Hearing Lab

Through the sense of hearing we are placed into direct, intimate contact with the surrounding world. Musical, vocal, and other sonic impressions flood us constantly. We possess a wealth of empirical data concerning the reception and transmission of sound in the human ear.

The normal human ear is sensitive to sonic frequencies ranging from about 20 to 20,000 Hertz (1 Hz = 1 cycle/second), although the range varies with age and other individual factors. Several mammalian species, including bats, dolphins and whales, and many rodents, can detect much higher frequencies. Elephants, on the other hand, detect lower frequencies. Sensitivity of the human ear varies with the sonic frequency. Hearing in humans is most sensitive in the range 500-4000 Hz.

DIRECT BONE CONDUCTION AND THE RINNE TEST

The conduction of sound through the middle ear is facilitated by the concerted action of the three smallest bones in the human body, the auditory ossicles. The outermost bone, the malleus (hammer), is secured to the inner aspect of the eardrum itself. The innermost bone, the stapes (stirrup), is positioned with its foot plate in the oval window of the cochlea. The incus (anvil) connects the two. These three bones respond to external impressions coming to the eardrum from the surrounding world and transmit the delicate vibrations to the fluid within the cochlea. This aspect of the hearing process is ordinarily referred to as the conductive phase.

Sound can also be transmitted to the fluid of the cochlea by direct conduction through the bones of the skull, i.e., by a process in which no vibrations pass through the auditory ossicles. This kind of direct bone conduction provides an alternative pathway for sound transmission in individuals with middle-ear defects. To some extent you hear the sound of your own voice through the mechanism of direct bone conduction.

The Rinne test, originally designed by the German otologist, Dr. A. Rinne, differentiates between conductive and sensorineural hearing impairments, and is an important aspect of auditory diagnosis.

A vibrating tuning fork is held against the mastoid process of the temporal bone (the knob at the base of the ear) until the subject can no longer hear the tone, at which time the investigator quickly places the fork in front of the ear. Someone with normal hearing can still hear the tone for a short time by direct air conduction and is said to be Rinne positive. Individuals with middle-ear defects usually are Rinne negative; that is, they hear better with temporal bone conduction than with conduction through the middle ear. Individuals with sensorineural defects (defects of the sensory mechanism in the cochlea itself, defects in the cranial nerve VIII, or central nervous system damage) are Rinne positive; that is, they can hear much better on a relative basis through air conduction than through bone. The auditory thresholds for Rinne positive, however, are much higher.

Materials: tuning forks, sterile cotton

Procedures
1. Direct bone conduction of sound can be demonstrated by placing the handle of an inaudible vibrating tuning fork in the middle of the forehead or in between the front teeth. The ears should be stopped with cotton or with the little fingers.
2. Students should work in pairs for this test; one as subject, the second as investigator. The investigator lightly strikes the tuning fork with a soft mallet (or their palm), and presses it to the mastoid process of the subject. As soon as the subject reports they can no longer detect the sound, the investigator positions the fork in front of the external ear. If the subject can hear the sound at this point, they are Rinne positive. Both ears should to be evaluated.
   Be sure to enter your results in the data sheet!
3. The test should also be conducted in the reverse manner; that is, air conduction followed by bone conduction, to verify the conclusions.
   Strike the tuning fork again and place the tuning fork close to the subject's ear.
   • Ask the subject to tell you when s/he can no longer hear the sound, then place the tuning fork on the subject's mastoid process (bone conduction). If the subject hears the sound again, s/he has conduction deafness in that ear and is Rinne negative.

Repeat these steps with just one ear, but this time simulate conduction deafness by putting a small piece of cotton in the ear.
AUDITORY ADAPTATION
The human senses of taste, smell, perception of warmth, and other senses as well, show fatigue or adaptation. We will investigate this phenomenon for hearing by carrying out the procedures described below.

Materials: stethoscope, tuning forks

Procedures
1. Students should work in pairs; one as subject, the second as investigator.
2. The subject places a stethoscope in their ears and sits in front of the investigator. The investigator strikes the tuning fork lightly with a soft mallet or with the palm of his hand and holds it close to the bell of the stethoscope so that the sounds received in each ear are approximately equal.
3. After a brief interval, the investigator then firmly pinches one tube of the stethoscope and repeats procedure 2. When the sound is reported by the subject to have diminished, the investigator releases the stethoscope tube, strikes the tuning fork again, and applies it to the stethoscope bell. What does the subject report?

AUDIOMETRY
The quantitative clinical evaluation of hearing capacity is ordinarily performed with a device known as the pure tone audiometer. This instrument produces tones of specific frequencies

Procedures
A series of tones will be played in the classroom. You will be instructed about the specific starting decibel level for each of the tones. As each tone is played, it is followed by one that is 5 dB lower in volume. Count how many tones you hear, and use the table on the chart to convert to dB, then graph. Would you expect to have the same hearing threshold for each of the tones played?

