Life in Space Activity: The Vestibular System

Vestibular-Ocular Reflex in Microgravity

The vestibular system is the part of the central nervous system that controls balance. Balance is maintained through a whole range of sensory information entering the brain from touch, vision and the inner ear. The vestibular system senses information about the body's motion and helps us maintain equilibrium. It also tells us the difference between when we are moving and when something outside is moving.

The vestibular system is comprised of three semicircular canals (anterior canal, posterior canal and the horizontal canal), two membranous sacs called the otolith organs in the inner ear (Utricle and Saccule) and the areas of the brain that process the information from these organs.

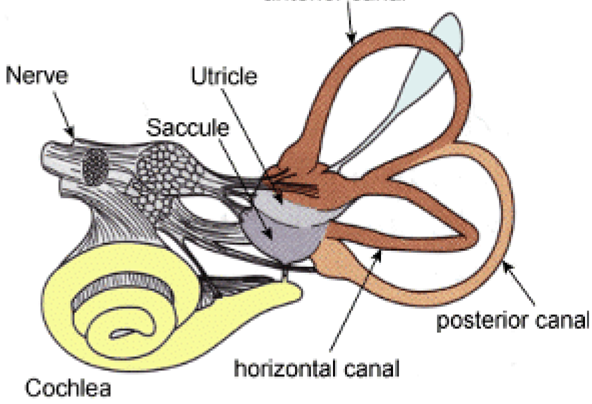

Figure 1: The Vestibular System

The canals contain fluid and hair. When the fluid in the canals moves the hair bends and a signal is sent to the brain about the direction the hair is moving, the brain then determines in which direction the body is accelerating or decelerating.

Because the three canals are orientated along each of the three axis it is possible to move the head the vestibular system can determine how the head moves in yaw (shaking), pitch (nodding) and rolling (ear to shoulder).

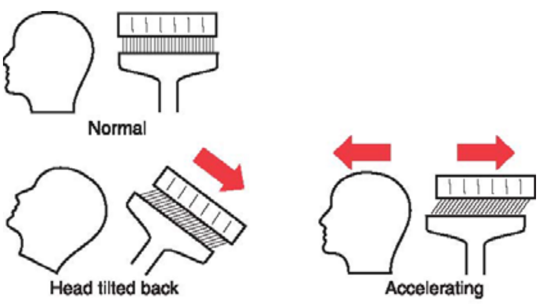

Figure 2: Otolithic organs sensing movement

The otolithic organs are also used for maintaining balance. Within the organs hairs are stuck into the walls and into the otolithic membrane. These membranes are made of a gelatine like substance loaded with otoliths (rocks). As the body moves the otolithic organs move with it but inertia causes the membrane to lag behind. This causes the hairs to bend. As the head tilts the membrane also moves causing the hairs to bend. In this way the brain can determine linear motion of the body and tilt.

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The eyes play an important role in balance, visual signals provide information about body position relative to surroundings. The eyes also move automatically in an opposite direction to the head to maintain a stable visual image. The co-ordination of eye and head movement is called the **vestibular-ocular reflex**. Without the vestibular-ocular reflex we would see the world bouncing up and down as we walk.

As you know the vestibular system relies on gravity to provide information about the position of the head. In the microgravity environment of space where the brain is receiving confused signals from the vestibular system the visual-ocular reflex breaks down. This means that while in space static visual acuity, the ability to see things while the body is at rest, is not affected but dynamic visual acuity, the ability to see things while the body is moving is different. As the eyes do not automatically move in relation to the head to hold a stable image as well as they do on earth it is more difficult for astronauts to see while moving their heads. Imagine the images from a video camera if you were filming while running, this is what you would see if your vestibular-ocular system wasn't working.

Scientists are studying the dynamic visual acuity of astronauts in space, undertaking experiments by having astronauts walk on a treadmill and asking them to identify numbers of varying sizes. The smaller the number the more difficult they are to distinguish, once astronauts cannot determine what the number is they have reached the limit of their visual acuity. Scientists are trying to determine ways of helping astronauts adapt to seeing clearly in space. To be fully effective while working in space astronauts need to be able to see clearly while moving their heads.

In today's activity you will undertake a similar experiment to investigate the visual acuity of yourself and a partner.

Activity Instructions

Materials Needed:

- Unlined White Paper
- Black Marker
- Ruler
- Measuring Tape

Procedure:

1. Using the markers and paper, make letter and number flashcards. The first card should have a letter or number that is 25 centimetres in height. The letters and numbers should then get increasingly smaller by 2.5 centimetre increments. Make one of the letters/numbers 2 centimetres tall and the last letter or number 0.5 centimetres tall. Use random numbers and letters so your partner will not simply guess the next card.
2. When each partner has completed his or her flashcards, move to an open area.
3. Using the measuring tape, mark off a distance of 3 metres. This is how far apart you and your partner should stand.
4. Place your flashcards in order so that the largest number is first and the last card is the smallest letter or number.
5. Standing 3 metres apart, have one partner do jumping jacks as the other flips through the flashcards. Stop when a flashcard is incorrectly identified. Record the number of correct responses.
6. Repeat Step 5 with the roles reversed. Remember to record results.
7. Standing 3 metres apart, have one partner stand still as the other flips through the flashcards. Stop when a flashcard is incorrectly identified. Record the number of correct responses.
8. Repeat Step 7 with the roles reversed. Remember to record results.
9. Answer the questions at the bottom of the Record Sheet.

Visual Acuity Record Sheet

Name	Number of Cards Correctly Identified (Jumping Jacks)	Number of Cards Correctly Identified (Standing Still)

1. Was there a difference between the visual acuity of the reader when he or she was standing still and performing jumping jacks? If so, what do you think caused this difference?

2. Do you think the body could adapt to the shakiness of doing jumping jacks and increase the ability to read when jumping?

3. Try the jumping jack part of the experiment again, and see if your reading abilities improve. Record the results below.

Name	Number of Cards Correctly Identified (Jumping Jacks)	Number of Cards Correctly Identified (Standing Still)

4. Produce of graph to show the results of your experiment.

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