Experiment 17: Oculomotor Muscle Activity

Background

The human eye has six muscles attached to its exterior surface. These muscles are grouped into three antagonistic pairs that control horizontal, vertical, and torsional movement and position of the eye:

- Around the vertical axis, the medial rectus muscle turns the eye toward the nose (adducts), and the lateral rectus muscle turns the eye away from nose (abducts).
- Around the horizontal axis, the superior rectus muscle turns the eye up (elevates) with a slight rotation toward the nose (intorts), and the inferior rectus muscle turns the eye down (depresses) with a slight rotation away the nose (extorts).
- Around the torsional axis, the superior oblique muscle rotates the top of the eye toward the nose (intorts) with a slight depression, and the inferior oblique muscle rotates the top of the eye away from the nose (extorts) with a slight elevation.

These muscles are innervated by motorneurons that have electrical activity with a tonic component that controls the position of the eye, and a phasic component that controls the velocity of eye movement. Even though the eye position commands and the eye velocity commands are linear functions of the firing frequency of the motorneuron, they are separate sets of commands. The eye velocity commands are sent along a direct path from specialized brain formations or fields to the motorneurons. However, the eye position commands are the products of the integration of eye velocity commands sent along a indirect path to a network of neurons that functions as a neural integrator. It is the output of the integrator that provides eye position commands to the motorneurons.

The integration of signals from different groups of neurons in the oculomotor system control five types of eye movement, each with a unique function and distinctive properties. These types are: saccades, pursuit, vestibular ocular reflex (VOR), vergence, and optokinetic reflex.

In this experiment, the subject will perform tasks that will generate electrical activity in oculomotor muscles that are unique to each of four different types of eye movement (saccades, VOR, pursuit, and vergence). The record of electrical activity from oculomotor muscles is known as electroculogram (EOG).

Saccades

The fovea is the region of the retina that sees in detail. Saccadic eye movements rotate both eyes so that image of interest falls on the fovea. You are using saccades at this very moment to point the fovea of your eyes at the words in this sentence. To compensate for the poor vision that occurs during saccades, saccadic movements are quick, with a velocity as high as 800 degrees of movement in a second. Saccades are also accurate because the saccadic system uses an internal estimate of eye position from its neural integrator to guide and stop the saccades.

Pursuit

This eye movement keeps the fovea pointed at a moving target, like a bouncing ball. There is an initial delay (latency) in pursuit movement because the signal from the eye, that indicates the object is moving, has be to conducted through many synapses to the brainstem. Initially, when the object starts to move, a saccade helps the fovea catch up to the object until the pursuit movement begins to track the object.

Vestibular Ocular Reflex (VOR)

This reflex keeps the image of the outside world stationary on the entire retina when the head moves. If you rotate your head to the right as you look this word, your eyes rotate to the left. VOR is a phasic response that is faster than pursuit because it is a simple central reflex arc that involves only three neurons. The signal that indicates the velocity of head movement originates in the semicircular canals of the ear and goes through an afferent nerve and an interneuron on its way to the motorneurons of the oculomotor muscles. The muscles rotate the eyes at a velocity that matches the velocity of the head, thus, keeping the image stationary on the retina.

The eyes are held on the image through a tonic response along an indirect path through a reverberating neural circuit between the afferent nerve and motorneurons. Without this neural circuit which is a short-term memory device, the eyes would drift back to center and off the image while the head was still rotated.

Vergence

This movement points the fovea of each eye onto an object when you look from a target that is distant to one that is closer, or vice versa. In vergence, the eyes rotate in opposite directions, unlike saccades where the eyes move in the same direction. Eyes converge when looking from far to near, and diverge when looking from near to far. Vergence is also important because it prevents double vision.

Optokinetic Reflex

This reflex is active when the full field of vision has moved across a large portion of the retina. Even though it is slower than the VOR, the optokinetic reflex is better suited for working on slow and prolonged movements. Thus, the optokinetic reflex compliments the vestibular ocular reflex, which is better on faster, less prolonged movements. This reflex can take place if a large object in your field of view is moving, you have the sensation that you are moving in the opposite direction even though you are stationary. The device used to test this reflex is known as an optokinetic drum, which projects a series of rotating images on the wall of a small circular room while the subject is seated in the center of the room.