BALANCE (EQUILIBRIUM)
We all are aware that in sitting, reclining, or standing erect we have a very particular sense of being in a state of balance. Without this sense we would be unable to maintain a fully alert conscious life, as anyone knows who has experienced disequilibrium or vertigo. The sense of balance or equilibrium is dependent upon the proper functioning of an organ of the inner ear, the semicircular canals, but is also associated with sight, hearing, and the proprioceptive sense (the awareness we have of our body movements and of where our limbs are located in space).

Procedures
Students will work in groups of three for this experiment.
1. Use one of the flooring tiles to roughly outline the subject's foot.
2. The subject should stand in the tile with one foot and touch the other foot to their knee in any way they choose.
3. The test will measure the length of time the subject can remain standing in this position (with one foot within the drawn outline and the other foot touching the knee) to a limit of 90 seconds. One student will act as timer; the second will observe the movements of the subject and call out the moment when the trial is terminated.
4. With the procedure outlined above, test the ability of the subject to balance themselves under four separate conditions.
   a. With eyes open and ears unplugged.
   b. With eyes blindfolded and ears unplugged.
   c. With eyes open and ears plugged.
   d. With eyes blindfolded and ears plugged.
5. It is probably wise to rotate the subject, timer, and referee after each trial to minimize the effects of fatigue.
6. Record your data and collect the class data for analysis.

Demonstration of Barany's test to evaluate function of semicircular canals and dynamic equilibrium receptors.
• Choose a subject for this demonstration who does not readily experience dizziness or become nauseated when rotated. If the subject experiences nausea during the demonstration, immediately stop rotation.
• Choose two people who are prepared to support the subject after inducing vertigo and dizziness.
• Provide the subject with a chair or stool that can be rotated. Have the subject sit on the chair and hold onto the arms or seat for safety. Decide how the subject will position his/her legs during rotation to ensure safety and prevent interference. Position 3-4 students around the chair to prevent the subject from falling off the chair.

• Tell the subject to slightly tilt his/her head forward and eyes closed

• Carefully turn the chair or stool clockwise (to the right). Complete 10 turns, one turn per 2 seconds and stop suddenly. Be prepared to support the subject until vertigo and/or dizziness has passed. The subject will still experience rotation, indicating that the semicircular canals are functioning. Endolymph continues to move within the membranous semicircular ducts for a short time after rotation has stopped.

Observe which way the subject's eyeballs are moving immediately after stopping rotation. Lateral movement of the eyes indicates stimulation of the crista ampullaris in the lateral semicircular canals. Vertical movement of the eyes indicates stimulation of the crista ampullaris in the anterior semicircular canals. Rotational movement of the eyes indicates stimulation of the crista ampullaris in the posterior semicircular canals.

Repeat, but this time focus on a distant object, and keep both eyes open during the rotation. Repeat the demonstration with the subject's head tilted toward one shoulder, and then again with the subject's chin resting on his/her chest.

**Results**

**Rinne Test**

Right Ear

A. Could you hear the tuning fork first at the Mastoid _________ and then at the Ear _________

B. Could you hear the tuning fork first at the Ear _________ and then at the Mastoid _________

Rinne positive or negative

Left Ear

A. Could you hear the tuning fork first at the Mastoid _________ and then at the Ear _________

C. Could you hear the tuning fork first at the Ear _________ and then at the Mastoid _________

Rinne positive or negative

Right Ear with Cotton

A. Could you hear the tuning fork first at the Mastoid _________ and then at the Ear _________

D. Could you hear the tuning fork first at the Ear _________ and then at the Mastoid _________

Rinne positive or negative

**BALANCE**

Your Data

With eyes open and ears unplugged. _______  With eyes blindfolded and ears unplugged._______

With eyes open and ears plugged. _______  With eyes blindfolded and ears plugged._______

Class Data

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What conclusions can you draw concerning the roles of hearing and sight with balance? Are they equally important or is one “more” important. Use the lab results to back your statement up!

QUESTIONS

1. Why does a tape recording of your own voice (even a good one) seem unusual to you? Relate to nerve and conductive aspects of hearing.

2. Describe how middle ear damage would affect hearing. Why do many people with middle-ear damage tend to speak loudly?
3. Why don't figure skaters and ballet dancers get dizzy when they spin? (Hint: what do they do with their heads) Relate to inner ear function.

4. There are many “balance” positions in yoga. A person in one of those positions is advised to stare at an object in front of them. Given the results of this lab activity, why does this make good sense?
### Tone Frequency

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Graph class and your data on the axis.

![Approximate Hearing Threshold Graph](image)

Clearly define the term “hearing threshold”.

Were your thresholds the same for each frequency, or were there significant variations between them? Explain!

Older people tend to have elevated thresholds in the higher frequencies. Why not at all frequencies? (hint: think about the physiology of the basilar membrane)