ELEC S421F Biomedical Informatics

Lab Session: ***BIOPAC Student Lab Lesson 10: Electrooculogram (EOG) I***

Student Name: ZHANG Hanhao

Student Number: 12399068

Group Number: 3

Aims:

- Describe how ECG is used as a tool for evaluating electrical events within the heart.
- Outline the procedures for performing a one-lead ECG recording.
- Correlate electrical events as displayed on the ECG with the mechanical events that occur during the cardiac cycle; and
- Describe rate and rhythm changes in the ECG associated with exercise and breathing.

Equipment & Materials:

- 2 x BIOPAC Electrode Lead Set (SS2L)
- BIOPAC Disposable Electrodes (EL503,) 6 electrodes per subject
- BIOPAC Electrode Gel (GEL1) and Abrasive Pad (ELPAD)
- *Optional:* BIOPAC Adhesive Tape (TAPE 2)—use to tape wires to reduce cable strain
- Pendulum: Can be made by attaching any object (i.e., 50 gm force calibration weight) to approx. 61 cm (24 inches) of string.
- Pen or other real object for vertical tracking
- Passages for reading: Passage 1 – easily understandable (i.e., entertainment article)
Passage 2 – challenging material (i.e., scientific article)
- Biopac Student Lab System: BSL 4 software, MP36, MP35 or MP45 hardware
- Computer System (Windows or Mac)

Procedure:

A. Setup

1. Turn the computer ON and turn OFF the MP36 unit
2. Plug the Electrode Lead Set (SS2L) horizontal lead to CH1

   Plug the Electrode Lead Set (SS2L) vertical lead to CH2
3. Using the alcohol wipe provided, clean and abrade skin at the electrode placement sites.
4. Attach six electrodes to Subject’s face as shown in Fig.1

Fig. 1. Proper electrode placement

5. Clip CH 1 Electrode Lead Set (SS2L) in the horizontal placement, following the color code (Fig. 2).

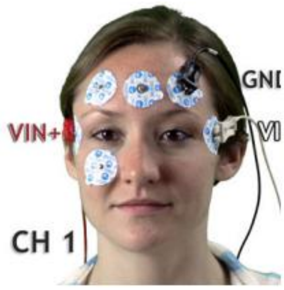

Fig. 1. Horizontal (CH 1) Lead Placement

6. Clip CH 2 Electrode Lead Set (SS2L) in the vertical placement, following the color code (Fig. 3).

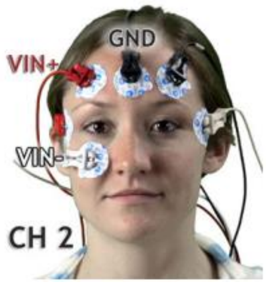

Fig. 1. Vertical (CH 2) Lead Placement

7. Start the BIOPAC Student Lab program
8. Choose Lesson L10 – Electrooculogram (EOG) I and then click OK. Type in filename and click OK.

B. Calibration

1. Subject is seated, relaxed, breathing normally, and facing away from monitor.
2. Click Calibrate. Make sure the subject Complete four horizontal eye movement cycles (extreme left-extreme right-return to center) and four vertical eye movement cycles (extreme up-extreme down-return to center). And wait for Calibration to stop.
3. Verify recording resembles example data. If similar, click Continue and proceed to Data Recording. If necessary, click Redo Calibration.

C. Data Recording

1. **Pendulum**
   - Subject should be seated about 25 cm (10 inches) from pendulum— adjust as necessary to maintain focus.
     Bottom of pendulum swing should align with bottom of Subject's nose.
     Director holds pendulum in front of Subject, ready to release
     Subject must focus on pendulum.
     Review recording steps.
   - Click Record and director releases pendulum.
   - Subject tracks pendulum with eyes only.
   - Wait for pendulum to stop swinging.
   - Click Suspend and verify recording resembles the example data.
2. **Simulate Pendulum**
   Subject must try to visualize the pendulum movement of the previous recording and track the imaginary pendulum with the eyes only. The initial swing should take up a large portion of the Subject's visual range along the horizontal axis and each successive swing should be reduced in amplitude until the eyes are still. Subject places eyes at the 2 o'clock position
   Review recording steps.
   - Click record and subject tracks an imaginary pendulum with decreasing swing cycles.
   - Director observes horizontal channel until there is little or no eye movement.
   - Click Suspend and verify recording resembles the example data.
3. **Vertical Tracking**
   - Director holds pen centered with the eyes - adjust as necessary to maintain focus. Subject must pick a focal point on the pen and track its movement WITHOUT moving head.
   - Director determines (and mentally notes) the upper and lower edges of the Subject's visual field by moving the pen up and down until Subject indicates it is out of view.
   - Director returns pen to a center position (eyes looking straight ahead) and the recording is ready to begin.
   - Click record and subject tracks pen while Director moves it from center to upper and lower edges of visual field.
   - Click Suspend and verify recording resembles the example data.

