Artifacts in Electroencephalography

In this lab you will be provided an introduction to the electroencephalogram, or EEG. You will also receive basic training on a sleep monitor that uses similar brain activity patterns to determine what sleep stage you are in. Due to physiological necessity, the sleep data will be collected outside of class.

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Background

The cerebral cortex contains huge numbers of neurons. Activity of these neurons is to some extent synchronized in regular firing rhythms; these are referred to as brain waves. Electrodes placed in pairs on the scalp can pick up variations in electrical potential that derive from this underlying cortical activity. Electroencephalogram, or EEG, signals are affected by the state of arousal of the cerebral cortex, and show characteristic changes in different stages of sleep (p 646). Electroencephalography is used, among other things, in the diagnosis of epilepsy and the diagnosis of brain death.

The EEG measures changes in the membrane potentials of cortical neurons near the scalp, especially the excitatory and inhibitory post-synaptic potentials (EPSPs and IPSPs). Very little contribution normally comes from action potentials propagated along nerve axons. The EEG reflects the algebraic sum of the electrical potential changes occurring from large populations of cells. Therefore, large amplitude waves require the synchronous activity of a large number of neurons (p 649). The rhythmic events that these waves reflect often arise in the thalamus whose activity is in turn affected by a variety of inputs including structures in the brainstem reticular formation. Changes in sleep state are a prominent way of altering the post-synaptic activity of large groups of neurons across the entire brain.

The EEG waveform contains component waves of different frequencies (p 650-653). These can be extracted and provide information about different brain activities. Sleep waves are theta (4 and 8 Hz; <30 µV), which are seen in sleeping adults and children and awake children, and delta (0.5 and 4 Hz; up to 100 - 200 µV), which is the dominant rhythm in sleep stages three and four, i.e. deep sleep.

EEG recording is technically difficult, mainly because of the small size of the voltage signals, which are typically 50 µV peak-to-peak. The signals are small because the recording electrodes are separated from the brain's surface by the scalp, the skull, and a layer of cerebrospinal fluid. A specially designed amplifier, such as the Bio Amp built into the PowerLab, is essential. It is also important to use electrodes made of the right material and to connect them properly. Even with these precautions, recordings may be spoiled by a range of unwanted interfering influences, known as artifacts. Artifacts are really any signal that is not brain activity and interferes with the ability to see what the brain activity actually is. It can be caused by various things, such as the environment (e.g. electrical noise at 60 Hz), the participant (e.g. eye blinks), or researcher error (e.g. not properly placing electrodes). Being able to identify artifacts is necessary for EEG research in order to help reduce/minimize them ahead of time and/or to know whether the activity you are observing is really from the brain or not.

Required Equipment (for in-class lab section)

- LabChart software
- PowerLab Data Acquisition Unit
- 5 Lead Shielded Bio Amp Cable
- EEG Electrodes with shielded lead wires
- Electrode Paste – to put inside electrodes

- Abrasive Gel
- 1 cotton round (per subject) – for applying abrasive gel
- Alcohol Swabs (2-3 per subject) – for preparing electrode site and cleaning up electrode paste
- 3-5 Q-tips – for applying electrode paste into electrodes and cleaning out electrodes
- Elastic bandage – for keeping electrodes in place, especially in hair where tape doesn't work
- 2 paper towel sheets – for cleaning up at the end and for spills during preparation

Required Equipment (for out-of-class lab section)

- Sleep Zeo Monitoring System
- Smart Phone device with Sleep Zeo app installed
- Power cord that can be plugged in to both the Sleep Zeo and the phone

Procedure

Equipment Setup and Electrode Attachment

1. Plug the powerstrip into the wall and turn on.

2. Make sure the PowerLab is turned off and the USB cable is connected to the computer.

3. Turn on the computer and monitor.

4. Connect the 5 Lead Shielded Bio Amp Cable to the Bio Amp Connector on the front panel of the PowerLab (Figure 1). The hardware needs to be connected before you open the settings file.

