LEARNING ACTIVITY II:
Vestibular-Ocular Reflex

OVERVIEW

In this activity, students will perform various investigations to understand the vestibular-ocular reflex and learn about the importance of visual cues in maintaining balance.

SCIENCE & MATHEMATICS SKILLS

Observing, communicating, collecting quantitative data, calculating frequencies, drawing conclusions.

PREPARATION TIME

10 minutes

CLASS TIME

50 minutes

MATERIALS

For IIA of the activity, each ***pair*** *or* ***group*** *of students will need the following items:*

- Pen or pencil
- Note pad
- Book

IIB of the activity will require the following:

- Chair that rotates smoothly—preferably with back and arms, such as a desk chair
- Watch or clock with second hand
- Note pad
- One blindfold (optional)
- Protractor
- Chalk
- String or yarn (3 feet)
- Push pin
- Yard stick for drawing lines
- Pen or pencil

MAJOR CONCEPTS

- The vestibular system helps to maintain balance and equilibrium.
- Vestibular-ocular reflexes coordinate eye movement relative to head movement.
- The nystagmus (one type of vestibular-ocular reflex) helps the eye to stabilize the field of vision after movement. The eyes usually move in the direction opposite the initial movement.

BACKGROUND

This lesson is similar to some of the exercises the Neurolab team conducted as they studied the vestibular function in space. It helps to demonstrate the importance of gravity and visual cues to the human balance and sensory systems. Gravity provides a continual downward force, which the vestibular system (particularly the otolith organs) uses to process information about motion and orientation. To understand the effects of space travel on the vestibular system, Neurolab scientists studied how the vestibular system reacts to certain stimuli, within Earth's gravitational field and under microgravity conditions.

The following activities will demonstrate the **vestibular-ocular reflex**, which is the body's way of coordinating signals from the visual field with signals from the vestibular organs of the inner ear. This reflex is extremely important for stabilizing vision when we are moving. When the head rotates or tilts in any direction, the eyes move in the opposite direction to compensate, maintaining a stable visual image. Therefore, movements of the eyes can provide clues about what is happening in the vestibular system. The eyes respond similarly to movement of objects outside the body. However, the vestibular-ocular reflex occurs only when the vestibular system is stimulated (in other words, when the head moves).

During these activities, students will observe eye movements and monitor the stability of the visual field during different types of movements: **saccadic**, the fast movement of the eye and **smooth pursuit**, the slow movement of the eye during the vestibular-occular reflex. In IIA, students will compare stability of a moving image under two conditions:
(1) when the object of vision is moving but the head is stationary; and
(2) when the head is moving but the object is stationary. When the head is stationary, the vestibular system is not activated, and the image blurs more quickly. When the head is moving, the vestibular system is stimulated and works together with visual and proprioceptive sensory systems to maintain a stable image.

In IIB, students will compare the effects of rotation on the sensation of spinning under varying conditions: (1) when the visual system is activated; (2) when the visual system is not activated; and (3) when the otolith organs are activated by a downward movement.

PROCEDURE

IIA: Stability of Moving Images

1. Assign each student a partner.
2. Have the partners stand about five feet away from each other. One student will be the subject, the other will be the recorder.

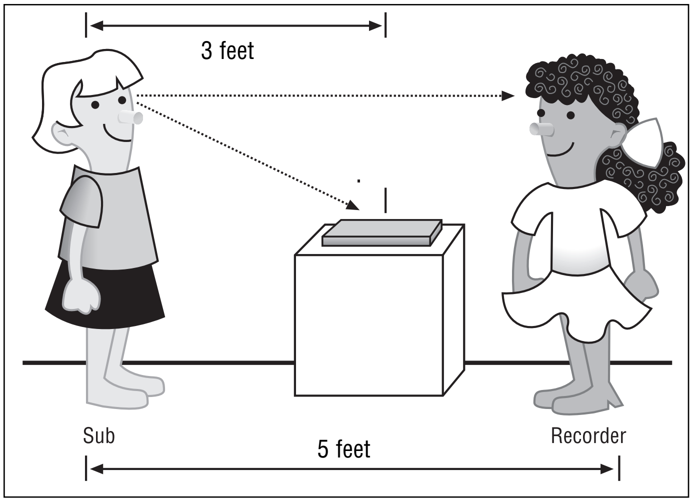

Figure 46 *Diagram of student observing saccadic eye movement.*

3. Tell the subject to look at his or her partner, and then to look away to a book placed about three feet away. The recorder should look at the subject's eyes and determine the type of eye movement he or she is exhibiting. The recorder should record the type of eye movement, saccadic or smooth pursuit.

4. Have the students reverse roles and repeat steps one through three.

5. Next, have each subject focus on the end of a pen or pencil held by the recorder about one foot in front of the subject's face. Tell the subject to hold his or her head still while the recorder moves the pen or pencil back and forth slowly in front of the subject's eyes. Instruct the recorder to move the pen or pencil from one side to the other as though he or she were trying to hypnotize the subject (Figure 47A).