Equipment Required

PC Computer
iWorx unit, and USB or serial cable
AAMI cable and ECG/EEG/EMG/EOG leads
Disposable ECG/EEG/EMG/EOG Electrodes
Alcohol swabs
Tennis ball on 5 feet of thin string

Equipment Setup

1. Connect the iWorx unit to the computer.
2. Select a person from your group to be the subject in this experiment.
3. Use alcohol swabs to clean the skin where the electrodes will be placed. Skin oils prevent good conduction of muscle potentials. Three electrodes will be placed on the head: one below the right ear; one at the outer canthus of left eye; and, one at the outer canthus of the right eye.
4. Remove the plastic disks from a disposable electrodes and apply them to the scrubbed areas (Figure 4-1 on page 4).
5. Attach three color-coded electrode cables to the ground and Channel 1 inputs on the lead pedestal. Snap the other ends onto the electrodes, so that:

- the red “+1” lead is on electrode next to the left eye.
- The black “-1” lead is on electrode next to the right eye.
- the green “C” lead (the ground) is on electrode below the right ear.

6. Drape the leads for the other electrodes over the subject’s shoulders to the lead pedestal which hangs freely down the subject’s back and over the chair. There should be no tension on the electrodes.
7. Attach the AAMI connector on the end of the gray patient cable to the isolated Channel 1 & 2 inputs of the iWorx unit (Figure 4-1 on page 4).

8 The subject should sit quietly with their hands in their lap.

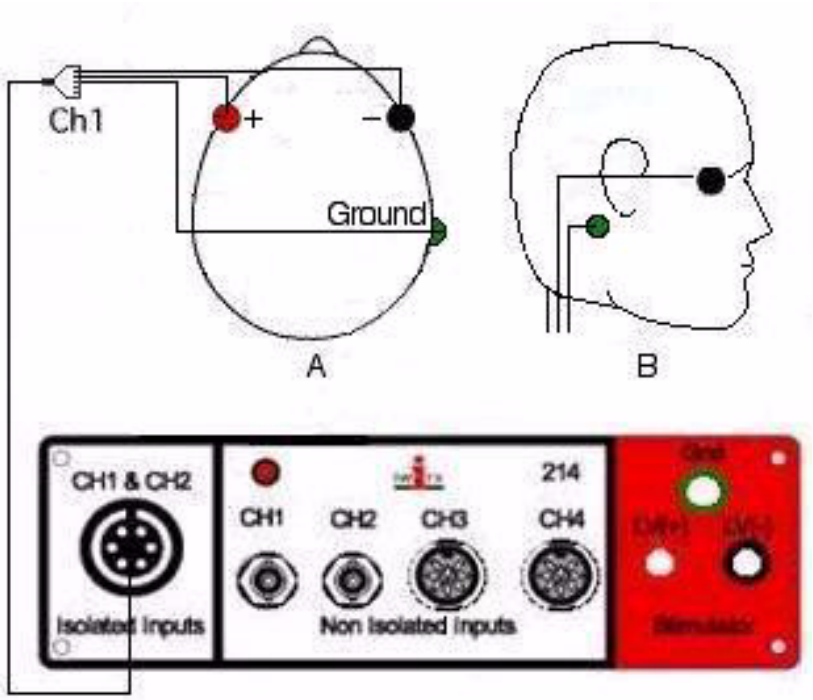

Figure 4-1: Placement of electrodes for recording an electroculogram (EOG).

Start the Software

1 Click the Windows **Start** menu, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the LabScribe icon on the Desktop

2 When the program opens, select **Load Group** from the **Settings** menu.

3 When the dialog box appears, select **AddedLabs.iws.** Click **Load**.

4 Click on the **Settings** menu again and select the **EOG** settings file.

5 After a short time, LabScribe will appear on the computer screen as configured by the **EOG** settings.

Exercise 1: Saccades

Aim: To demonstrate the type of electrical activity that occurs in the oculomotor muscles as the subject is reading.

Procedure

1 Select a paragraph for the subject to read as his or her EOG is recorded. The paragraph should be at least 10 lines long with a format and sentence structure that is simple. As you will find out, the number of words in each line, the length of each line, and the formatting of the paragraph will affect the shape of the EOG recording.

2 The subject should avoid any voluntary movements of his or her head or body during the recording. Only the subject's eyes should be moving while he or she is reading.

3 As the subject is focusing on the first word in the paragraph, click **Start** to begin recording. Instruct the subject to begin reading.

