Electro-oculography (EOG)

In this experiment, you will investigate eye movements by recording an electro-oculogram.

Background

The vertebrate eye is an important sensory organ that converts light energy into nerve impulses. In humans, the position of the eyes in the front of the head creates overlapping visual fields, which results in stereovision. Eye movements are controlled by a number of small muscles that insert onto the eyeball; the extrinsic eye muscles. These muscles allow the eyes to either track moving objects or fixate on stationary ones as the head moves.

"Gaze-shifting" is a reflex mechanism that moves the eyes in an attempt to keep the image focused on the fovea, the part of the retina with the highest density of photoreceptors and hence, greatest visual acuity. Tracking movements of the eye are either slow or rapid, depending on the movement of the object being tracked. Slow tracking movements (30-40 Hz) allow us to track distant moving objects and slow-moving near objects. When the object being tracked is moving rapidly, the tracking movements of the eye become rapid (900 Hz or more) and jump back and forth. These jerky, rapid movements are called saccades. When you read text from a book, saccades occur as you reach the end of one line and move to the next one. Eye movements are also controlled via reflexes linked to the vestibular system. Nystagmus, a rapid, jerking eye movement, occurs when the head moves rapidly and the eyes move in response to the moving fluid in the vestibular system. Nystagmus is often accompanied by a feeling of disorientation or vertigo.

Eye movements can be recorded using electrodes placed on the skin near the eyes. This kind of recording is called an electro-oculogram (EOG). An EOG records eye movement because of a voltage difference between the cornea and retina. As the eye moves, the vector of this electric field changes with respect to recording electrodes placed on the skin at fixed points. The EOG can also be used to measure the response of the retina to light. The current produced by the retina changes in intensity depending on the amount of light that enters the eye, and this will affect the intensity of the EOG signal given a constant eye movement. Because the EOG will be modified by light intensity and eye movement, one of these variables is held constant during a measurement.

Required Equipment

A computer system
PowerLab
EOG Pod
Shielded snap-on Lead Wires
Disposable pre-gelled ECG electrodes
Electrode Cream
A book or a page of text for reading
Meter stick or tape measure
Colored chalk or tape
Ballpoint pen

Procedures

A. Set up and calibration of equipment

Subject preparation

1. All the members of your lab group should participate in the experiment one by one.

2. Using a ballpoint pen, mark the areas on the skin for electrode placement as shown in Figure 1.

3. Lightly abrade the skin over the marks with an abrasive pad.

4. Peel off the backing of one of the disposable, pre-gelled ECG electrodes. Place a very small amount of electrode cream on the gelled surface of the electrode, and adhere the electrode over one of the marked areas on the volunteer. Repeat for the other two electrodes.

5. Connect the lead wires to the subject with the snap-on connectors as shown in Figure 1.

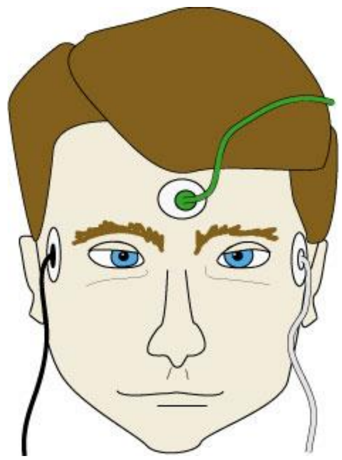

Figure 1. Connecting the EOG lead wires.

Equipment set-up

6. Connect three shielded lead wires to the rear of the EOG Pod (Figure 2).

7. Plug the EOG Pod into the Pod Port on Input 1 of the PowerLab.

8. Make sure the PowerLab is connected to your computer and turned on.

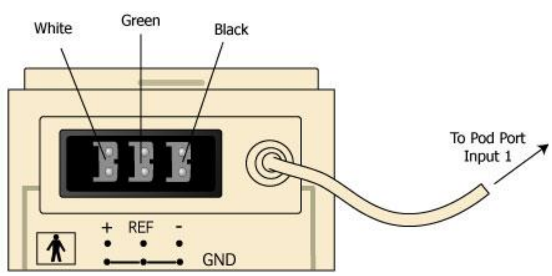

Figure 2. The back of the EOG Pod, showing lead wire connections.