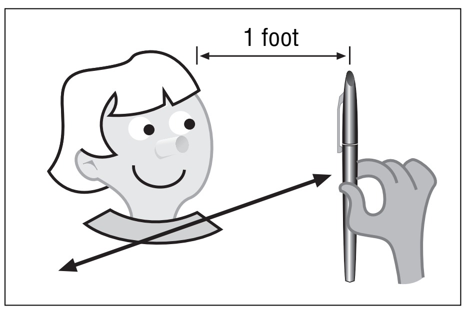

Figure 47A *Diagram of techniques for testing saccadic (fast eye movement).*

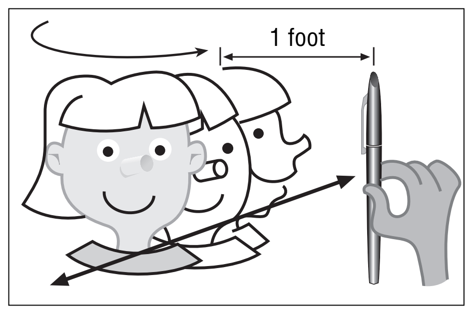

Figure 47B *Diagram of techniques for testing smooth pursuit (slow eye movement).*

6. Each partner should record the types of eye movement that are exhibited by the other: saccadic or smooth pursuit.

7. Let the team members switch roles and repeat the exercise.

8. Finally, have one student from each team hold a pen or pencil about a foot in front of his or her partner's face while the partner keeps his or her eyes on the pen or pencil. Both of the students should move their heads around while observing (Figure 47B).

9. Have the students record their observations of each other's eye movements.

10. Discuss these observations with the students. Ask if the eye movements were the same in each trial. Have students compare and contrast their observations.

IIB: Effects of Rotation on Vision

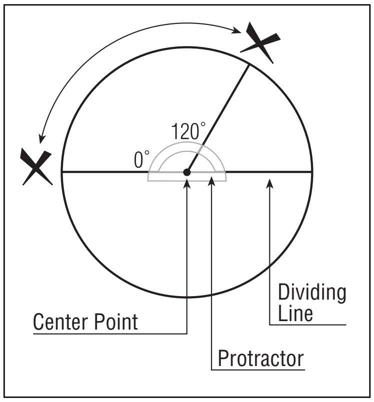

Figure 48 *Diagram of 120 degree floor drawing.*

1. Instruct students to draw a circle on the floor by attaching a three-foot string to a piece of chalk and attach the other end to a push pin. Have the students establish a dividing line by drawing a line through the center of the circle. They should then align the center point of the protractor with the center of the dividing line of the circle. Direct the students to place a mark outside of the circle at the dividing line (0˚). They should place another mark outside of the circle at 120˚. The students should make sure that the marks are visible to the person rotating the chair (Figure 48).

2. Select one rotating chair with arms for this activity and place the chair at the center of the circle. Since students will be spinning in the chair, caution them to exercise care. Students sitting in the chair should hold the arms of the chair during the rotation.

3. Before beginning, demonstrate to students how to turn the chair carefully, so that the student sitting in the chair does not tumble out. If necessary, review the procedure with the students to make sure that they understand what they are supposed to do.

4. Have students conduct the activity in groups. One student will be the subject, a second student will spin the chair and the remaining students will be recorders and time keepers.

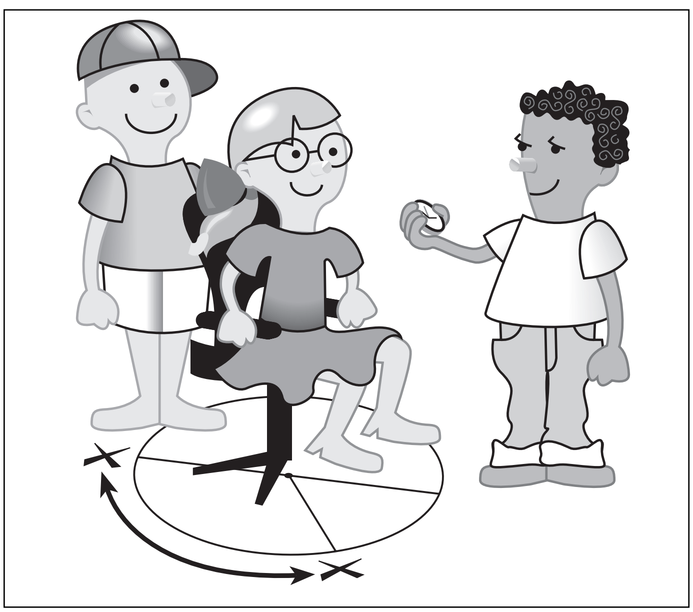

Figure 49 *Diagram of student rotating student 120 degrees per second.*

5. Have each subject sit erect in a rotating chair. Another team member should turn the student in the chair for a full minute at 120 degrees per second, then suddenly bring the student to a full stop (Figure 49).

6. The other members of the team should observe the eyes of the student sitting in the chair after it has been stopped. Using the watch, they should time how long it takes for the effect of spinning on the student's eyes to stop and record their observations.

