Vital lab worksheet #07

Electroencephalography

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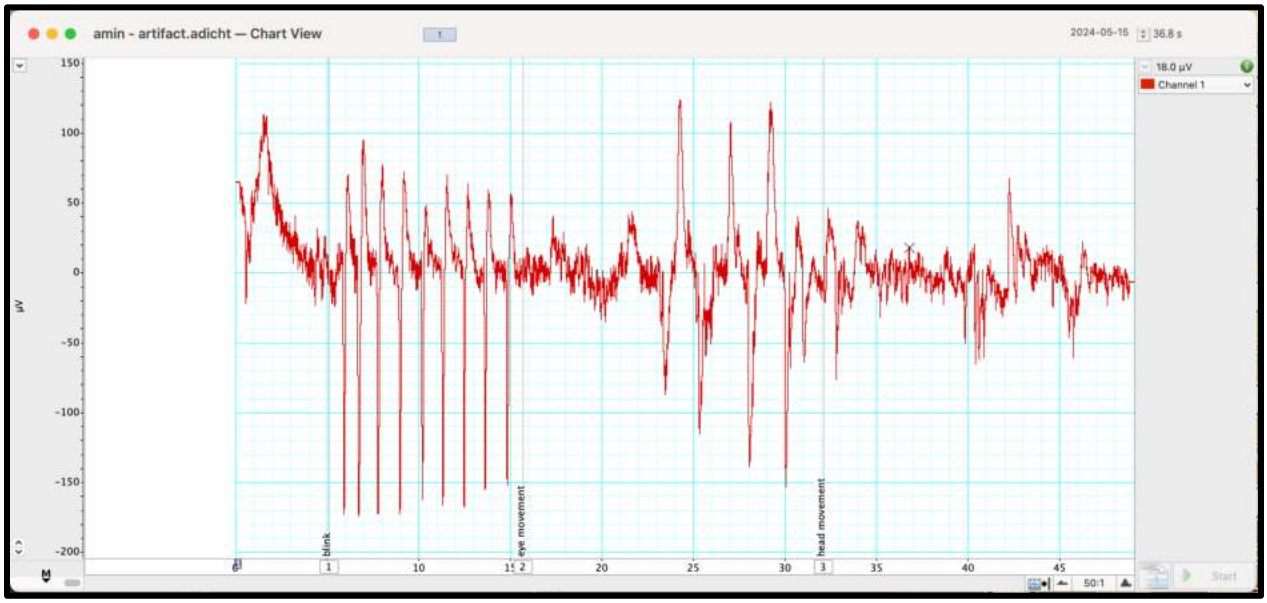
Analysis:

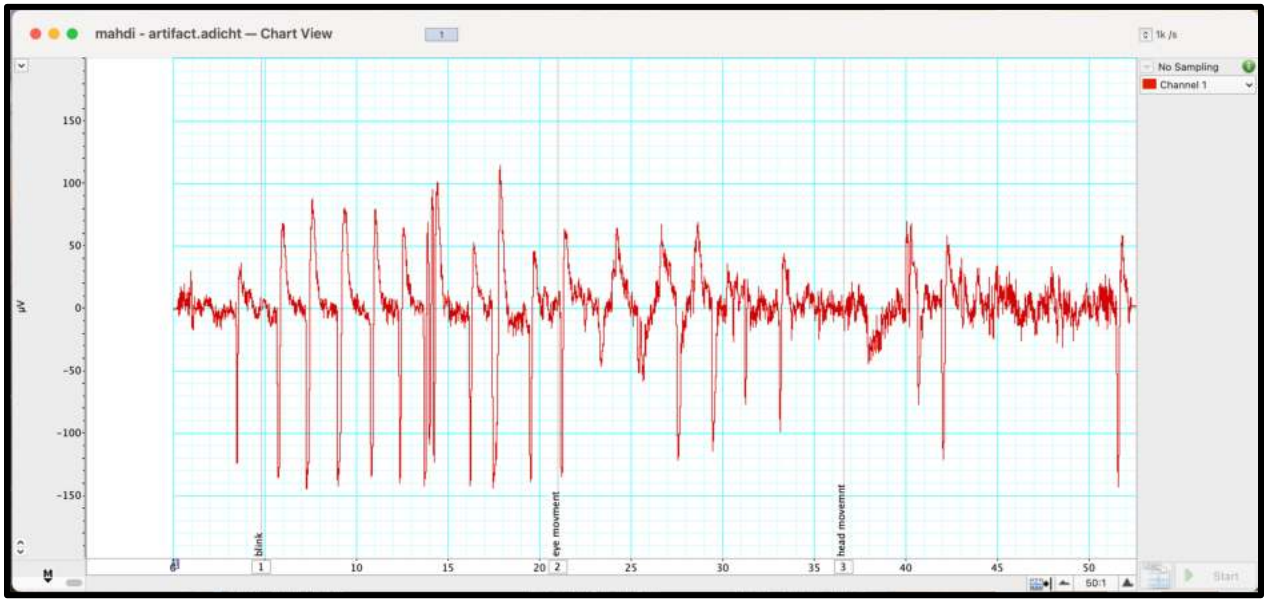
Exercise 1: Recognizing artifacts

1. Examine the vertical scale at the left of the window, and note the positions corresponding to +50 µV and –50 µV. True EEG signals rarely exceed these limits. Use the drag scale to stretch the display vertically.
2. Use the scroll bar at the bottom of the Chart window to review the recordings. You will probably find large signals outside the ±50 µV range. Such large signals are artifacts. If you do not see such signals, check the electrode connections, and if necessary, remove and re-attach any connections that seem of dubious quality.

