ECE441 Lab 1

Overview

This lab will introduce you to the hardware and software you will use to complete the ECE441 lab exercises.

Deliverables

This lab is worth 2% of your overall grade. The grade will be assessed based on in-lab components. There is no report for this lab. The preparation of this lab is not graded, but should be completed *before* the lab session.

You **must** attend the session for the entire duration of the lab, unless you finish early and your TA confirms that you have completed the required deliverables and may leave.

Your grade will be assessed based on the following requirements:

- Demonstrating completion of each section to your TA
- Answering TA evaluation questions during the session

Preparation

You will be collecting surface electroencephalography (EEG) data using hardware and software developed by OpenBCI, an open-source brain computer interface project. Please read this preparation section carefully before the lab session.

Hardware

Our EEG recording hardware consists of a headset and a control board, named the “Ultracortex Mark IV” and “Cyton”, respectively. For your reference, the documentation for the headset and control board can be found at https://docs.openbci.com/.

Mounted onto the headset are 8 dry recording electrodes, which have spiked contacts (except for the ones positioned over the forehead, which are flat). The individual wearing the headset for data recording during the lab session should, on the day of the lab session, avoid using any leave-in hair products (e.g. dry shampoo, hair gel, hair spray), as this could negatively impact the quality of the recording.

The data from the control board is transferred to a computer via a Bluetooth connection to a USB receiver. This USB receiver is plugged into a standard USB port.

The hardware components are shown in figure 1.

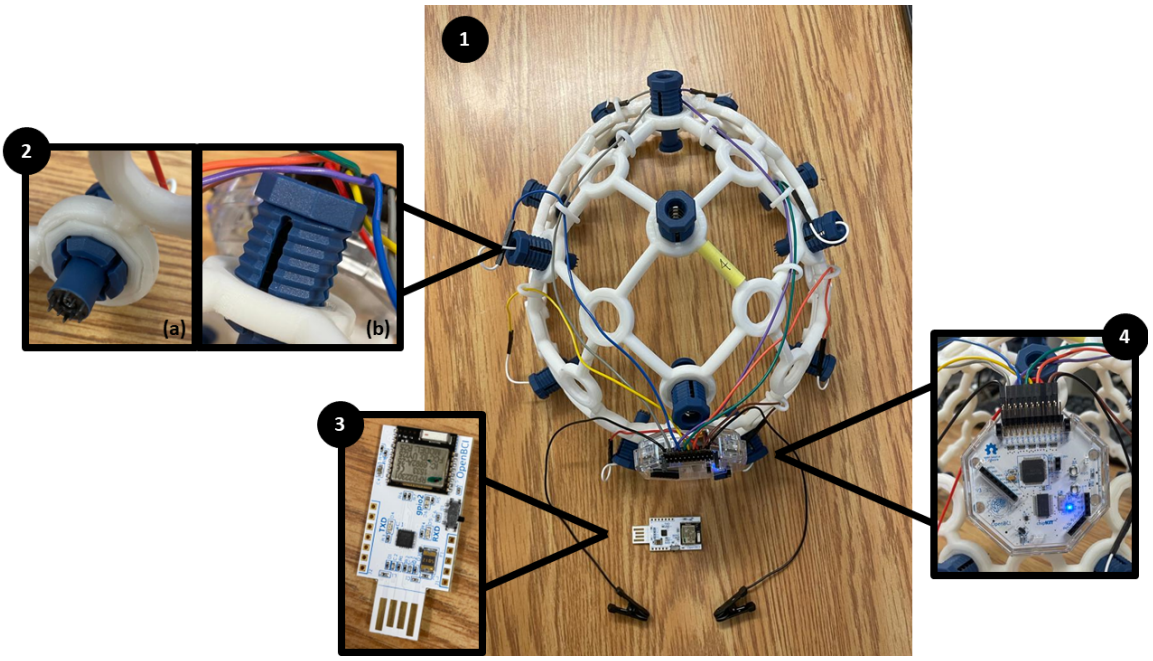


Figure 1: The hardware used for ECE441 labs. The overall setup (1) shows the Mark IV Ultracortex headset (the white frame). The electrodes (2) have a spiked contact (2a) and can be tightened through a corkscrew mechanism (2b). The USB receiver (3) connects to a standard USB port and pairs with the Cyton board (4).