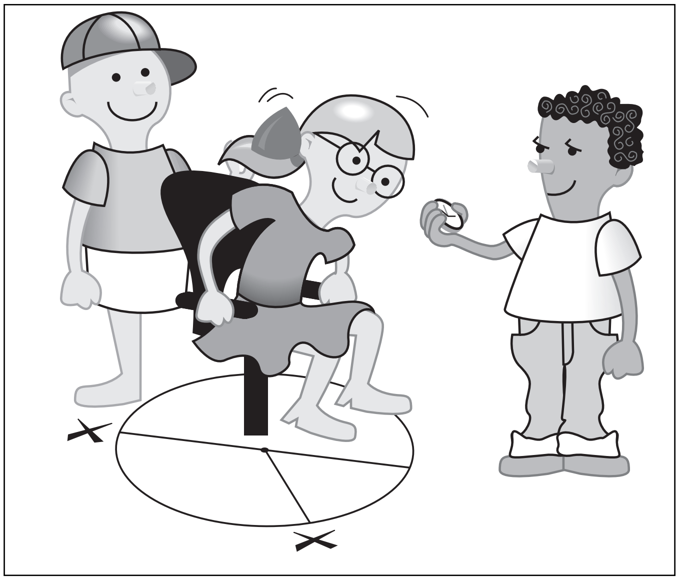

Figure 50 *Diagram of student rotating student 120 degrees per second while head is in pitched position.*

7. Have the students repeat step 3, but instruct the student in the chair to hold his or her head forward during spinning. The other partners should observe how long this student's eye movement lasts after the chair has stopped and then record these observations (Figure 50).
8. Have students within the groups switch roles so that they all will have an opportunity to participate in the various roles of this activity.
9. Have the students in each group summarize their data and present a group average of time required to stabilize eye movement after the spinning, both in step 3 and step 5.

Evaluation

REVIEW QUESTIONS

1. **What does the vestibular-ocular reflex do?**
   The vestibular-ocular reflex coordinates eye movement relative to head movement.
2. **What does the vestibular system do?**
   The vestibular system helps the body to maintain balance. It helps the body to determine the difference between motion of the body and motion of things in the world.
3. **What is the difference between "saccadic" and "smooth pursuit"?**
   There are two components of eye movement during the vestibular-ocular reflex. The fast movement of the eye is called "saccadic" and the slower movement is called "smooth pursuit."
4. **Why is the vestibular system important to movement?**
   It helps the body to maintain balance and to adjust to movements of the body as well as movements outside of the body.
5. **What is motion sickness?**
   The symptoms of dizziness, drowsiness, and nausea that are caused by the coriolis effect or pseudo-coriolis effect.

THINKING CRITICALLY

1. **Why do people who have problems with their vestibular systems suffer from motion sickness?**
   If the vestibular system is damaged, the signals going to the brain are inappropriate or missing, causing motion sickness.

2. **How is motion sickness related to visual cues?**
   The symptoms of motion sickness may be triggered by visual stimuli. The pseudo-coriolis effect is inducted by visual illusions of self-motion.

3. **What would happen if the vestibular system were destroyed? Explain how one would act and feel.**
   A person would have problems adjusting to movement and maintaining balance. The person may experience some motion sickness.

4. **Why might a person experience motion sickness when not moving or in an IMAX theater?**
   The visual illusions would overload the vestibular system producing the pseudo-coriolis effect.

5. **Will the vestibular system adapt to microgravity? Without gravity to give us a constant downward reference, how will the roles of visual and touch cues change?**
   The vestibular system would respond and adapt to microgravity. Without gravity, the vestibular system would have to make adjustments to the constant movement of the body just as it does when astronauts are in space.

SKILL BUILDING

Have students use the Internet to locate resources related to disorders of the vestibular system (Figure 51). How might Neurolab research provide insight into these disorders?

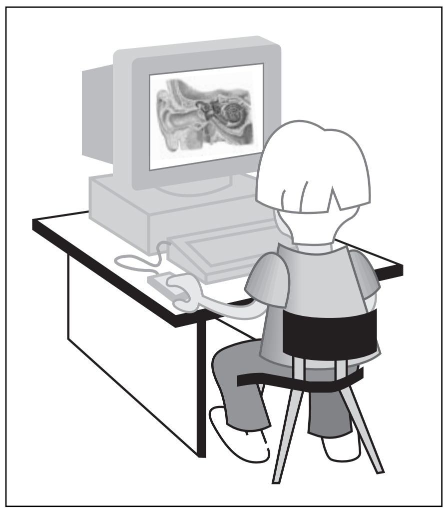

Figure 51 *Diagram of student using the Internet.*

STUDENT ACTIVITY SHEET

IIA. Stability of Moving Images

Name ______________________________ Date ______________

Head Position (stationary or side-to-side)	Description of eye movement (smooth or saccadic)	Subject	Recorder

STUDENT ACTIVITY SHEET
IIB. Effects of Rotation on Vision

Name ______________________________ Date ______________

Head Position	Description of eye movement	Length of time for eyes to stop moving	Person in chair (subject)	Person spinning (observer)