Amin



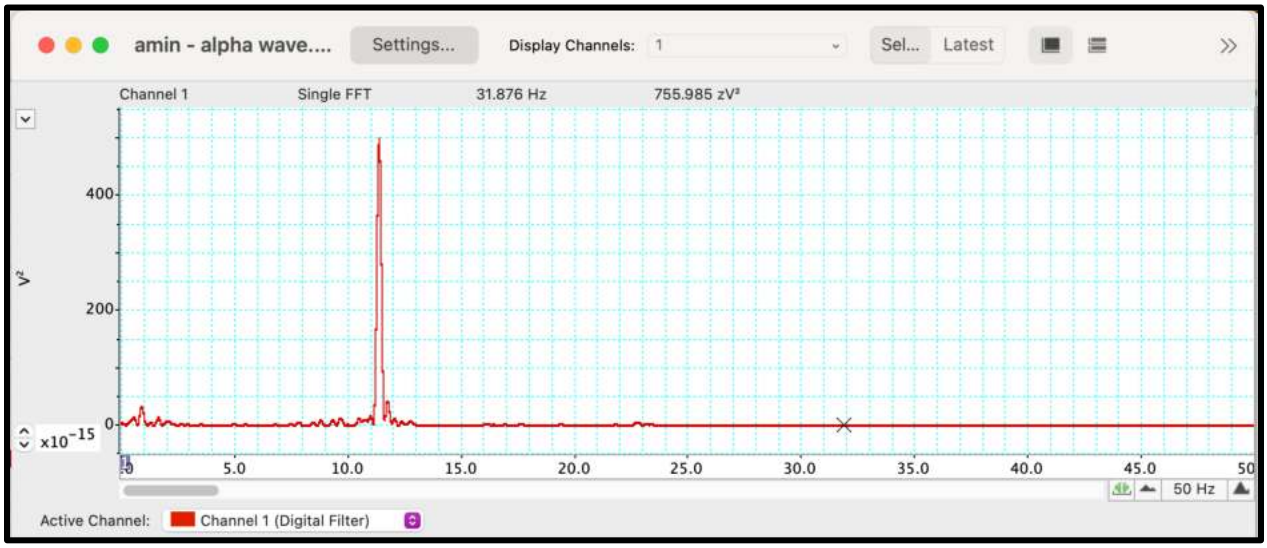
Mahdi



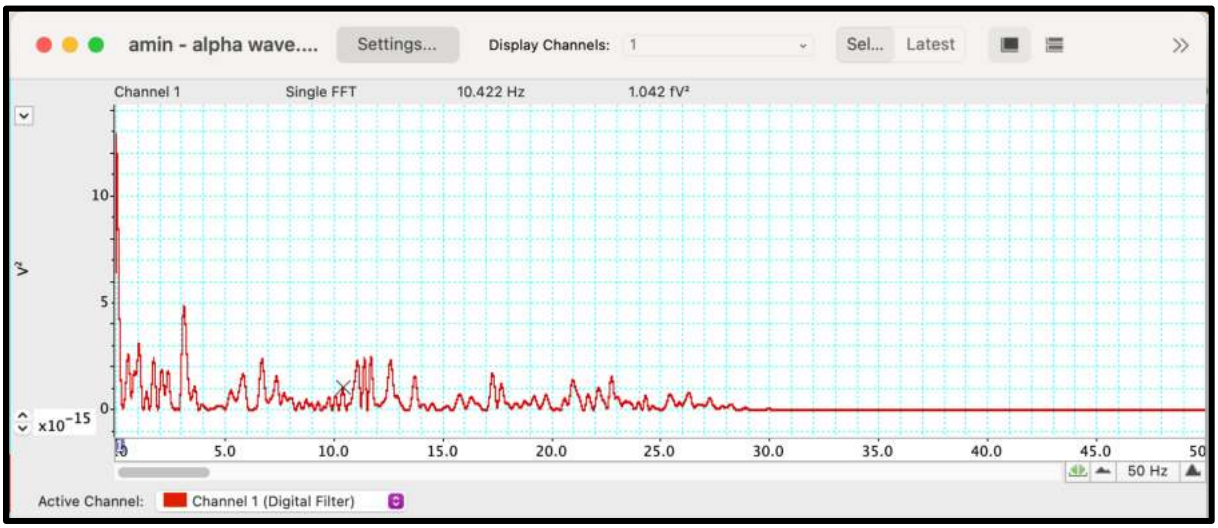
Exercise 2: Alpha waves in the EEG

1. Use the View buttons in the Chart window to change the horizontal compression to 2:1. This stretches the data out, and makes it easier to see alpha wave activity.
2. Use the scroll bar to review those parts of your recording that were made with the subject's eyes shut, looking for alpha waves. You can recognize these by their amplitude (usually less than 50 µV, although it can be quite variable from subject to subject) and their timing. Each cycle of an alpha wave should last almost exactly 0.1 s (Figure 4).
3. If you cannot find any alpha waves, check that you are examining records taken with the subject's eyes shut. If you still cannot find signs of alpha activity, or if your records consist mainly of large-amplitude artifacts, you may need to re-attach one or more electrodes, following the instructions given in 'Connecting the equipment' above. Note however that some otherwise normal subjects may not exhibit alpha wave activity. If this seems to be the case, then try a different subject.
4. Use the View buttons in the Chart window to change the horizontal compression to 10:1. Drag across several seconds' worth of the trace to select it, in an 'eyes shut' part of the recording. Then from the Windows menu, choose Spectrum.
5. The Spectrum window displays the frequency content of the selected data (Figure 5). 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. The amplitudes (vertical axis) are plotted as a function of the frequency (horizontal axis).
6. Alpha activity shows up in the spectrum as a clear peak in the 8–12 Hz range. This is easiest to see if you expand the horizontal axis. Spectral analysis can show frequency components of a signal even if they are too small to be recognized directly in the display.
7. Make a data selection of several seconds from an 'eyes open' part of the recording, and again display the spectrum. Note that there is now no distinct peak in the alpha frequency range (8–12 Hz).