Calibration

9. Have the volunteer fix their gaze on a point directly in front of them.

10. Using the knob on the front of the EOG Pod, adjust the signal so that it zeroes in the dialog box.

11. When the EOG Pod is successfully zeroed, click OK.

12. **Note:** The EOG Pod is a "DC coupled" device. This means that the signal is prone to drift. You may need to occasionally re-zero the EOG Pod before each exercise.

B. Recognizing artifacts in the EOG

Because the EOG electrodes are on the skin surface, it is important to recognize signal artifacts and distinguish them from the actual EOG signal. Eye blinks are unavoidable, and will alter the EOG signal from that of tracking movements. It is also possible to record electromyograph (EMG) signals from muscles in the face.

1. Click Start and begin recording.
2. Prepare a **comment** called "blink" by typing into the comment field in the View window. Do not press the return key.
3. Have the subject blink several times, and enter the comment into your recording by pressing the return key.
4. Prepare a **comment** called "EMG".
5. Have the subject clench their teeth together for several seconds, and enter the comment.
6. Click Stop.
7. Observe the data trace to become familiar with these two artifact signals.

Exercise 1: EOG and angular displacement

1. Using a tape measure, mark the floor one meter from the wall.
2. Have the volunteer sit comfortably so that their head is one meter from the wall, as you marked on the floor.
3. Make temporary marks on the wall at the subject's eye level with tape or chalk according to the measurements shown in Figure 3.
4. Have the subject look at the center mark directly in front of them.
5. Click Start to begin recording.
6. Enter a **comment** in your data trace called "slow tracking".
7. Without turning their head, have the subject stare at the mark furthest to their left (0°) for two to three seconds. During this time, enter a **comment** called "0".
8. Have the subject move their gaze to each mark on the wall, from left to right, holding their gaze for two seconds at each one. Enter a **comment** corresponding to the view angle each time the subject views another point.
9. Click Stop to end the recording.

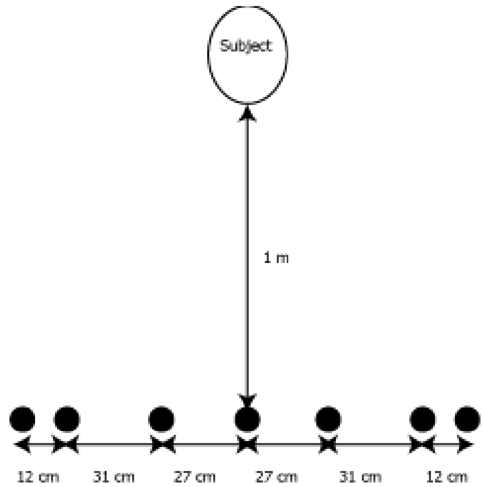

Figure 3. Suggested spacing for 15° viewing angles at a distance of 1 meter.

Exercise 2: Saccades

Saccades are fast tracking movements of the eye that are not smooth. The easiest way to observe saccades is to record EOG while the volunteer reads a page of text.

1. Click Start to begin recording.
2. Enter a **comment** in your data file called "fast tracking".
3. Have the subject read a paragraph from a book or sheet of paper.
4. Click Stop to end the recording.

Exercise 3: Smooth tracking

1. Have the subject look straight ahead. Have one member of your group hold a pen or pencil in front of the volunteer, about 50 cm away.
2. Click Start to begin recording.
3. Enter a comment called "smooth tracking" into your recording.
4. Move the pencil left and right slowly in front of the volunteer. The volunteer should fixate on the pencil without moving their head.
5. Click Stop to end the recording.

Exercise 4: Nystagmus

Nystagmus occurs when the eye responds reflexively to signals from the vestibular system.