4. **Simulate Vertical Tracking**
    - Subject centers eyes and prepares to simulate vertical eye-tracking.
    - Click record and then subject tracks the imaginary pen with eyes only, imagining the pen moving to the upper then lower edges of visual field, then returning to center. This upper/lower cycle should be repeated five times.
    - Director observes vertical channel until there is little or no eye movement.
    - Click Suspend and verify recording resembles the example data.
5. **Read Silently (Easy)**
    - Director holds easy reading material centered in front of Subject as close as possible, while maintaining focus.

      Subject must be able to read entire passage without moving head and keep head still, move only eyes, and try to avoid blinking.

      Director must hold the reading material as still as possible.
    - Click record and subject reads material silently and announces when finished.
    - Click Suspend and verify recording resembles the example data.
6. **Read Silently (Challenging)**
    - Director holds reading material that should be more challenging than that from "Read Silently (Easy)." centered in front of Subject as close as possible, while maintaining focus.
    - Click record and subject reads material silently and announces when finished.
    - Click Suspend and verify recording resembles the example data.
7. **Read Aloud (Challenging)**
    - Director holds reading material that should be the same as that used in "Read Silently (Challenging)." centered in front of Subject as close as possible, while maintaining focus.
    - Click record and subject reads passage aloud.
    - Click Suspend and verify recording resembles the example data.

Results:

DATA REPORT

Student's Name: Zhang Hanhao

Lab Section: BIOPAC Student Lab L10 – Electrooculogram (EOG) I

Date: 21 Oct 2022

I. Data and Calculations

Subject Profile

Name: Zhang Hanhao Height: 1.67 m

Age: 22 Gender: Male / ~~Female~~ Weight: 50 kg

A. **Pendulum Tracking** — Complete Table 10.1.

Note: Your data may have more or fewer cycles than the 7 allotted in the tables.

Table 10.1 Pendulum Tracking vs. Simulation Tracking (using Horizontal data)

Cycle	Pendulum		Simulation	
1	1.51 sec	1.720 mV	1.96 sec	1.602 mV
2	1.48 sec	1.654 mV	1.82 sec	1.630 mV
3	1.44 sec	1.645 mV	1.67 sec	1.568 mV
4	1.43 sec	1.547 mV	1.61 sec	1.547 mV
5	1.42 sec	1.499 mV	1.72 sec	1.450 mV
6	1.42 sec	1.425 mV	1.75 sec	1.347 mV
7	1.38 sec	1.307 mV	1.63 sec	1.237 mV

B. **Vertical Tracking —** Complete Table 10.2.

Table 10.2 Vertical Tracking vs. Simulation

Cycle	Real Object		Simulation	
1	3.34 sec	0.0817 mV	2.97 sec	0.07253 mV
2	3.29 sec	0.1521 mV	3.19 sec	0.07950 mV
3	3.10 sec	0.1866 mV	5.24 sec	0.07849 mV
4	3.03 sec	0.1516 mV	4.52 sec	0.07193 mV
5	2.97 sec	0.1554 mV	3.64 sec	0.05715 mV
6	1.19 sec	0.1345 mV	4.63 sec	0.07947 mV
7	0.37 sec	0.0158 mV	3.97 sec	0.13816 mV

C. **Saccades—Complete Table 10.3.**

Table 10.3 Saccades

Measurement	Read Silently 1		Read Silently 2		Read Aloud	
	1st line	2nd line	1st line	2nd line	1st line	2nd line
Number of words	9	9	7	7		
Number of saccades	7	8	6	6	5	7
Time interval between saccades #1	0.38 sec	0.11 sec	0.30 sec	0.09 sec	0.10 sec	0.16 sec
#2	0.09 sec	0.22 sec	0.09 sec	0.14 sec	0.14 sec	0.12 sec
#3	0.20 sec	0.14 sec	0.17 sec	0.18 sec	0.14 sec	0.11 sec
#4	0.33 sec	0.08 sec	0.22 sec	0.26 sec	0.14 sec	0.19 sec
#5	0.11 sec	0.11 sec	0.12 sec	0.23 sec		0.20 sec
#6	0.11 sec	0.15 sec				0.13 sec
#7		0.21 sec				
#8						
#9						
Average time interval between saccades (Calculate)	0.203 sec	0.146 sec	0.18 sec	0.18 sec	0.13 sec	0.152 sec

II. Questions

D. Focusing a camera changes the distance between the lens and the film. Does the eye focus by changing the distance between the lens and the retina? Explain your answer.