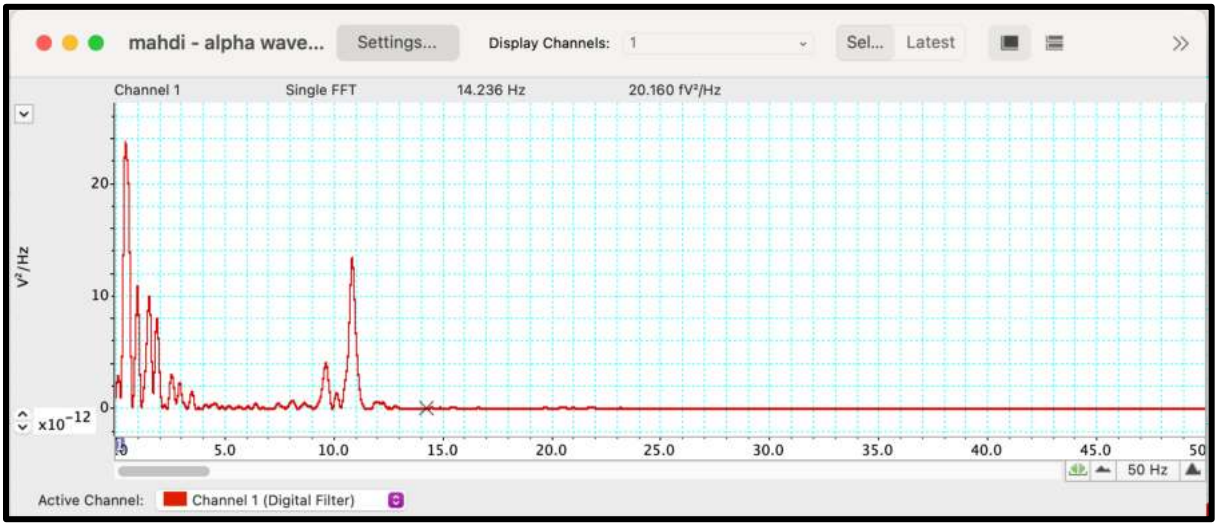
Amin Eyes closed



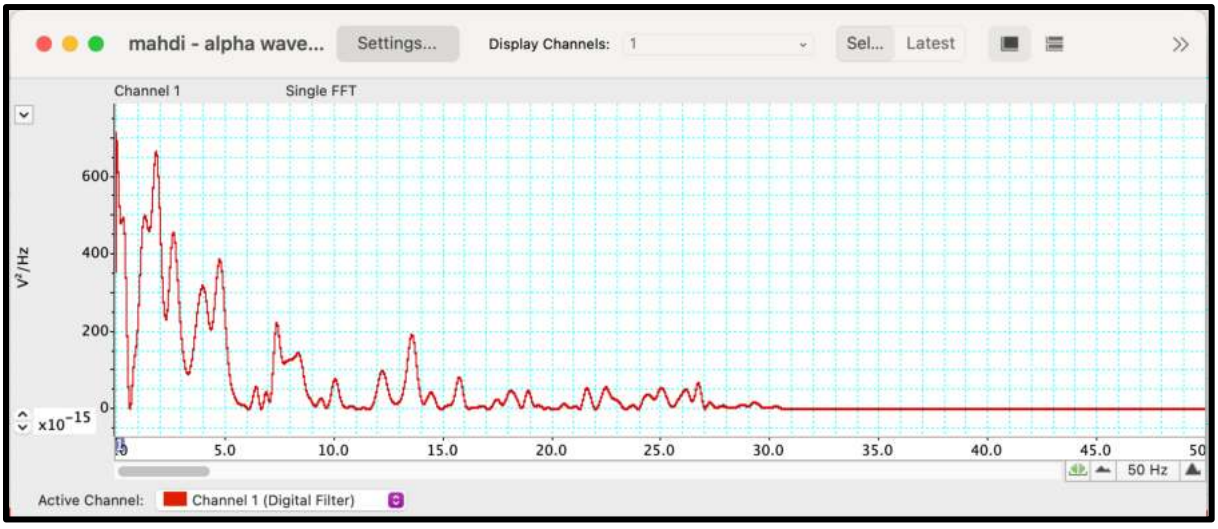
Amin Eyes opened



Mahdi Eyes closed



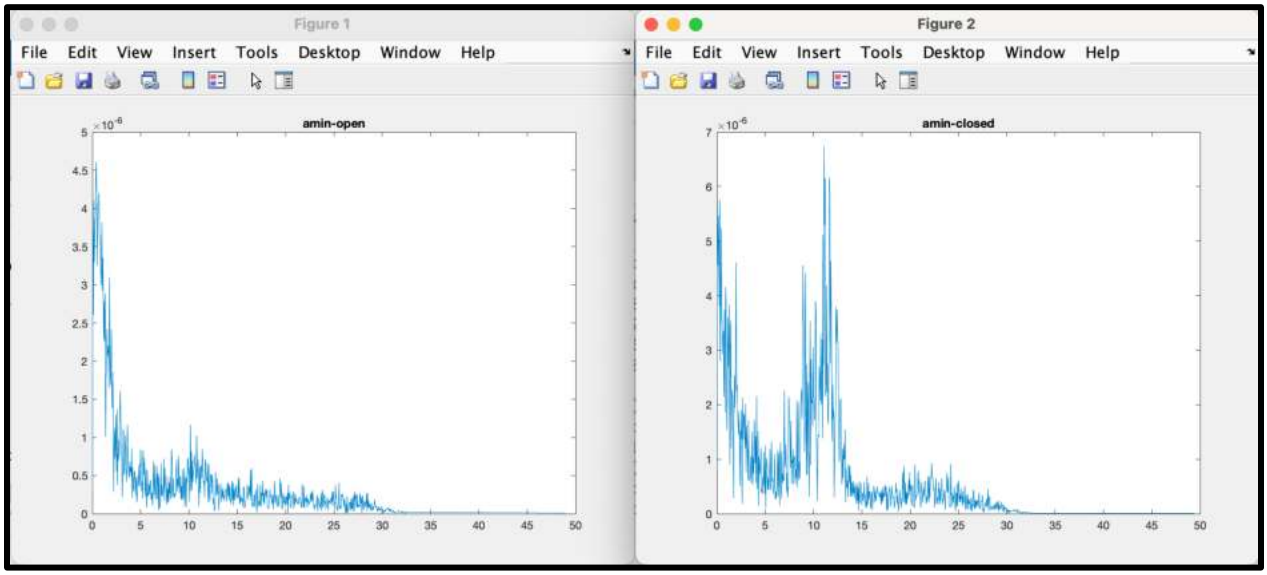
Mahdi Eyes opened



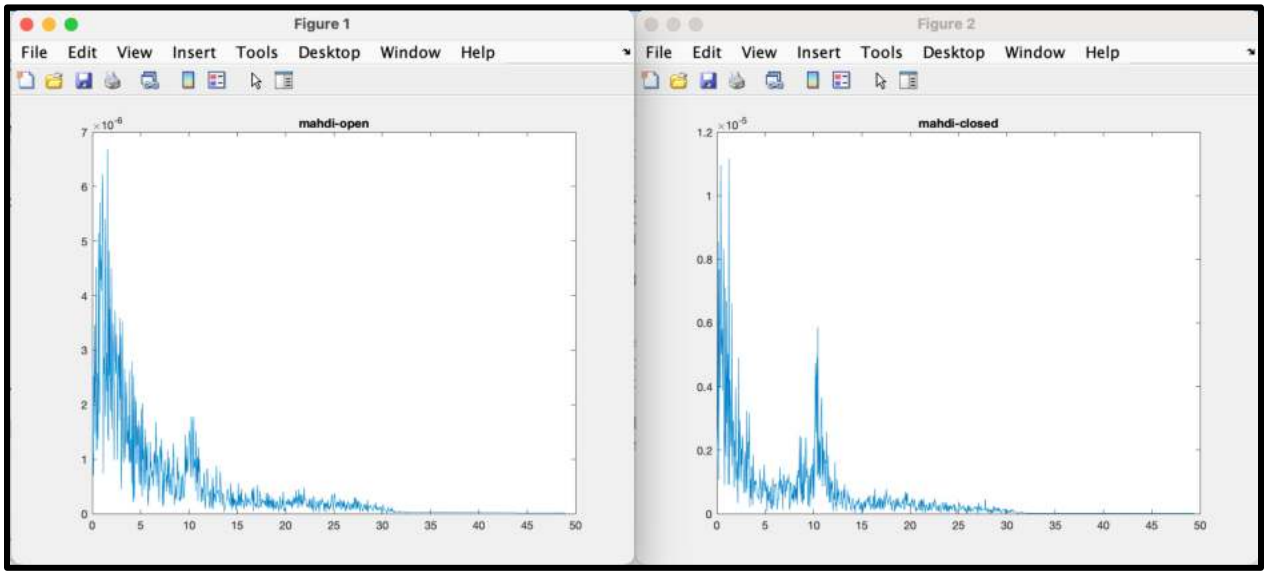
Exercise 3: Alpha wave with longer period

After recording the signal with eyes open and closed, calculate the power spectrum of the recorded signal in each of the mentioned states using MATLAB. For recording and calculating the