Important hardware notes:

- When handling the headset, avoid jostling the jumper cables between the board and the electrodes. If your wires disconnect, ask your TA to help reconnect them in the correct way.
- If any parts fall off of your headset, bring it to your TAs attention immediately.
- When handling lab equipment, do so with care! The equipment is fragile.

Software

The software that allows us to save recorded data is the OpenBCI GUI. You will only be permitted to record data using the provided lab computers. The OpenBCI GUI is already installed on the lab computers for your use.

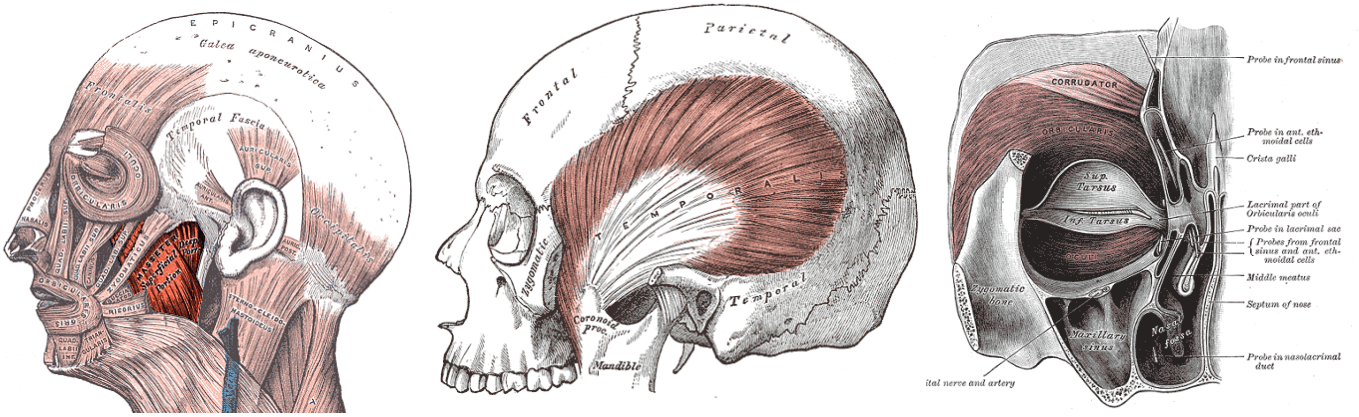
Important software notes:

- The OpenBCI GUI is *extremely* slow on first startup, and the program sometimes “hangs” or appears unresponsive after clicking on a button in the interface. Do not attempt to interact with the program when it is not responding, just wait for it to start responding again.
- It is recommended that when running the OpenBCI GUI there should be no other software running in the background.

Physiology and Anatomy

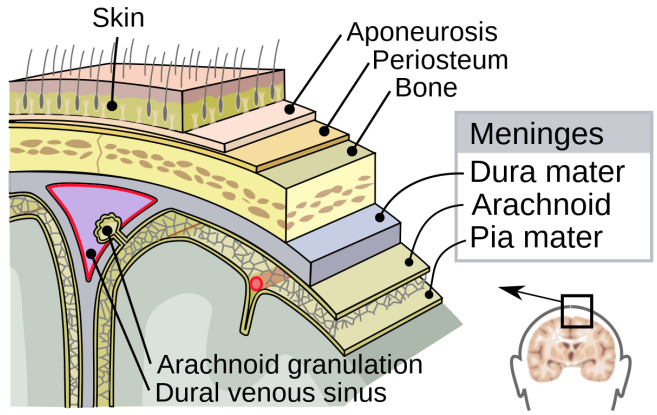
In this lab, you will examine how signals unrelated to brain activity can affect the recordings obtained through our EEG system. Any electrical signals in the physical vicinity of the EEG electrodes can interfere with the EEG signal and be recorded.

When jaw clenching, the most active muscles are the masseter & temporalis (located between the cheekbone and jaw, and on the side of the head, respectively); during blinking, it is the orbicularis oculi (surrounding the eye).