No, human eyes accomplish it by changing the shape of lens. When focusing on nearby objects, the ciliary muscle attached to the lens by a suspensory ligament, contracts, reducing tension on the suspensory ligament thereby allowing the lens to thicken. When focusing on objects that are far away, the ciliary muscle relaxes to make the lens thinner.

E. Define the following terms:

Cone — Cone is used for day vision and color vision.

Rod — Rod is used for vision in dim light and for the detection of movement in the visual field.

Fovea — Place where focused light produces the sharpest image.

Visual Field — The total area in which objects can be seen in the side (peripheral) vision as human focus eyes on a central point [1].

Visual Fixation — Muscular control of the eye works to keep the image on the fovea.

Saccade / Microsaccade — Eyes continue to move in repetitive, involuntary, imperceptible, minute, jerky movements.

F. Why is vision in darkness more effective when focusing away from the fovea rather than focusing directly on the fovea?

Rods are used for vision in dim light and for the detection of movement in the visual field. Rods are concentrated in the periphery of the retina, the tendency to focus away from the fovea in darkness. ‘

G. Explain the difference between “voluntary fixation” and “involuntary fixation”:

Voluntary fixation involves a conscious effort to direct gaze to a selected object in field of view and ‘lock on’ to it.

Involuntary fixation involves subconscious mechanisms that operate to keep the selected object in the field of view once locked on to it.

H. Examine the data in Table 10.1 and answer the following questions

a) Did the amplitude continue to decrease with each successive swing cycle during pendulum tracking? Explain

Yes. The brain subconsciously grades the contractions of extraocular muscles so as to maintain the visual fixation point as the pendulum slows and speeds up during its swing by using visual sensory information regarding change of position of the moving pendulum. The oscillating, or back and forth involuntary movements of the eyes are a form of tracking movement in which the eyes maintain a visual fix on an object moving within the visual field.

b) Did the amplitude continue to decrease with each successive swing cycle during simulated pendulum tracking? Explain

Yes. And the EOG becomes sinusoidal but jerky, suggesting a reduction in neuromuscular control of the eyes due to the loss of visual sensory input to the brain.

c) Did the time interval (period) of each successive swing cycle increase, decrease, or remain constant during pendulum movement? Explain

It remain constant in the beginning but slightly decreased.

d) Did the time interval (period) of each successive swing cycle increase, decrease, or remain constant during simulated movement? Explain

The changes are drastic and difficult to judge. The subject cannot concentrate on imaging simulated movement.

e) Are the waveform shapes different between vertical tracking and simulated vertical tracking data? Explain

Yes. The vertical tracking is sinusoidal and simulated vertical tracking is jerky.

I. Examine the data in Table 10.2 and answer the following questions:

a) Do the cycle amplitudes increase, decrease, or remain constant during vertical tracking? Explain

It remain constant. The vertical tracking movement distance is almost the same.

b) Do the cycle amplitudes increase, decrease, or remain constant during simulated vertical tracking? Explain

It remain constant but increased instantly at the end. The subject head moved.

c) Do the cycle periods increase, decrease, or remain constant during vertical tracking? Explain

It decreased slightly. The pen move faster than start.

d) Do the cycle periods increase, decrease, or remain constant during simulated vertical tracking? Explain

It remain constant. The imaging object speed is almost the same.

e) Are the waveform shapes different between vertical tracking and simulated vertical tracking data? Explain

Yes. The vertical tracking is sinusoidal and simulated vertical tracking is jerky.

J. Examine the data in Table 10.3 and answer the following questions:

a) Did the number of saccades match the number of words for each line? Explain any differences.

No, the subject do not read the word completely.

b) Is the average time interval between saccades different when reading an easy passage vs. a challenging passage? Explain

Yes. When reading difficult word or unreasonable sentence, subject should focus more to recognize it or image the pronunciation.

c) Is the average time interval between saccades different when reading the same passage silently vs. aloud?