4 Click **AutoScale** in the Channel 1 title area when a cyclic pattern appears (Figure 4-2 on page 5).

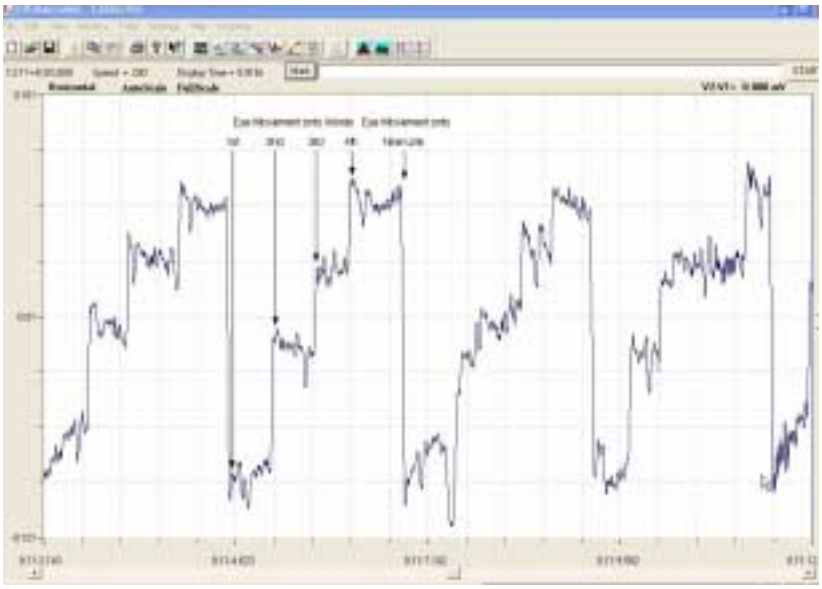

Figure 4-2: Electroculogram (EOG) of a subject reading a list of 5-letter words. Four words are distributed on each line and the subject reads the words from left to right. As the subject moves his eyes to the right to read the next word, the level of the recording rises a step. As the subject moves his eyes back to the beginning of the next line, the amplitude of the EOG drops.

5 Type the subject's name and the word "Reading 1" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the data. Also, observe the subject's eyes as he or she is reading.

6 Click **Stop** to halt recording when the subject has finished reading the paragraph.

7 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file(e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an ***.iwd** file).

8 Repeat Steps 3 through 6 while the same subject attempts to move from word to word on the lines in the same paragraph with a "slow saccadic" movement. Mark the recording to indicate the type of movement the subject is attempting. Observe the subject's eyes as he or she attempts to read with this type of movement.

9 Select **Save** in the **File** menu.

10 The number of words per line and the complexity of a paragraph's format and sentence structure will affect the pattern of electrical activity in an EOG. Repeat Steps 3 through 6 while the subject reads a new paragraph (Reading 2) with a different format, like a paragraph from a page with multiple columns.

11 Select **Save** in the **File** menu.

Questions

1 How does the pattern of the EOG recorded during the reading of the first paragraph compare to the pattern during the reading of the second paragraph? How do the paragraphs differ?

2 How does the pattern of the EOG recorded during the "slow saccadic" reading of the first paragraph compare to the normal reading of the same paragraph? How does the motion of the subject's eyes differ between these readings?

Exercise 2: VOR

Aim: To demonstrate the type of electrical activity that occurs in the oculomotor muscles as the subject remains focused on an image or word on a page while rotating his or her head from side to side.

Procedure

1 Select an image or word on a printed page upon which the subject can focus as the subject rotates his or her head from side to side. Pick an image or word that is distinct from the items on the rest of the page, it will be easier for the subject to focus on this target.

2 Inform the subject to avoid any voluntary movements of his or her body during the recording. Only the subject's head should be moving while he or she is focusing on the target.

3 As the subject is focusing on the target, click **Start** to begin recording. Instruct the subject to begin rotating his or her head slowly from side to side.

4 Click **AutoScale** in the Channel 1 title area when a cyclic pattern appears (Figure 4-3 on page 7).

5 Type the subject's name and the acronym "VOR" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the data. Also, observe the subject's eyes as the subject is rotating his or her head.

6 Click **Stop** to halt recording when the subject has finished the exercise.

7 Select **Save** in the **File** menu.

8 Repeat Steps 3 through 6 on the same subject while he or she increases or decreases the degree or velocity of head rotation.