power spectrum, first, keep the eyes open for 20 seconds, then close both eyes and keep them closed for 20 seconds. Repeat this process 10 times for each individual. What conclusion do you draw from comparing the two spectra?

Amin



Mahdi

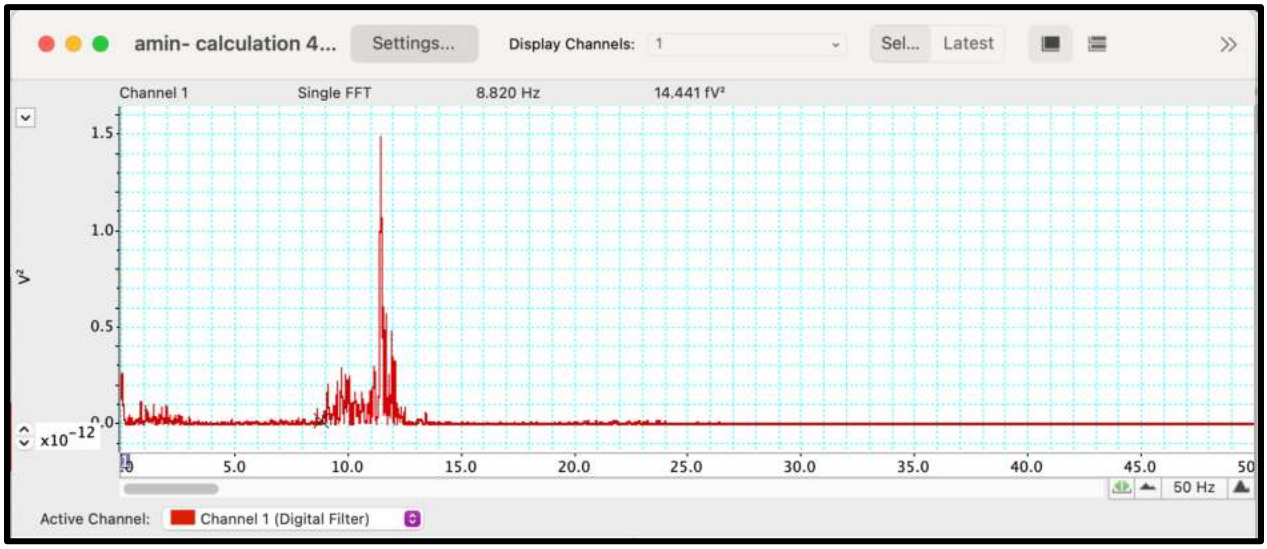


As shown in the MATLAB figures, when the eyes are closed, we can see alpha waves which are in the range of 8-13 Hz. we see some picks in the range of alpha wave when the eyes are closed.

