotions or memories. Check your ability to identify the odors with the answer key.

Exercise 5: Eyes and Vision

Materials:
Snellen and astigmatism charts
Wire screens and meter sticks, rulers
Flashlight
Pins

The elastic properties of the eye lens allow its refractive power to be varied so that the image of an object from almost any distance can be focused properly on the retina. Photoreceptors - rods and cones - are located in the retina. The refractive abilities of the eye and the functions of its inner structures are routinely tested in eye examinations.

A. Refraction: Test for Visual Acuity and Astigmatism.

The refractive power of the cornea and vitreous humor is constant. The strength of the lens can be varied by making it more or less convex.
The strength of a lens is expressed in diopters:

$$\text{Strength (diopters)} = \frac{1}{\text{focal length (meters)}}$$

The refractive power of the normal eye when an object is 20 feet or more away is 67 diopters. To correct visual defects, the individual must either adjust the distance between the eye and the object or wear corrective lenses that change the degree of refraction. When a distant object (20 feet or more) is brought in front of the retina, the individual is said to have myopia (nearsightedness), generally due to an elongated eyeball. Glasses with concave lenses may be used to correct myopia. In Hyperopia (hypermetropia or farsightedness, the image is brought to a focus behind the retina, generally because the eyeball is too short. Glasses with convex lenses may be used to correct hyperopia.

Astigmatism is a visual defect produced by an abnormal curvature of the cornea. Or lens or by an irregularity in their surface. Because of this abnormality, the refraction of light rays in the horizontal plane is different from the refraction in the vertical plane. Astigmatism is corrected by cylindrical lens.

Procedure:
1. Stand 20 feet (6 m) from the Snellen eye chart. Covering one eye, attempt to read the line with the smallest letters you can see. Determine the visual acuity form the chart. Repeat the procedure with the other eye.

2. Stand about 20 feet from an astigmatism chart, and cover one eye. This chart consists of a number of dark lines radiating from the central point, like spokes on a wheel. If astigmatism is present, some of the spokes will appear sharp and dark, whereas others will appear blurred and and lighter because they are coming to a focus either in front or behind the retina. Repeat the procedure using the other eye.

3. Repeat the test is applicable using glasses. To verify that astigmatism has been corrected, hold the glasses in front of your face while standing 10 feet from the chart and rotate the glasses 90**°.** The shape of the wheel should change when glasses are rotated. Report your results.

B. Pupillary Reflex
The correct amount of light is admitted into the eye through an adjustable aperture, the pupil, surrounded by the iris. Circular muscle constrict the pupil in bright light, whereas radial muscles work to dilate the pupil in dim light. These responses are mediated by the autonomous nervous system. Sympathetic nerves stimulate the radial muscles, and the parasympathetic stimulates the circular muscles to constrict the pupil.

Procedure:
1. Stay with the subject in a darkened room for at least 1 minute, allowing his/her eyes to adjust to dim light.

2. Shine a narrow beam of light (flashlight) from the right side into the subject's right eye. Observe the papillary reflex in the right eye and also in the left eye. The papillary reflex in the other (left) eye is called the *consensual reaction.*

3. Repeat this procedure fro the left side with the left eye.

Report your results.

C. The Blind Spot
The retina contains two types of photoreceptors, rods and cones. They synapse with other cells - bipolar neurons, which in turn synapse with ganglion cells whose axons form the optic nerve transmitting sensory information out of the eye into the brain. In the fovea, only one cone will synapse with one bipolar cell, whereas several rods may converge on a given bipolar cell. Rods are more sensitive to low levels of illumination (night vision), whereas cones require more light and provide color vision. The axons of all ganglion cells in the retina gather to become the optic nerve that exits the eye at the optic disc. This is also called the blind spot because there are no rods or cones in the optic disc, so an object whose image is focused here will not be seen.

Procedure:
1. Hold the drawing about 20 inches from your face with the left eye covered or closed. Focus on the circle; this is more easily done if the circle is positioned in line with the right eye.

2. Keeping the right eye focused on the circle, slowly bring the drawing closer to your face until it disappears. Continue to move the drawing slowly toward your face until it appears again.

3. Repeat this procedure with the right eye closed or covered.

Report your results.

D. Color Vision and Color Blindness
Theory of color: There are three systems red, green and blue. Color discrimination will be impaired if one system of cones is defective (color blindness) or has been bleached by continued viewing of an object. Color blindness is caused by an inherited lack of one or mote types of cones. Pigments are coded in the X chromosome, therefore color blindness is far more common in men.

Procedure:
1. Use the Ishihara test. Report your results.