Gray, H. (1918) *Anatomy of the human body.*

Skin is the only layer of tissue between muscles and the electrodes. Meanwhile, brain tissue is protected by 3 meninges, cerebrospinal fluid, bone, periosteum, aponeurosis/muscle, and skin. Each of these tissues has its own impedance, which in turn attenuate the electrical activity generated by the brain.



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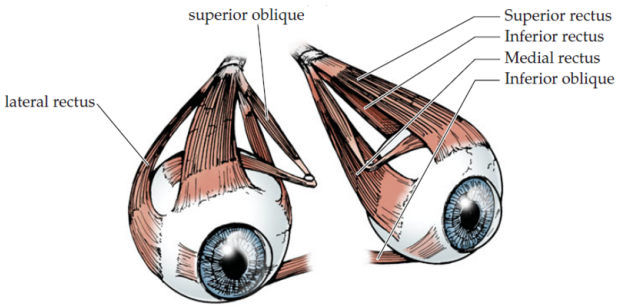
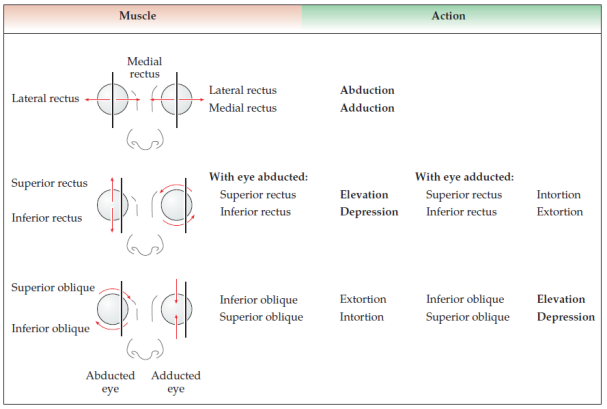
There are 6 different muscles that control eye movement. Since this type of artifact –although almost identical to EMG– contains information pertaining to a specific group of muscles, and also its amplitude, location, and time duration all represent meaningful data, it is considered as a different type of artifact than EMG.
More information on the muscles that cause this artefact and their specific functions can be found in the images below.





Martin, J. (2012). *Neuroanatomy Text and Atlas*

On the following electrode diagram, label the muscle activity that could affect the electrode recordings at each electrode:

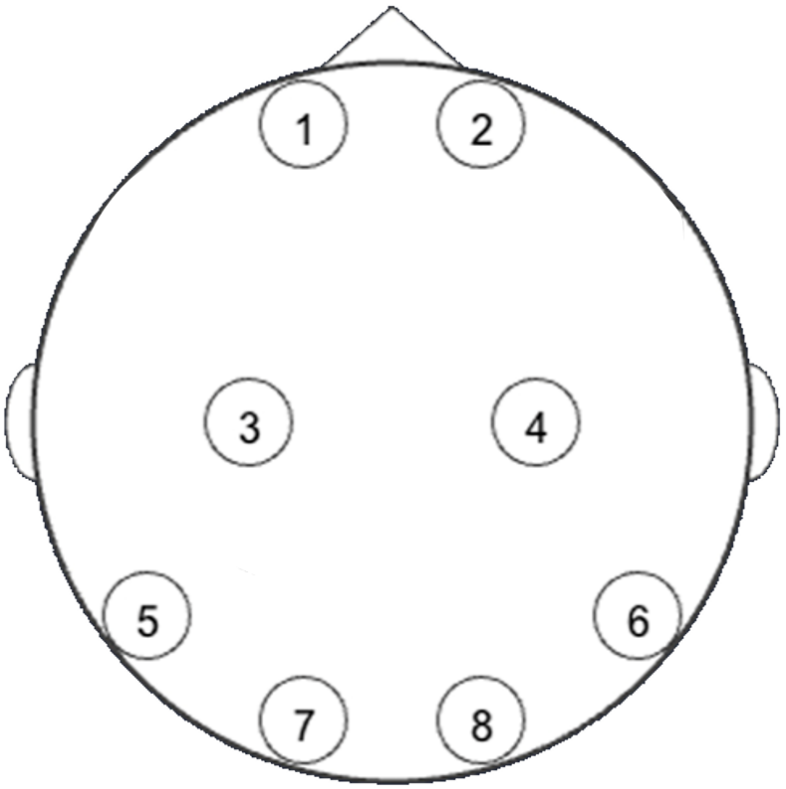


Figure 2: Electrode placement diagram for the Ultracortex Mark IV headset. Electrodes 1 and 2 are placed over the forehead. This diagram is adapted from the OpenBCI Documentation.