Exercise 4: Calculating mathematic problems

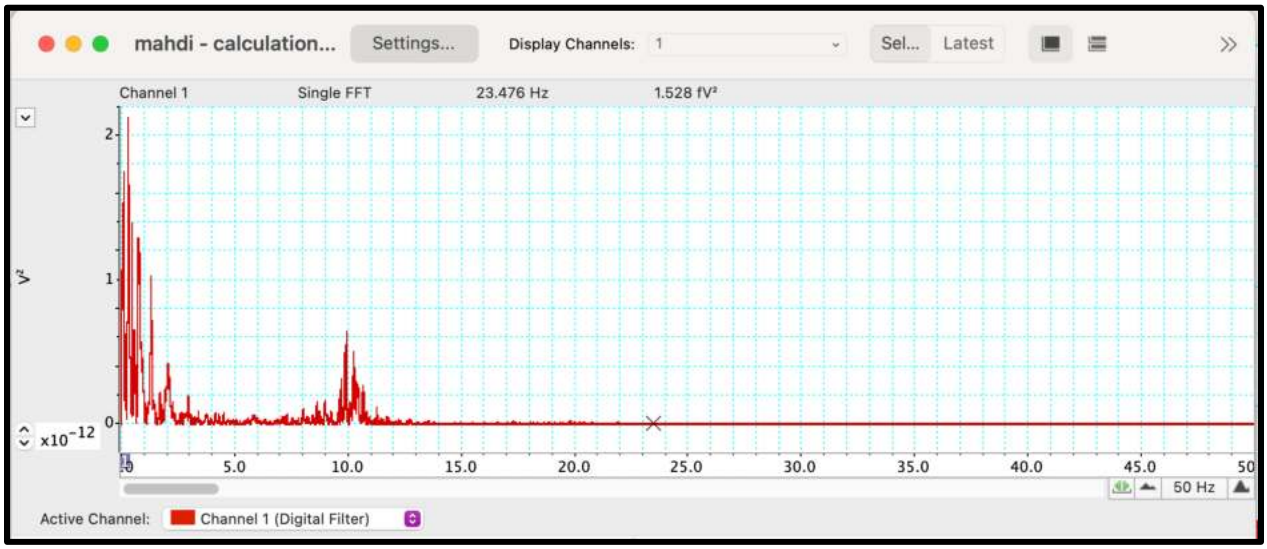
Repeat Exercise 3 while the individual performs a mental arithmetic task (such as continuous multiplication by a fixed number) with their eyes open and also with their eyes closed. In this experiment, the duration for which the eyes remain open or closed should be 40 seconds, and the experiment should be repeated 4 times for each individual. In each repetition (for a particular individual), the numbers used for the calculations should be changed. What results do you obtain from this experiment? Please explain.