5. Attach the EEG Electrodes to the Bio Amp Cable – you ought to hear it click into place. Channel 1 "positive" (black electrode) will lead to the inion (the bump on the back of the head above the neck), Channel 1 "negative" (white electrode) will lead to the forehead, Channel 2 will be empty, and the Earth (green electrode) will lead to the other side of the forehead. Refer to Figure 1 for proper placement, but do not attach them to the volunteer yet. Follow the color scheme on the Bio Amp Cable.

6. Remove any jewelry from the volunteer's face, ears, and neck. Abrade the skin on the forehead and back of the head with Abrasive Gel and cotton round. This is important as abrasion helps reduce the skin's resistance. After abrasion, clean the area with an alcohol swab to remove the dead skin cells.

7. While the skin is drying, scoop Electrode Paste into the EEG Flat Electrodes using a Q-tip, completely filling the center cavity and having the paste slightly rise above the edges of the entire electrode. Hold the electrodes and wires in place with your finger. If there is enough electrode paste, it will squish to the skin and help hold it in place.

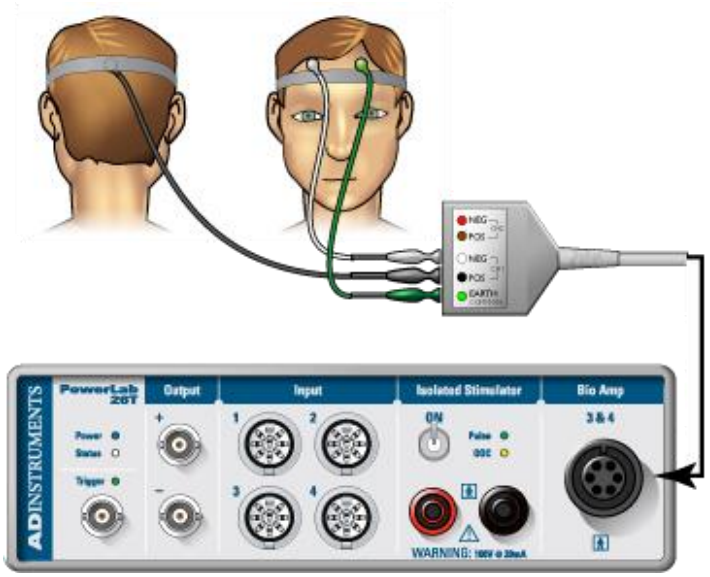

Figure 1. Equipment Setup

8. Use the elastic bandage to wrap tightly around the head. This will help the electrodes maintain good contact with the skin.

9. Check that all three electrodes are properly connected to the volunteer and the Bio Amp Cable before proceeding.

10. Turn on the PowerLab.

Exercise 1: Checking the signal to make sure it looks valid

In this exercise, you will learn to ensure proper connections of the electrodes.

1. Launch LabChart and open the settings file "EEG Settings" from the **recent files** section of the **Welcome Center** or within the NEUR330 folder for this lab.

2. Select **Bio Amp** from the Channel 3 (green) Channel Function pop-up menu, which is called EEG. Make sure the settings are as follows: Range 200 µV, High Pass 0.5 Hz, and Low Pass 50 Hz.

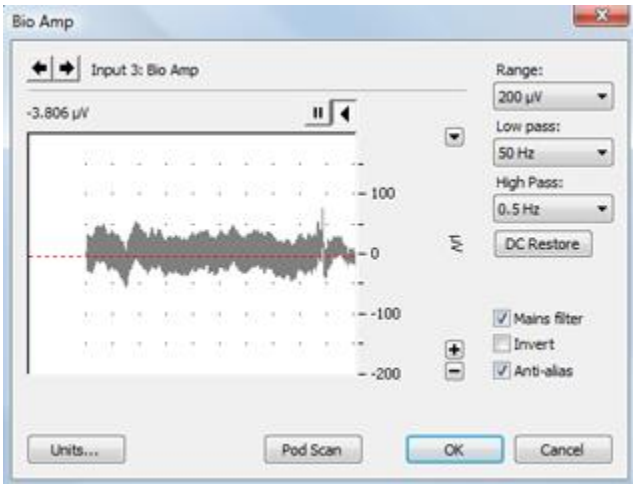

Figure 2. Bio Amp Dialog Box

3. Check to make sure that the data line is fairly small (within the range of +/- 50 µV (see Figure 2). If it is not, try to adjust the electrodes to have better contact with the skin. Verify with the instructor that the signal looks correct.