Summary of keywords

- Hardware
    - Headset (Ultracortex Mark IV)
    - Control board (Cyton)
    - Dry electrodes
- Software
    - OpenBCI GUI

Experiment

GUI setup

1. Ensure that your USB receiver and headset have the same numerical label. This numerical label will be the *channel number* you will select later on.
2. Plug the USB receiver into a USB port.
3. Power on the board by sliding the switch on the side to the top position.
4. Pair the board and headset using the following settings:
    - Data source: Cyton (live)
    - Transfer protocol: Serial (from Dongle)
    - Serial connect > manual
        - Com port: select the com port with the active device
        - Radio Configuration > Change Channel
            - Select the number labelling your USB receiver and headset.
5. Click “Start Session”

Hardware setup

1. Loosen every electrode and spacer on the headset by turning the outer shell counterclockwise until there is no space remaining on the threading.
2. Place the headset with the Cyton board at the back of the head. To attempt to reduce variability in the region of the brain being recorded by each electrode across lab sessions, you will place the headset to align the CZ “electrode”, shown as a star in figure 3, in a specific manner.

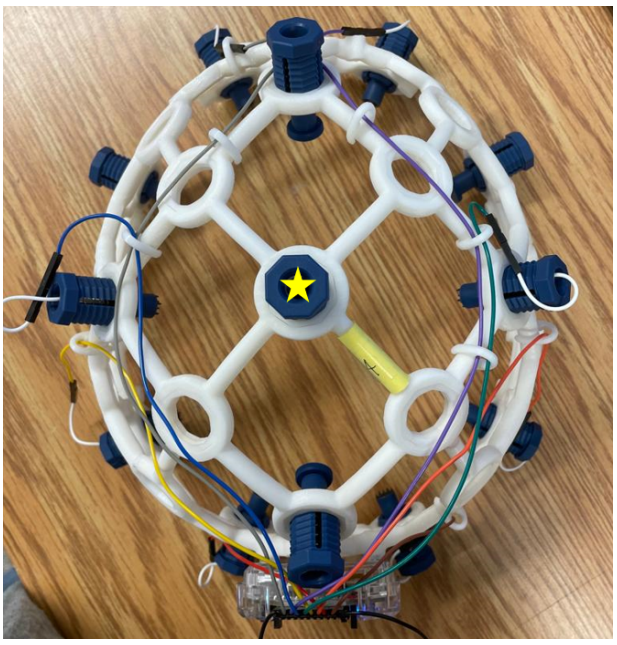


Figure 3: “Electrode” CZ is denoted as a star. It is the electrode at the center of the headset.

Figure 4 provides a visual guide for a rough adaptation of the standard procedure for EEG electrode placement. Identify (1) the indent at the junction between the forehead and the nose to (2) the base of the skull. Using the provided string, “draw” the green line joining (1) and (2) along the midline of the skull. Align the placement of CZ with the *midpoint* (by total length) of the green line. Typically, CZ electrode placement is also determined by the midpoint of another line (depicted in purple) draw between the left and right preaurical points. Since the OpenBCI headset does not permit precise placements of electrodes, **we will only use the green line** for our placement.