Amin Eyes closed calculation

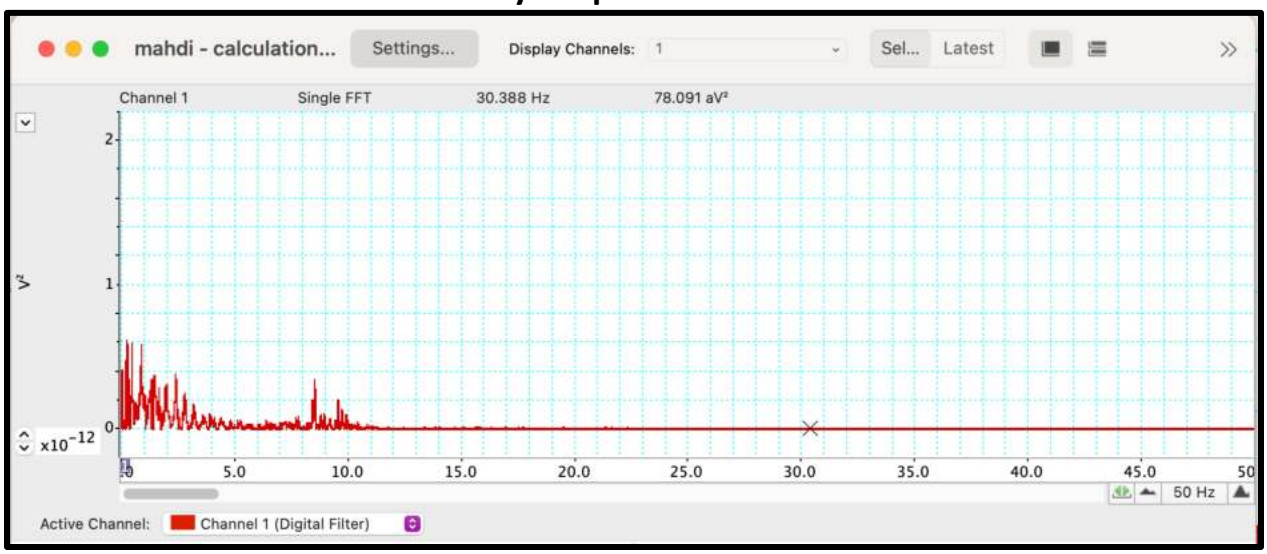


Amin Eyes opened calculation

Mahdi Eyes closed calculation



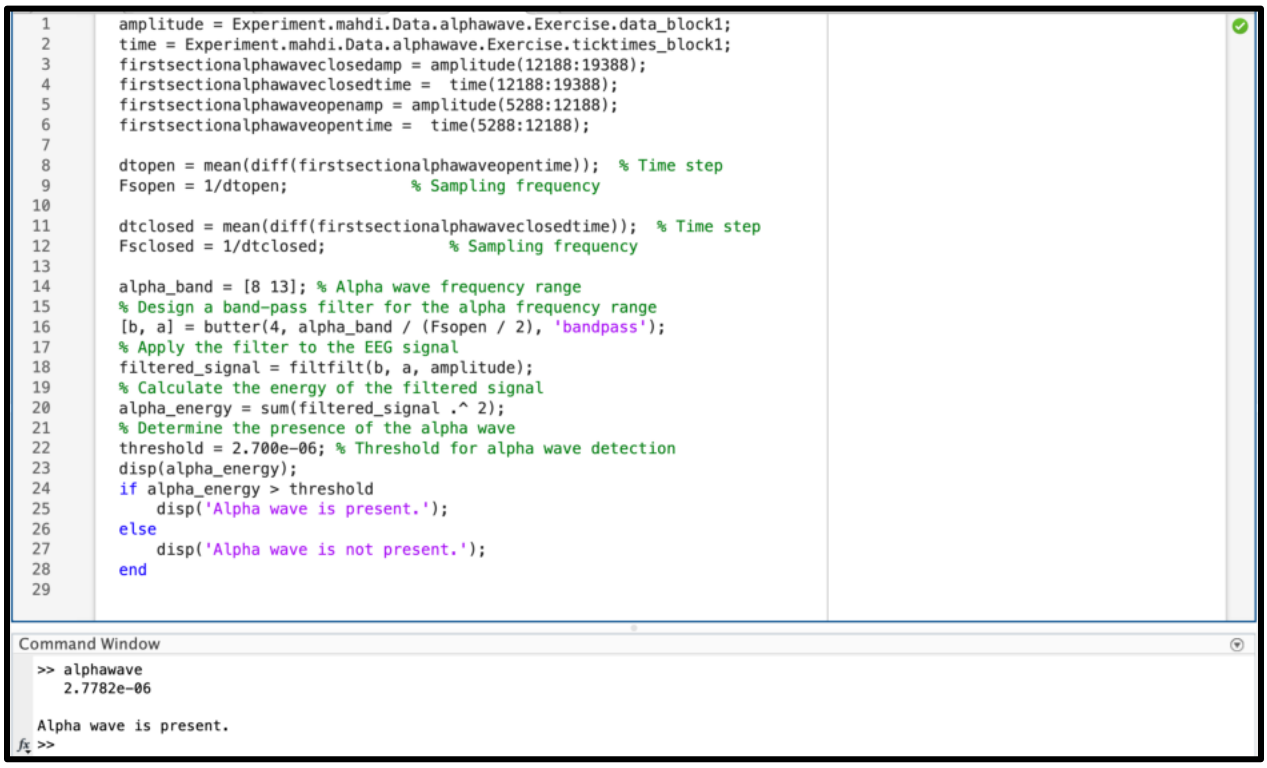
Mahdi Eyes opened calculation



As we can see while doing mathematics problems the amplitude in the frequencies increases.
While doing mathematic problem the amplitude in alpha wave increases (it increases in other waves as well).

Exercise 5: Finding alpha wave

Write a program in MATLAB that announces the energy of the received EEG wave signal. Note that the calculation range is 8 to 13 Hz, which corresponds to the presence or absence of the alpha wave frequency.



```
amplitude = Experiment.mahdi.Data.alphawave.Exercise.data_block1;
time = Experiment.mahdi.Data.alphawave.Exercise.ticktimes_block1;
firstsectionalphawaveclosedamp = amplitude(12188:19388);
firstsectionalphawaveclosedtime =  time(12188:19388);
firstsectionalphawaveopenamp = amplitude(5288:12188);
firstsectionalphawaveopentime =  time(5288:12188);

dtopen = mean(diff(firstsectionalphawaveopentime));  % Time step
Fsopen = 1/dtopen;             % Sampling frequency

dtclosed = mean(diff(firstsectionalphawaveclosedtime));  % Time step
Fsclosed = 1/dtclosed;             % Sampling frequency

alpha_band = [8 13]; % Alpha wave frequency range
% Design a band-pass filter for the alpha frequency range
[b, a] = butter(4, alpha_band / (Fsopen / 2), 'bandpass');
% Apply the filter to the EEG signal
filtered_signal = filtfilt(b, a, amplitude);
% Calculate the energy of the filtered signal
alpha_energy = sum(filtered_signal .^ 2);
% Determine the presence of the alpha wave
threshold = 2.700e-06; % Threshold for alpha wave detection
disp(alpha_energy);
if alpha_energy > threshold
    disp('Alpha wave is present.');
else
    disp('Alpha wave is not present.');
end
```

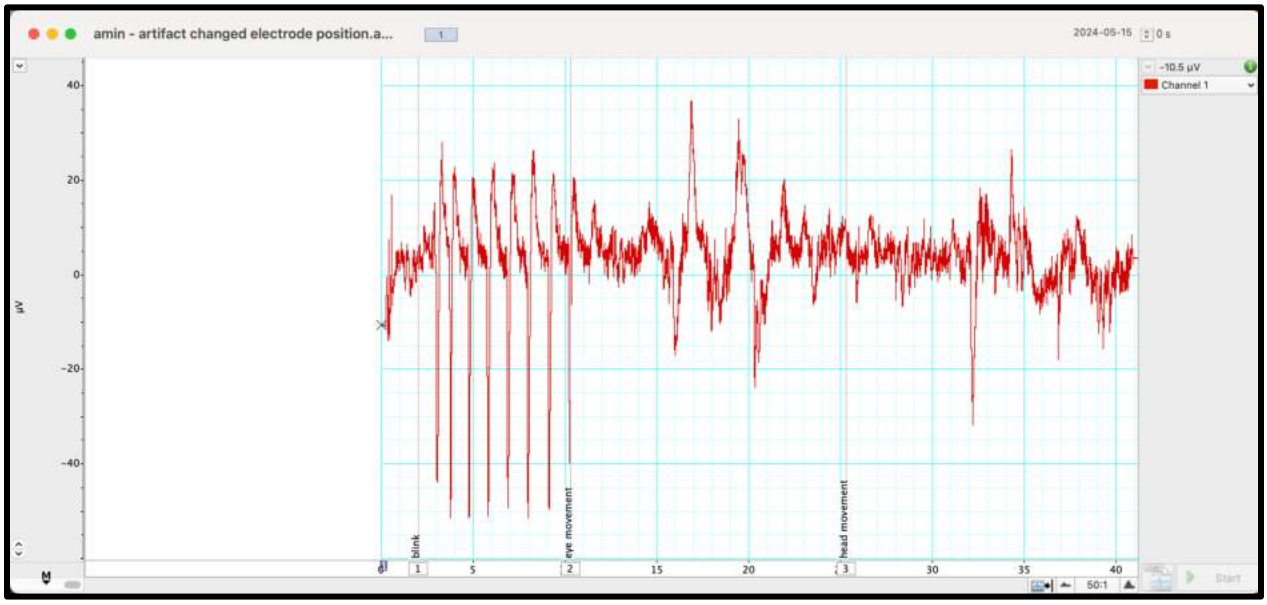
```
Command Window
>> alphawave
   2.7782e-06

Alpha wave is present.
>>
```

As we can see after giving the recorded signal with closed eyes to the program it will detect if there were alpha waves or not, by seeing if the signal energy wave is greater than the alpha wave threshold.