Yes. But the value is not accurate because the subject has been read serval times duo to recording is not similar to the example data

d) Are the waveform shapes different between Read Silently 2 and Read Aloud data? Explain

Yes. The movement of the facial muscles can also create signal artifact.

K. Name the cranial nerves tested and the extraocular muscles tested when the subject is asked to follow the eraser on a pencil when moved in a one-foot circle, two feet from face.

Cranial Nerves Cranial Nerve III, the oculomotor nerve and Cranial Nerve IV, the trochlear nerve.

Extraocular Muscles Superior rectus, Inferior oblique, Medial rectus, and lateral rectus.

L. Define corneal–retinal potential (CRP) and explain its relation to electrooculography and the electrooculogram.

Corneal – retinal potential (CRP) is the potential between the front and the back of the eyeball, and is primarily due to hyperpolarizations and depolarizations of nerve cells in the retina. Electrooculography is a technique for recording voltage changes as the eyeballs move in their orbits. The electrooculogram (EOG,) is an electroencephalographic record of the voltage changes obtained while the subject, without moving the head, moves the eyes from one fixation point to another within the visual field. The CRP can be observed as an EOG signal by attaching a set of electrodes on the skin around the eyes. Because the EOG signal reflects the eye position, it can be used to detect eye movements. [2]

Discussion:

The EOG recording is hampered by several challenges, including difficulties of separating signal from noise, and removing artifacts such as skin resistance, EEG/EMG artifacts, eyelids/blinks, and electronic/mechanical noise. [3] The EOG measurement is susceptible to baseline drift due to minor electrode/skin offset potential changes occurring over several minutes as well as potential baseline shifts due to electrode displacement on the skin surface (typically from electrode leads tugging on the electrodes). To help minimize baseline changes, a 0.05 Hz High Pass filter is used. If the eyes fixate on a position for several seconds, the recorded signal will slowly return to baseline (0 mV). Any movement of the facial muscles or jaw can introduce EMG (muscle) artifact or cause slight baseline shifts due to movement of the EOG electrodes. Therefore, it is important to minimize facial and jaw movement when recording EOG data.

When performing the experiments, relevant safety measures need to be paid attention to. MP36/35 unit should be turned off. If using an MP45, make sure USB cable is connected and "Ready" light is ON. The subject also has obligations to provide what medications are taking if any and whether there was an allergic to the tape that can be used to attach the electrodes. During the exercise EOG test, subjects should tell the experimenter to pause current progress if he feel nervous or uncomfortable.

There are many ethical issues should be considered before or during the experiments such as many users don't want to get EOG recording because of privacy concerns. Gender, age, height, and weight are required to be provided before experiments, which may be considered disrespectful. Recording may explore Some patients would view the head electrodes device as minimally invasive. When the MP36/35 turn on, the subject can feel the current go through. Inversely, the patient may choose to ignore the measurements sent as a result of not trusting the 'simply' device.

This experiment suggests that electrooculography is commonly used to assess visual defects involving neuromuscular control of the eyes. Some applications include the use of electrooculography in the design of robotics, such as motorized wheelchairs and other devices that can be guided or otherwise controlled by movement of the subject's eyes.

Conclusion:

EOG signals can be an effective way to record human eye movements for many experimental and clinical applications, but these measurements are also noisy and contain many artifacts such as blinks, head movements. [3] The EOG measurement method in this experiment is not standard. The director moving the object vertically and horizontally will greatly influence the EOG recording baseline. Therefore, to measure a more accurate eye tracking EOG signal, not only performing signal processing after this experiment but also using a more mechanical operation is needed.

Appendix

[1] “Visual field: MedlinePlus medical encyclopedia,” *MedlinePlus*. [Online]. Available: https://medlineplus.gov/ency/article/003879.htm#:~:text=The%20visual%20field%20refers%20to,eyes%20on%20a%20central%20point.

[2] F. Fang and T. Shinozaki, “Electrooculography-based continuous eye-writing recognition system for Efficient Assistive Communication Systems,” *PLOS ONE,* vol. 13, no. 2, 2018.

[3] P. D. S. H. Gunawardane, R. R. MacNeil, L. Zhao, J. T. Enns, C. W. de Silva and M. Chiao, "A Fusion Algorithm for Saccade Eye Movement Enhancement With EOG and Lumped-Element Models," in IEEE Transactions on Biomedical Engineering, vol. 68, no. 10, pp. 3048-3058, Oct. 2021, doi: 10.1109/TBME.2021.3062256.