9 Select **Save** in the **File** menu.

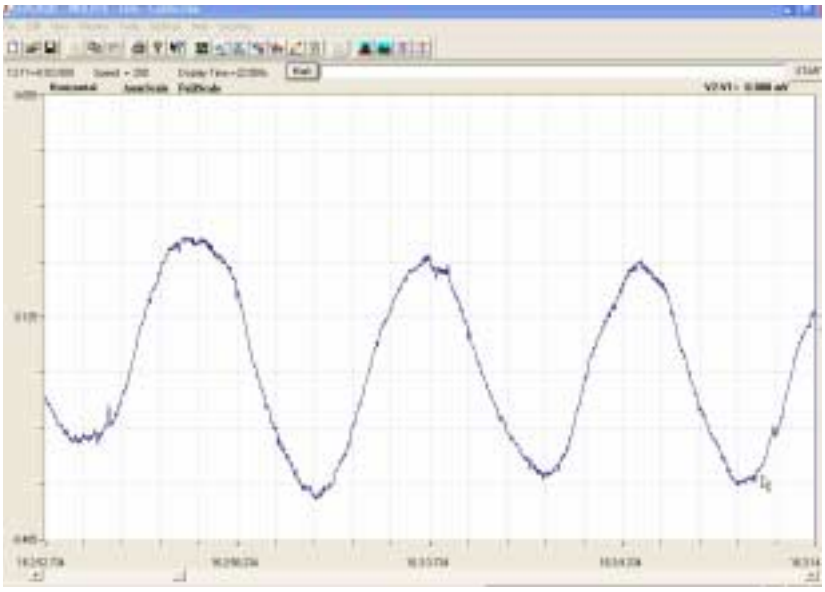

Figure 4-3: Electroculogram (EOG) of a subject rotating his head from side to side as his eyes remain focused on the target.

Questions

1. How does the pattern of the EOG recorded while the subject is rotating his or her head slowly compare to the pattern during the period when the rotation of the head is to a different degree or with a different velocity?
2. Describe the motion of the subject's eyes during VOR. Is it smooth or saccadic?
3. Does the motion of the subject's eyes differ between VOR's of different degrees or velocities?

Exercise 3: Pursuit

Aim: To demonstrate the type of electrical activity that occurs in the oculomotor muscles as the subject follows a moving object

Procedure

1. Suspend a target, like a tennis ball on a fine string, in front of a uniform background of a contrasting color, like a blackboard or a wall. Set the length of the string at about 3 feet. You should be able to swing the target from side to side like a pendulum.
2. Inform the subject to avoid any voluntary movements of his or her head or body during the recording. Only the subject's eyes should be moving while he or she is following the target.
3. Pull the target to the side in preparation for its swinging like a pendulum; the subject should be focused on the target and ready to follow it when it is released.

4 Click **Start** to begin recording, then release the target. Click **AutoScale** in the Channel 1 title area when a cyclic pattern appears (Figure 4-4 on page 8).

5 Type the subject's name and the word "Pursuit" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the data. Also, observe the subject's eyes as he or she is following the target.

6 Click **Stop** to halt recording when the target has completed about 10 oscillations.

7 Select **Save** in the **File** menu.

8 Lengthen the string used suspend the target by a foot or more, so the target will swing more slowly. Repeat Steps 3 through 6 on the same subject.

9 Select **Save** in the **File** menu.

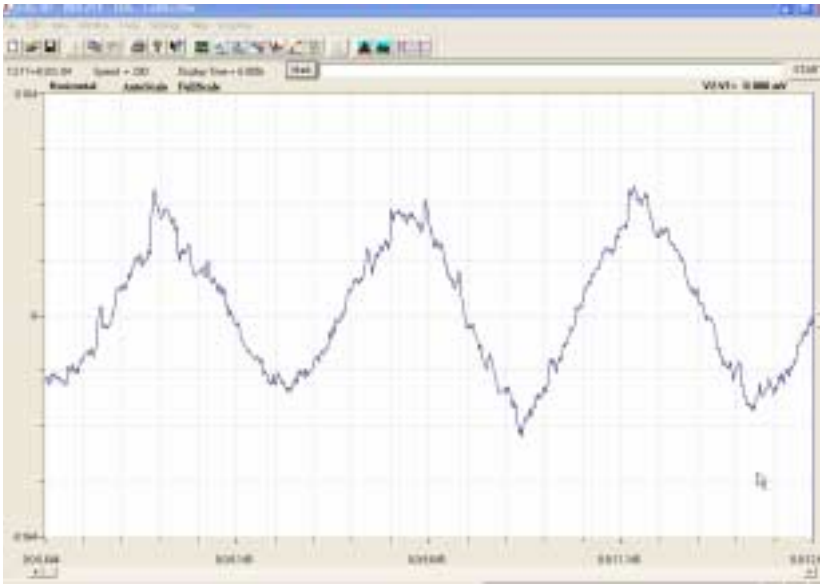

Figure 4-4: Electroculogram (EOG) of a subject following an oscillating target.