1. Click Start to begin your recording.
2. Enter a **comment** called "nystagmus" in your data trace.

3. Have the volunteer look straight ahead at the center mark on the wall.

4. Next, have the volunteer turn their head rapidly from left to right while they try to maintain their gaze on the center mark.

5. Click Stop to end the recording.

Analysis

Exercise 1: EOG and angular displacement

1. **Select** the block of data that contains the recording from the slow tracking exercise.
2. Open the **Zoom View** by clicking the Zoom toolbar button.
3. Place the **Marker** on the portion of the trace corresponding to the 0° mark.
4. Move the **Waveform Cursor** to each segment of the trace and record the EOG amplitude in Table 1 of your Data Notebook.

Table 1. EOG amplitude vs. view angle. View angles are given in Figure 3.

View Angle (degrees)	EOG amplitude (mV)
0	
15	
30	
45	
60	
75	
90	

Exercise 2: Saccades

1. **Select** a portion of your data from Exercise 2 when the subject was reading.
2. Open the **Zoom View** by clicking the Zoom toolbar button.
3. Your data should look similar to that shown in Figure 4.
4. Locate a single saccade in the data trace, and place the **Marker** at its start.
5. Move the **Waveform Cursor** to the end of the saccade.
6. Record the duration of the saccade from the readout at the top of the Zoom View window.
7. Repeat this procedure for three additional saccades, and record all the durations in Table 2 of your Data Notebook.
8. Calculate the average saccade duration and record the value in Table 2 of your Data Notebook.

Figure 4. Saccades during reading. Note the position of the Marker and Waveform Cursor.

Table 2. Saccades during reading

Parameter	Duration (ms)
Saccade 1	
Saccade 2	
Saccade 3	
Saccade 4	
Average saccade duration	

Exercise 3: Smooth tracking

1. Observe the data trace from Exercise 3.
2. Look for evidence of saccades.

Exercise 4: Nystagmus

1. **Select** a portion of your data trace from Exercise 3 and open the **Zoom View** window.
2. Using the **Marker** and **Waveform Cursor**, determine the maximum EOG amplitude for movement in the left and right directions.
3. If possible, locate a saccade in the trace and determine its duration as you did for Exercise 2.
4. Record your results in Table 3 of your Data Notebook.

Table 3. EOG parameters during nystagmus

Parameter	Value
Maximum EOG amplitude to left	mV
Maximum EOG amplitude to right	mV
Saccade duration	ms

Results

Report:

1. a copy of the Zoom View window showing the recording artifacts from EMG and blinking. Label each event;
2. a graph of EOG amplitude (mV) versus angular displacement (degrees). On the graph, indicate the best-fit line through the data points;
3. a copy of the Zoom View window showing saccades;
4. a copy of the Zoom View window showing the EOG during nystagmus;

Conclusions

Answer the following questions in complete sentences (discus your results).

1) Were you able to detect any EMG or blink artifacts in your experimental EOG recordings? Briefly discuss why blinking would cause an artifact.

2) Describe the relationship between EOG amplitude and angular displacement. Was the response linear? Discuss why you think you obtained this result.

3) Discuss the velocity of saccades in your recording. Why are saccades an important aspect of vision? Do you notice saccades when you are reading?

4) Did saccades occur during slow tracking? If so, how can you explain their appearance in the data?

5) How did the EOG amplitude compare between slow tracking and nystagmus? Discuss the relationship between the vestibular system and eye movements.

Study Questions

Write a paragraph that explains the physiological principles of why eye movements can be recorded. What do you expect to learn from this experiment? Briefly describe the techniques and equipment you will use to record the electro-oculogram.

1. Why do you suppose it is important to recognize artifacts in your data trace? What are the most noticeable artifacts in EOG?

2. Do you think that the recorded EOG signal is proportional to eye movement? In other words, is the response linear over the range of eye movement? Please explain? (**Notice:** to answer the question you need to study more!)

3. When you observe saccadic eye movements during reading (see Figure 4), what activity do you suppose correlated with the largest response?

4. Is there evidence of saccades during the slow tracking exercise? If so, why do you suppose they occurred?