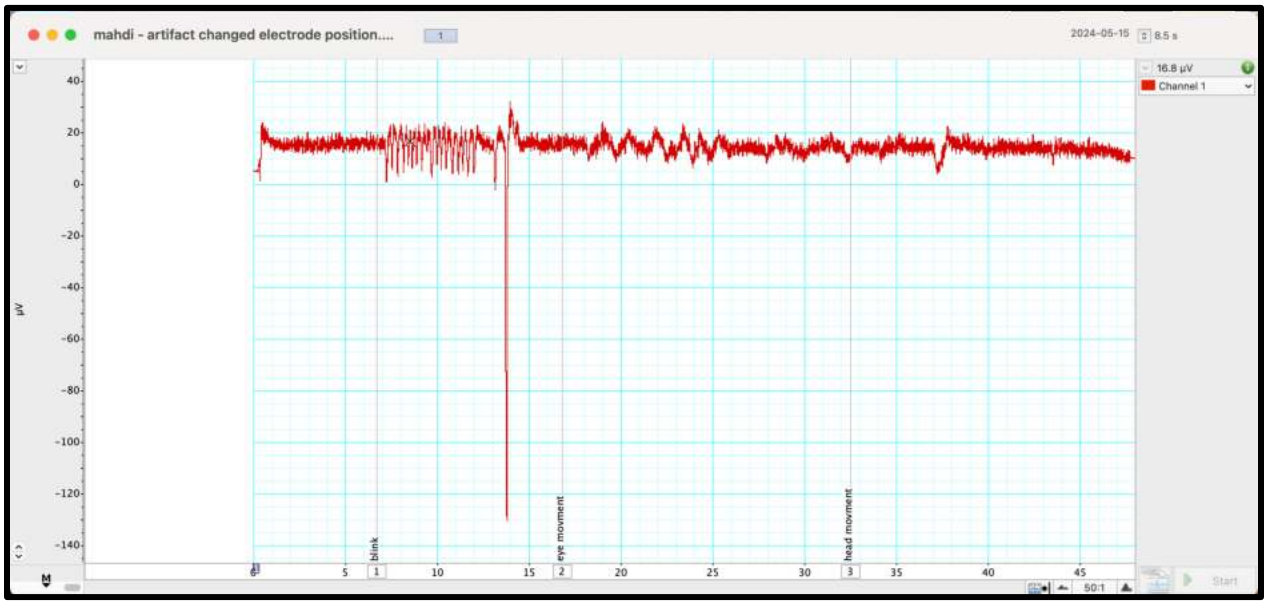
Exercise 6: Changing electrode position

Separate the electrode signal from the frontal region and connect the second electrode to the back of the head exactly at the point opposite to the first electrode. Then, repeat exercise 1 and 2. Compare the results with those obtained from the initial arrangement.