   Main problem areas:

   a. There is not enough electrode paste in the electrode.

   b. There is too much hair in between the electrode and the scalp.

   c. One of the electrodes has come loose and is no longer touching the skin. This can happen if the headband slips a bit.

4. Once a nice clean signal has been established, hit 'ok' to exit back to the Chart View.

5. **Start** Recording. Add a **comment** with "clean data." **Stop** recording after a couple of seconds.

6. Save your data in a folder labeled 'Student Data' in the NEUR330 folder, using the name of the lab, the exercise, and initials of the people in your group (e.g. Lab_6_initial_EEG_data_DN).

Exercise 2: Observing participant artifacts

Many artifacts can come from the actions of the participant. Knowing what they look like can help instruct participants on how to reduce them but it is also helpful to know if the data just needs to be thrown out when these artifacts occur. The big differences between them are that blinks tend to be fast, sharp deflections in a consistent voltage pattern whereas eye movements and head movements tend to be more drawn-out and the direction varies (depending on the direction of the movement).

7. **Start** Recording. Add a **comment** with "blinking," and have the volunteer blink 3-4 times, spaced out by 1-2 seconds. **Stop** recording after ten seconds.

8. This time, the volunteer will be making eye movements and holding the new positions. **Start** Recording. Add a **comment** with "eye movements." Have the volunteer gaze up, wait 1 second, then gaze down, wait 1 second, gaze to the left, wait 1 second, then gaze to the right, wait 1 second, and then look straight ahead again. Make sure the volunteer keeps their head still and only moves their eyes.

9. This time, the volunteer will be making head movements and hold the new positions. **Start** Recording. Add a **comment** with "head movements." Have the volunteer gaze up, wait 1 second, then gaze down, wait 1 second, gaze to the left, wait 1 second, then gaze to the right, wait 1 second, and then look straight ahead again. Make sure the volunteer moves their whole head.

10. Save your data file. There is no need to change the name of the file, you will just be saving into the same file that you started doing above.

Exercise 3: Observing mechanical artifacts

Many artifacts can come from the actions of the researcher. Knowing what they look like can help to fix the equipment before collecting more data to make sure that only valid data is collected.

11. Now you will purposefully mess up the electrode placement to see what junky data looks like. Start with problem area c, i.e. move the black electrode on the back of the head off of the scalp by lifting it out above the headband. **Start** Recording. Add a **comment** with "loose electrode." **Stop** recording after 5 seconds.

12. Now mess up the data by putting the electrode back in place, but with hair in between the electrode and the scalp. **Start** Recording. Add a **comment** with "too much hair." **Stop** recording after 5 seconds.

13. Now mess up the data by wiping most of the electrode paste off of the black electrode with a paper towel. Put the electrode under the headband again and up close to the scalp. **Start** Recording. Add a **comment** with "too little paste." **Stop** recording after 5 seconds.

14. **Save the data file** again and then save it to a USB for everyone in your group.

Exercise 4: Clean up the equipment

1. Once all of the data has been collected and saved, the electrodes can be removed from the participant and put away before the data is analyzed.

2. First remove the headband and take the electrodes off of the scalp.

3. Use a paper towel and then alcohol wipes to remove any excess paste off of the scalp.

4. Now clean the electrodes. First use a paper towel to remove most of the paste from the electrode (pretty much everything but the part in the middle). Then use a Q-tip to get the paste out of the middle. This can be done by inserting the Q-tip into the middle and twisting it around. Finally, use an alcohol wipe to clean any remaining paste from the electrode tip, including pushing the wipe into the middle using a Q-tip.

