Electroencephalography (EEG)

In this experiment, you will be provided an introduction to the electroencephalogram, or EEG, and will explore the electrical activity of the brain. You will record an electroencephalogram from a volunteer and examine the effects of language on alpha brain waves.

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Background

The EEG waveform contains component waves of different frequencies. These can be extracted and provide information about different brain activities. Alpha waves (between 8 to 13 Hz; average amplitudes of 30 to 50 µV) will be studied in this experiment. Alpha rhythm is seen when the eyes are closed and the subject relaxed. It is abolished by eye opening and by mental effort such as doing calculations or concentrating on an idea. It is thus thought to indicate the degree of cortical activation; the greater the activation, the lower the alpha activity. Alpha waves are strongest over the occipital (back of the head) cortex and also over frontal cortex.

The other types of brain waves are beta (13 to 30 Hz; <20 µV), which are prominent in alert individuals, theta (4 and 8 Hz; <30 µV), which are seen in sleeping adults and children and awake children, delta (0.5 and 4 Hz; up to 100 - 200 µV), which is the dominant rhythm in sleep stages three and four, and gamma (30 and 50 Hz). Most people recognize gamma rhythm, but its importance is controversial. It may be associated with higher mental activity, including perception and consciousness.

Required Equipment

- SuperLab software
- 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 – to prepare forehead
- 1 cotton round (per subject) – for applying abrasive gel
- Alcohol Swabs (2 per subject) – for preparing electrode site and cleaning up electrode paste
- 3 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
- Eye cover – for blocking unnecessary visual input
- Headphones – for listening to word lists
- Pillow and stack of books for resting the participant's head comfortably

Procedure

Equipment Setup and Electrode Attachment

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

2. Turn on the computer and monitor.

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

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. Channel 1 "positive" will lead to the inion (the bump on the back of the head above the neck; think "black on back"), Channel 1 "negative" will lead to the right side of the forehead (think "white on right"), the Earth will lead to the other side of the forehead, and Channel 2 will be empty. 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 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.

8. Attach the black electrode to the back of the participants head, making sure to move the hair out of the way to get good contact with the skin. If there is enough electrode paste, it will squish to the skin and help hold it in place. Attach the other two electrodes to the forehead of the participant. Use the elastic bandage to wrap tightly around the head. This will help the electrodes maintain good contact with the skin.

9. Have the volunteer sit in a comfortable position where they will be able to stay without moving for the entirety of the experiment. They can rest their head on a pillow placed on top of a stack of books. Make sure they are not pressing down on the wires.

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

11. Turn on the PowerLab. Also turn on the StimTracker.

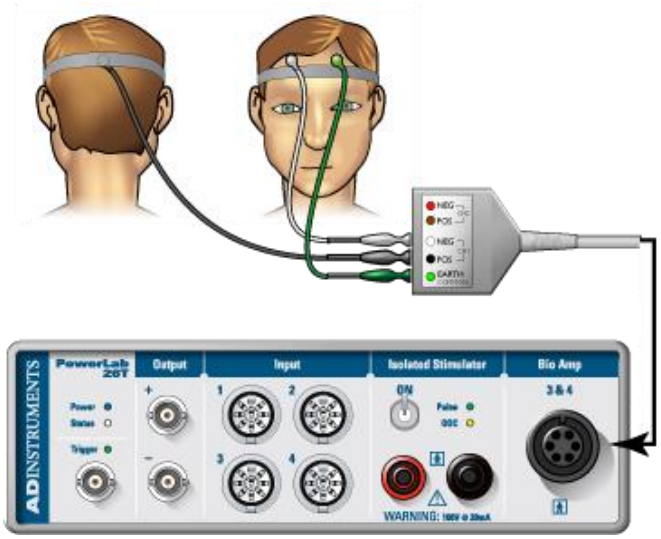

Figure 1. Equipment Setup

Exercise 1: Alpha Waves in the EEG

In this exercise, you will examine the effects of listening to real words versus nonsense words on alpha waves in the EEG.

1. Open up the Instructor Example Data to see what the end product will look like. If necessary, switch to the Chart View window. Notice the comment lines that indicate the start and stop of different word lists. There will be a total of 6 word lists that last about 1 minute each.

2. Open a new data record using the settings file "EEG Settings with comments" from the appropriate folder in the NEUR330 folder.

3. Select **Bio Amp** from the Channel 3 (green EEG) 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. (See Figure 2)

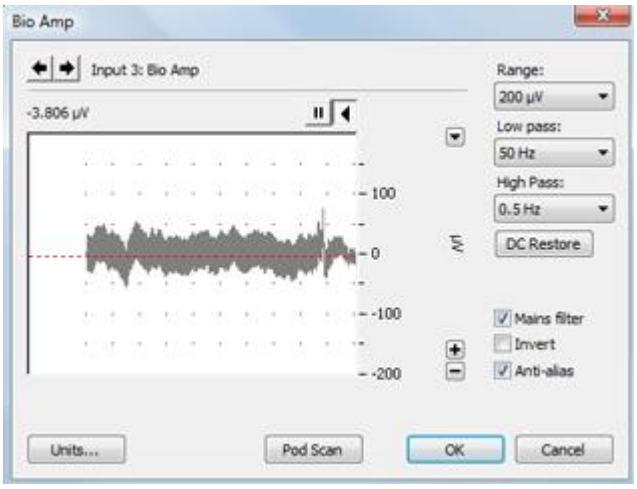

Figure 2. Bio Amp Dialog Box

4. Plug the headphones into the computer and set the computer speaker output level around 40. Place headphones on the subject being careful that the EEG wires are not touching the headphones.