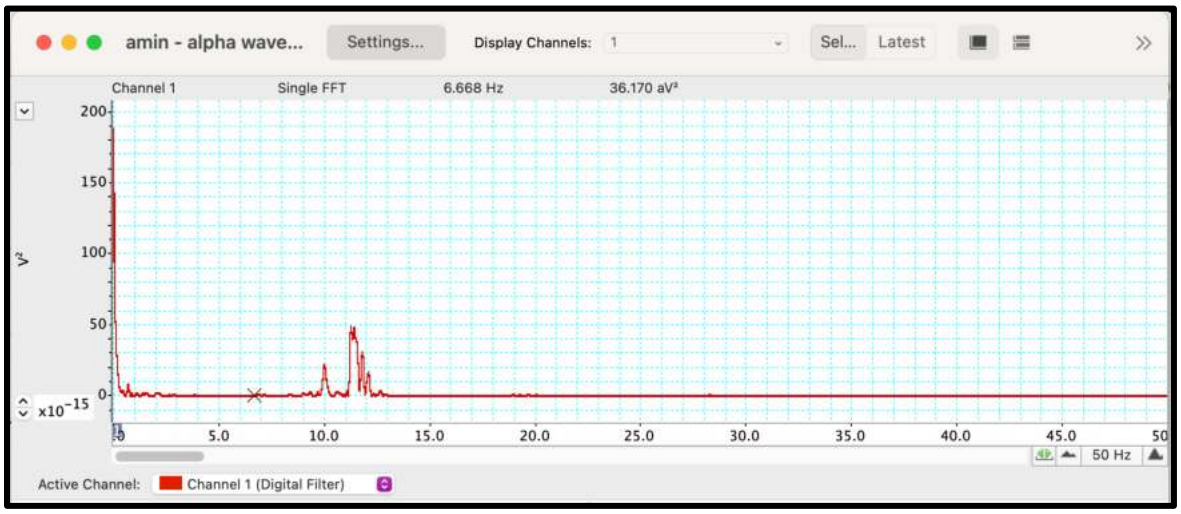
Amin



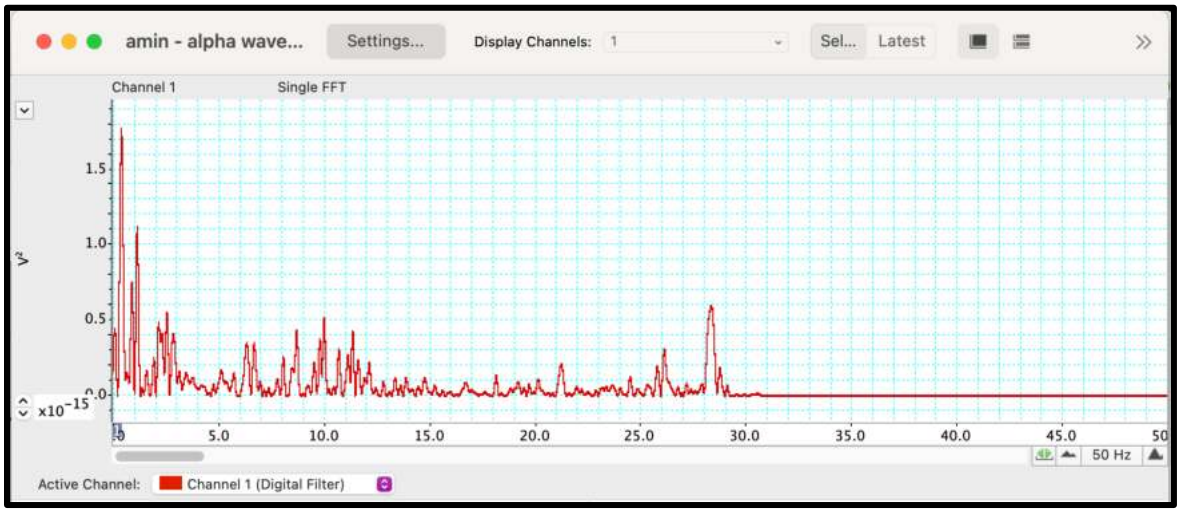
Mahdi



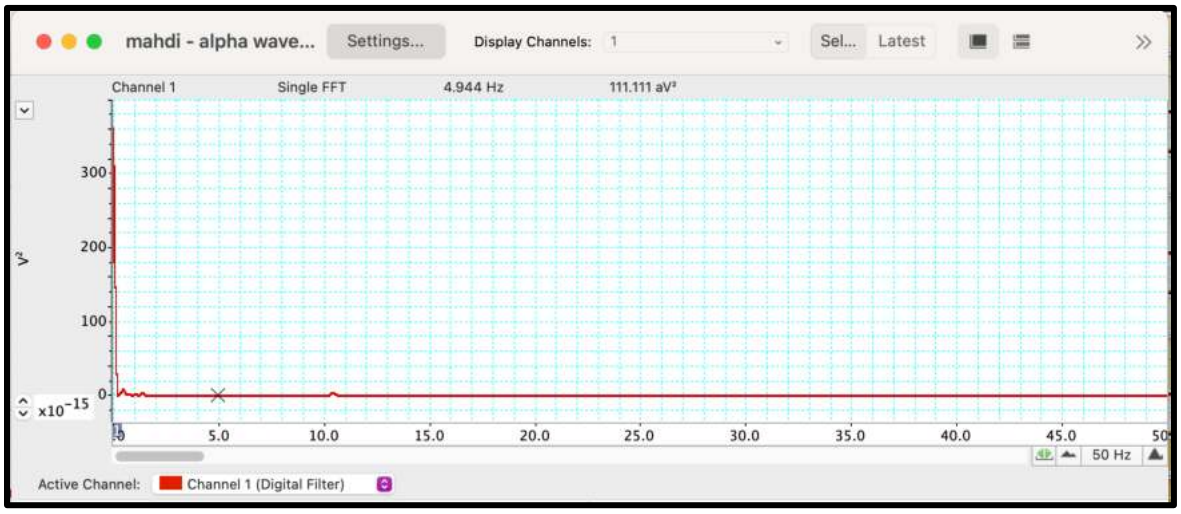
Amin Eyes closed



Amin Eyes opened



Mahdi Eyes closed

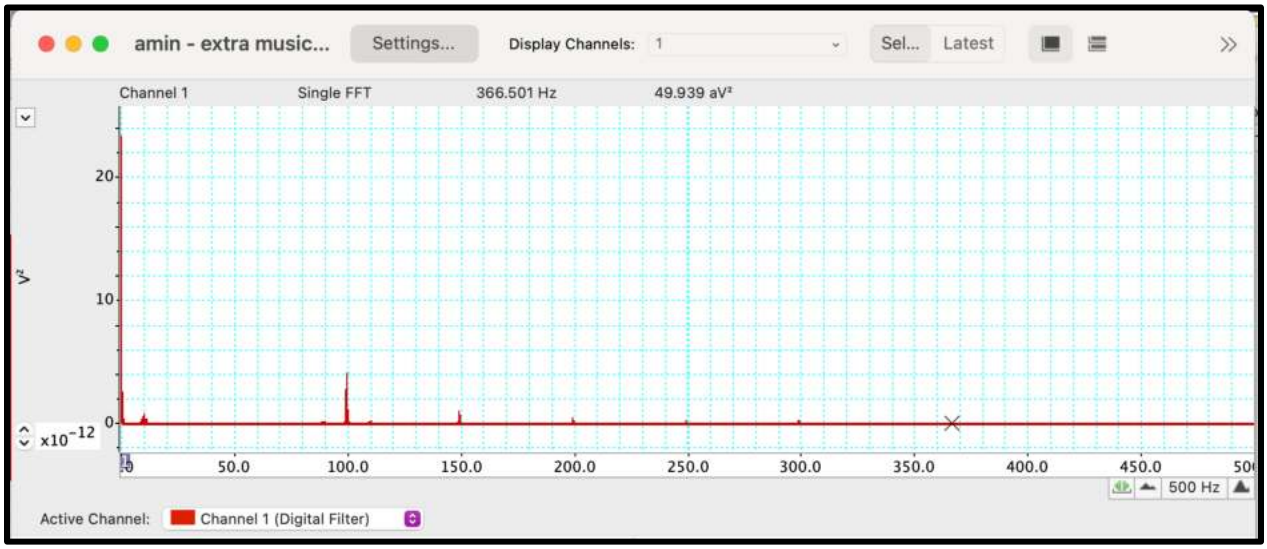


Mahdi Eyes opened

As we can see in the eyes closed data, the amplitude in the range of 8 – 12 Hz is less than the previous experiment when the position of the electrode was different, we can still detect the alpha wave but the amplitude is less than the previous experiment.

Extra:

In this part we will see the effect of music on EEG, we played a music for the volunteer and then we recorded the EEG for both eyes closed and eyes opened and then we used the fast furrier transform to see the frequencies of the EEG.



As we can see there are picks on the higher frequencies as well (100,200,300 Hz), and there are periodic.