5. Unplug the electrode wires from the PowerLab hardware and gently roll them up and put them back into the equipment briefcase.

Exercise 5: Analyzing Participant Artifacts

1. Examine the vertical scale at the left of the Chart View, and note the positions corresponding to +50 µV and –50 µV. True EEG signals rarely exceed these limits. Examine the entire data trace and **Autoscale**, if necessary. There may be some large signals outside the ±75 µV range. Such large signals are artifacts. **Print the entire Chart View to PDF** and save it in the NEUR330 folder.

2. Locate the comment for 'Eye Blinks'. First determine the time of one eye blink using the waveform cursor and note the time on your data notebook. Next determine the magnitude of the artifact deflection by setting the marker (by right-clicking or dragging the M symbol from the lower lefthand corner) to the time right before it started and then record the change in amplitude from this baseline point to the largest deflection. Next determine the duration of the artifact by moving the cursor to the time point where the deflection ends and record the time difference on your data notebook.

3. Repeat the process of analyzing the 1 artifact for each of the 'Eye Movements' and 'Head Movements'.

Exercise 6: Analyzing Mechanical Artifacts

4. Locate the comment for 'clean data'. You will simply be measuring the largest and the typical amplitude of the different sections of data to see what sorts of differences are visible, if any. Move the waveform cursor along the data time course to see what the typical peak amplitude is for this section of data and record it on your data notebook (this is more of a rough estimate than a specific value). Now find the maximum peak amplitude in this section of data and record it on your data notebook (this is an actual observed data point so it can be more accurate).

5. Repeat the process of analyzing the 3 artifact types of "Loose Electrode", "Hair in the Way", and "Too Little Paste".

6. Now the equipment can all be shut down and the carts rolled back into the equipment storage room.

Exercise 7: Prepare to record sleep stages (at home)

1. Check out a Sleep Zeo monitoring device from your instructor. You will use 1 per group during class and then students will need to take turns bringing them home since there are only 6 devices and many more students. Everyone will get a chance to have a turn eventually.

2. Make sure that the phone is charged fully by keeping it plugged in overnight and shutting it off completely when not in use. Turn on the phone to verify how it works now in class.

3. Make sure that the Sleep Zeo is charged during the day (for a minimum of 45 minutes before sleep). The power cord is the same one as for the phone and goes into the USB slot on the bottom of the device.

4. Open the Sleep Zeo app. From the main home screen of the phone, click on the double square icon in the lower righthand corner to access the list of apps on the phone. Scroll to the last page of apps to see the Zeo app and open it. It will likely open up to the recording of the last night's sleep (note this is the 'track' setting).

5. There will be a note on the screen indicating whether or not the headband is connected. Each headband has already been paired to a phone so if it shows up as 'not connected' then you most likely just need to charge the headset by plugging it into the wall (do that now). When it is charging it will flash a green light.

6. The Sleep Zeo device is connected to the phone through Bluetooth. This only needs to be done once – do not try to repeat this process if linking has already occurred! If the headband is not showing up as paired, click on the phone button with the 4 squares (upper left one is solid white) to see the options and then choose 'pair headband'. As the instructions say, you just need to hold down the button on the phone until it flashes orange and then click on 'pair your headband' on the phone. Again, do not do this if it is already paired.

7. To record the data overnight you just need to put on the headband (after unplugging it and plugging in the phone) and go to sleep. Make sure that it is comfortably tightened so that it doesn't fall off by isn't too tight. Practice this now by adjusting the Velcro straps on the side of the headband.

8. Your data will save automatically in the 'history' area of the app instead of the 'track' area. The 'track' area shows the current data.

9. After each night of sleep you will enter your information on the Zeo question report sheet and then turn it in to the instructor after answering the additional questions.

10. When done with the Sleep Zeo device, pass it on to another member of your group or return it to your instructor.