5. In the external monitor, open the Word_List_EEG SuperLab file. You will soon run the program to present different word lists to the participants, but only after you start recording the EEG data.

6. Make sure the subject is relaxed and comfortable. Have them close their eyes and remain quiet. Put the eye cover over their eyes with the straps over the headphones. Keep extra noise to a minimum and keep all distractions away from the volunteer.

7. **Start** recording in Labchart.

8. In the SuperLab program, run the program (the green arrow at the top). Uncheck the 'save data' box and then continue. Do not move the mouse or touch the computer after making it run or it could crash the program.

9. **Make sure there are comment lines appearing** in the EEG data to ensure that everything is working properly.

10. **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. EEG_lab_AlphaWaves_DN) after all of the word lists have been presented.

11. Use the **View Buttons** to change the horizontal compression scale to 50:1 or 100:1 to view all of the data, then **Autoscale** the vertical axis. **Print the entire time course of the data into a PDF**.

12. You can now take off the EEG equipment and clean up.

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

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

    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.

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

Analysis

Exercise 1: Recognizing Artifacts

1. If necessary, reopen the saved data file with the EEG data. Make sure the window is set to Chart View.

2. First determine when the different word lists were presented and record these times on your data notesheet. Note that the c1 and c2 comment lines indicate the start and stop of the lists.

3. 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.

4. Count the number of artifacts in just the first presentation of each of the different type of word lists.

Exercise 2: Alpha Waves in the EEG

1. Highlight all of the area between the first and last comments and from the Window menu along the top, select **Spectrum**.

   The Spectrum window displays the frequency content of the selected data (you may need to click on 'channel 3: EEG' as the display channel). A mathematical technique known as the Fast Fourier Transform is applied to the raw data. The result of this analysis is a list of amplitudes at different frequencies (Figure 3). The amplitudes (vertical axis) are plotted as a function of the frequency (horizontal axis). Alpha activity shows up in the spectrum as a clear peak in the 8-13 Hz range. Spectral analysis can show frequency components of a signal even if they are too small to be recognized in the Chart View.

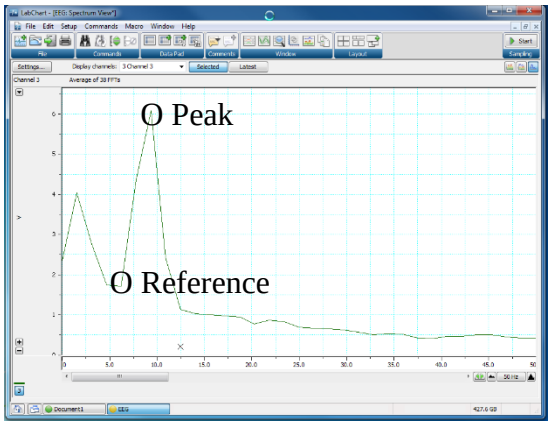

Figure 3. Spectrum of an EEG

2. Move the cursor along the spectrum to find the Hz value in the FFT in the 8-13 Hz range that shows a peak amplitude (see Figure 3). Mark the Hz value (which is along the x-axis) on the data notebook – this will be used as the Peak Hz, i.e. the x-axis point, for all remaining calculations. Find the Hz value that is 1 or 2 spots to the left of it that is prior to the peak starting, i.e. that is part of the normal descending pattern of the line and not part of the upwards bump. Mark this as the reference Hz value on the data notebook. **Print** a PDF of this spectrum view.

3. The prior analysis used all the data, but to look for consistencies to see if coherent versus incoherent word lists make a difference you have to use just subsets of the data. From within the Chart View, locate a 15-40 second time window during the nonsense word list data trace that does not have any artifacts. Highlight it and go back into the Spectrum view. Note that the small pink splotches in the bottom part of the Spectrum View indicate when blinks occur.

   Record the amplitude of the voltage at the peak and reference Hz values in the table on your data notebook. Also record the # of FFTs included in the analysis as this gives a sense of how reliable the data is. You will leave blank the column labeled 'contrast' for now.

4. Repeat step 3 using time windows for the other word lists and record these values in the table on your data notebook also.

5. Something that you may have noticed is that the absolute amplitudes for the peak and reference Hz sometimes fluctuate for different clips based on things unrelated to the brain signal of interest (such as due to the # FFTs and the amount of 1/f noise). For this reason we will determine the relative amount of alpha waves between conditions based on the contrast of the peak and reference amplitudes instead of the peak amplitude directly.

6. On your data notebook, fill in the column on the table labeled contrast by first subtracting the peak amplitude from the reference amplitude and then dividing that difference by the sum of the peak and reference amplitude (see equation and example below).

$$\frac{PeakAmp - RefAmp}{PeakAmp + RefAmp}$$

(8 – 2) / (8 + 2) = 6/10 = .6

7. Save the data file and PDFs to your USB, shut down the computer and put away the equipment.

8. Remember to complete the lab report questions by yourself outside of class.