Questions

1 How does the pattern of the EOG recorded while the subject is pursuing a fast moving target compare to the pattern during the pursuit of the slower moving target?

2 Describe the motion of the subject's eyes during pursuit. Is it smooth or saccadic?

3 How does the motion of the subject's eyes differ between pursuits of different velocities?

Exercise 4: Vergence

Aim: To demonstrate the type of electrical activity that occurs in the oculomotor muscles as the subject focuses from a distant to a near target and back.

Procedure

1. Find two objects that are similar in size and shape. Place one object 2 to 3 feet in front of the subject. The second object should be twice the distance (4 to 6 feet) from the subject as the first object. The objects should be aligned so the subject can see both objects without moving his or her head or body.
2. Instruct the subject that he or she will alternate between focusing on the distant and the near targets. The subject should focus on a target for about two or three seconds before switching to the other target.
3. Inform the subject to avoid any voluntary movements of his or her head or body during the recording. Only the subject's eyes should be moving while focusing on the near or distant targets.
4. As the subject is focusing on the distant target, click **Start** to begin recording and inform the subject the recording has started. After two to three seconds of focusing on the distant target, the subject should quickly move his or her focus to the near target for two to three seconds. Also, observe the subject's eyes as focus points are changed.
5. Click **AutoScale** in the Channel 1 title area when a cyclic pattern appears (Figure 4-5 on page 9).

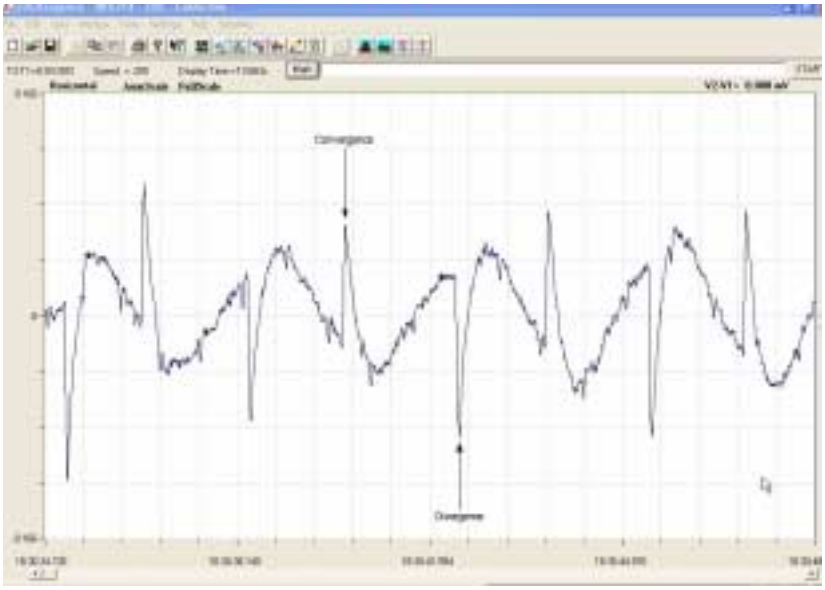

Figure 4-5: Electroculogram (EOG) of a subject focusing on distant and near targets.

6 The subject should continue to alternate between the distant and the near targets about ten times. During the recording, type the subject's name and the word "Divergence" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach this comment to the data when the subject moves his or her focus to the distant target. Type the word "Convergence" in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach this comment to the data when the subject moves his or her focus to the near target.

7 Click **Stop** to halt recording when the subject has finished the exercise.

8 Select **Save** in the **File** menu.

9 Have the subject repeat Steps 4 through 7 while moving his or her focus from one target to the other more slowly.

10 Select **Save** in the **File** menu.

Questions

1 Does the pattern for convergence differ from the pattern for divergence?

2 How does the pattern of the EOG from quick movements between targets compare to the pattern from slow movements between targets?

3 Describe the motion of the subject's eyes while focusing from one target to the other and back.

4 How does the motion of the subject's eyes differ between quick and slow vergences?