Decoding Life Signals Lab: Alpha Wave Detection

Overview

In this lab exercise, you will analyze EEG recordings that demonstrate one of the most reliable phenomena in neuroscience: the alpha wave response to eye opening and closing. When a person closes their eyes, alpha waves (8-13 Hz) become prominently visible in the occipital lobe (back of the head). This lab will teach you to identify, measure, and analyze these alpha rhythms using multiple visualization techniques.

Part 1: Loading the EEG Alpha Wave Recording

Opening the Pre-recorded Data

1. Download the "EEG_sample_eyes_closed-open.txt" file from the course website
2. Launch the OpenBCI GUI application
3. In the System Control Panel (left side of the screen), select "PLAYBACK (from file)" from the DATA SOURCE options
4. In the PLAYBACK FILE section, click the text field to browse and select the EEG file
5. Click "START SESSION" at the bottom of the System Control Panel to load the recording

Configuring the Display

1. After starting the session, focus on the three active EEG channels:
    - Channel 1: Fp1 (Left frontal pole - above left eyebrow)
    - Channel 2: Fp2 (Right frontal pole - above right eyebrow)
    - Channel 8: O1 (Left occipital - back of the head, left side)
2. In each widget, use the "Channels" dropdown to select these channels
3. Adjust the vertical scale to 200 μV initially
4. Set the time window to display 5 seconds at a time

Part 2: Understanding the Recording

Recording Structure

The instructor alternated between eyes-closed and eyes-open states:

- The recording **begins with eyes closed**
- Each state (eyes closed/open) lasts approximately 30 seconds
- Several cycles of alternation were recorded
- Look for clear transitions between states in the O1 channel (channel 8)

Part 3: Applying Filters

To improve signal quality and focus on relevant frequencies:

1. Click on the "Filters" button in the top toolbar
2. Configure the following filters:
    - Bandpass Filter

      : Set Start at 0.5 Hz and Stop at 30 Hz
        - This removes very slow drift and high-frequency noise
    - Notch Filter

      : Set to 50 Hz to remove electrical interference
        - Select "50 Hz" or the frequency that matches your local power grid
    - **Filter Type**: Butterworth
    - **Order**: 4
    - Apply to "All" channels
    - Click "Save" to apply these settings
3. Observe how the filters clean up the signal, making the alpha waves more visible

Part 4: Using Different Visualization Widgets

1. Time Series Widget

- Focus especially on channel 8 (O1)
- Look for rhythmic, sinusoidal waves around 10 Hz during eyes-closed periods
- Notice how these waves diminish or disappear when eyes are open
- Compare the amplitude of activity between eyes-open and eyes-closed states

2. FFT Plot

Configure the FFT Plot widget:

- Set Max Freq to 40 Hz
- Set Max µV to 200 µV (adjust as needed)
- Use Log scale for better visualization
- Set Smoothing to 0.9
- Set Filter to "Filtered"

Observe:

- During eyes-closed periods, look for a prominent peak in the 8-13 Hz range (alpha band)
- During eyes-open periods, notice how this peak diminishes
- Compare the FFT patterns between frontal (Fp1/Fp2) and occipital (O1) channels

3. Spectrogram

Configure the Spectrogram widget:

- Set Max Freq to 30 Hz
- Set smoothing to 0.9
- Use Log scale for power visualization

Observe:

- Look for bands of increased activity in the 8-13 Hz range during eyes-closed periods
- Note how these bands appear and disappear with eye opening/closing
- Pay attention to the timing of these changes relative to the experimental protocol

4. Band Power Widget

This widget separates brain activity into traditional EEG frequency bands:

- Delta (0.5-4 Hz): Slow waves associated with deep sleep
- Theta (4-8 Hz): Associated with drowsiness and some cognitive processes
- Alpha (8-13 Hz): Present during relaxed wakefulness, especially with eyes closed
- Beta (13-30 Hz): Associated with active thinking and concentration
- Gamma (>30 Hz): Associated with complex cognitive processing

Observe:

- During eyes-closed periods, the alpha band should show increased power
- Compare the relative strength of each band between eyes-open and eyes-closed states
- Note which channel (Fp1, Fp2, or O1) shows the strongest alpha response

Part 5: Data Analysis Tasks

Alpha Wave Analysis

1. Identify periods of eyes-closed and eyes-open throughout the recording
2. For each period, note:
    - The approximate amplitude of alpha waves in the Time Series
    - The peak frequency within the alpha band using the FFT Plot
    - The relative power of the alpha band compared to other bands

Channel Comparison

1. Compare the alpha response between channels:
    - Frontal (Fp1, Fp2) vs. Occipital (O1)
    - Left hemisphere (Fp1) vs. Right hemisphere (Fp2)
2. Where is the alpha response strongest? Why?

Questions to Answer

Basic Observation Questions:

1. What is the approximate frequency of the alpha rhythm you observed? Is it consistent throughout the recording?
2. How much does the amplitude of alpha activity increase during eyes-closed compared to eyes-open (approximate percentage)?
3. How quickly does the alpha rhythm appear after eye closure? How quickly does it disappear after eye opening?
4. Did you notice any "alpha blocking" events where the alpha rhythm briefly disappeared during an eyes-closed period? What might cause this?

Signal Processing Questions:

1. How did applying the bandpass filter affect the visibility of alpha waves in the Time Series display?
2. In the FFT plot, what was the approximate peak frequency in the alpha band during eyes-closed periods?
3. In the Spectrogram, what color changes did you observe in the alpha band region when transitioning between eyes-open and eyes-closed?
4. In the Band Power widget, how did the relative heights of the alpha band compare between eyes-open and eyes-closed conditions?

Submission Guidelines

1. Document at least three clear examples of transitions between eyes-open and eyes-closed states
2. Provide screenshots of:
    - Time Series showing alpha waves (eyes closed) and their absence (eyes open)
    - FFT Plot showing the alpha peak during eyes-closed periods
    - Spectrogram highlighting the alpha band changes
    - Band Power widget comparing eyes-open and eyes-closed states
3. Answer the questions based on your analysis
4. Discuss potential sources of variation in alpha responses between individuals

Good luck exploring one of the most robust phenomena in human electrophysiology!