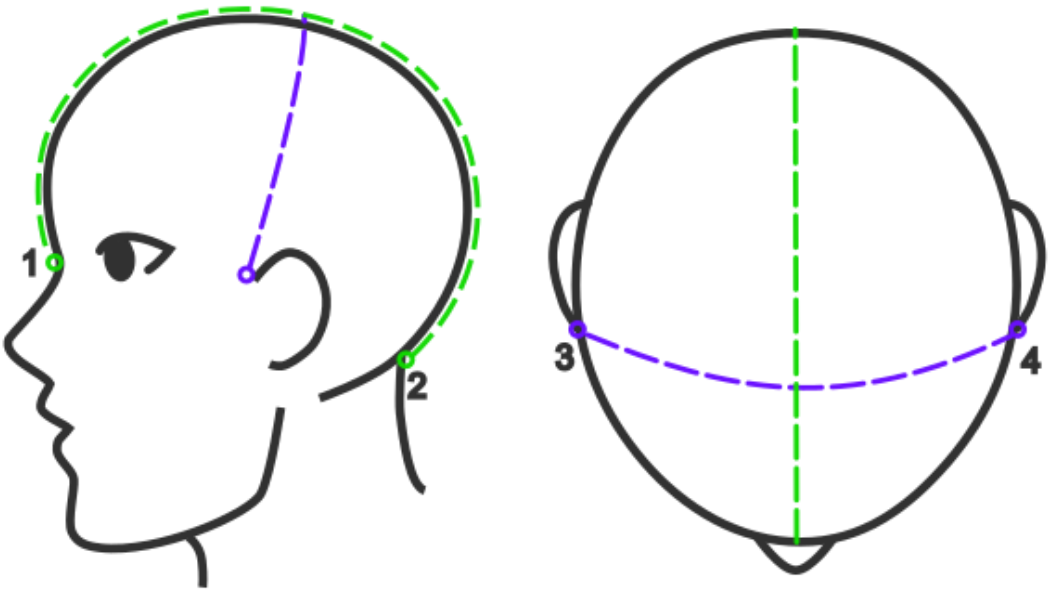


Figure 4: Cz electrode placement should be at the point of intersection of the green and purple lines, which are placed such that they bisect each other.

Gradually tighten the electrodes.

- Do not fully tighten individual electrodes first; start by slightly tightening every electrode on the headset, alternating between electrodes that are roughly “opposite” each other. This ensures that the headset roughly converges in a way that evenly spaces it over the head.
- Be careful to not overtighten the electrodes, as this can cause pain and scalp irritation. Tighten a little at a time, and make sure the wearer of the electrode does not feel discomfort with the tightness of the electrode.

Clip the ground clips to each earlobe.

3. In the GUI, click “Start Recording”. Confirm that each of the 8 channels has a signal being recorded. If you have a recording issue, make sure you resolve it by the end of the session with the TAs help.

Artefacts

50Hz is for Euro power grid

When we change to None, peak at 60Hz

Perform a demonstration of the following types of artefacts to the TA. To receive full notes answer the questions made by the TA and try to explain your thought process.

1. 60Hz noise
    a. Turn off the 60Hz notch filter, examine the noise. Turn the 60Hz notch filter back on.
    b. Was there any change in the signal? Report your findings to the TA.
2. EMG

Spike is because of the surrounding noise

    a. While staying still, clench and unclench your jaw/grind your teeth.
    b. While staying still, blink a couple of times in a rapid succession, then try to not blink for a few seconds.
    c. Were there any abrupt changes in the signal while performing these activities? Report your findings to the TA.
3. Motion
    a. Gently shake your head left and right –as if signalling “no”–; next, nod your head up and down –as if signalling “yes” –.
    b. Did you see any changes in the EEG recording while you performed these movements? Report back to the TA.
4. EoG
    a. While sitting in front of the screen, –without moving your head– focus your gaze on the left end of the screen, then to the right end of the screen, in a rapid manner, alternate between the two.
    b. During this eye movement, did any channel experience any irregular activity?

Wrap-up

1. In the GUI, click “stop recording”.
2. Check that you can find the recording files, and open them to make sure there is data being saved. The files should be saved in

    ```
    C:\Users\<utorid>\OpenBCI_GUI\Recordings
    ```

    Your files will not be persisted on the lab machines. If you would like to keep your recording files, you **MUST** transfer the files to the W:\ drive, email them to yourself, save them to a USB drive, etc.

    For this lab, you will not do any additional work on the signals you recorded.
3. In the GUI, click “end session”.
4. Power off the control board by sliding the switch back down to the middle position (there are 3 positions in total, do not slide the switch all the way to the bottom position).
5. Place all of the components back in the boxes and return the box to your TA.

References

Gray, Henry. *Anatomy of the Human Body.* Philadelphia: Lea & Febiger, 1918; Bartleby.com, 2000. www.bartleby.com/107/.

Martin, J. H. (2012). Neuroanatomy Text and Atlas (4th ed.). McGraw Hill. p. 283.

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