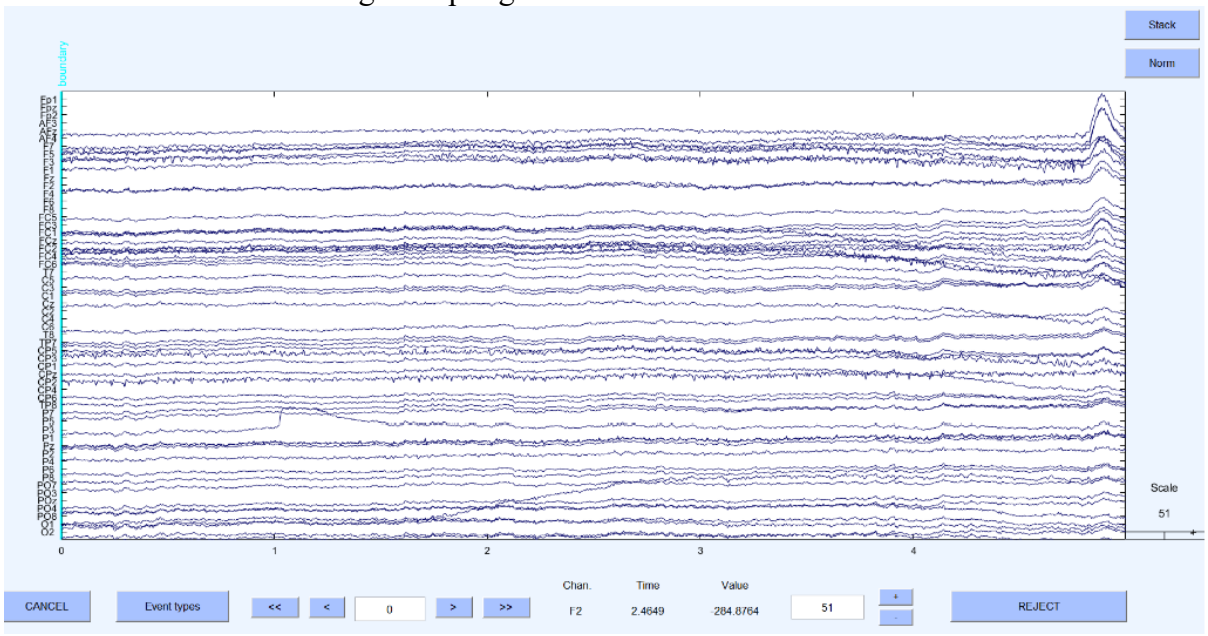
Biomedical Robotics 2022
EEG data analysis

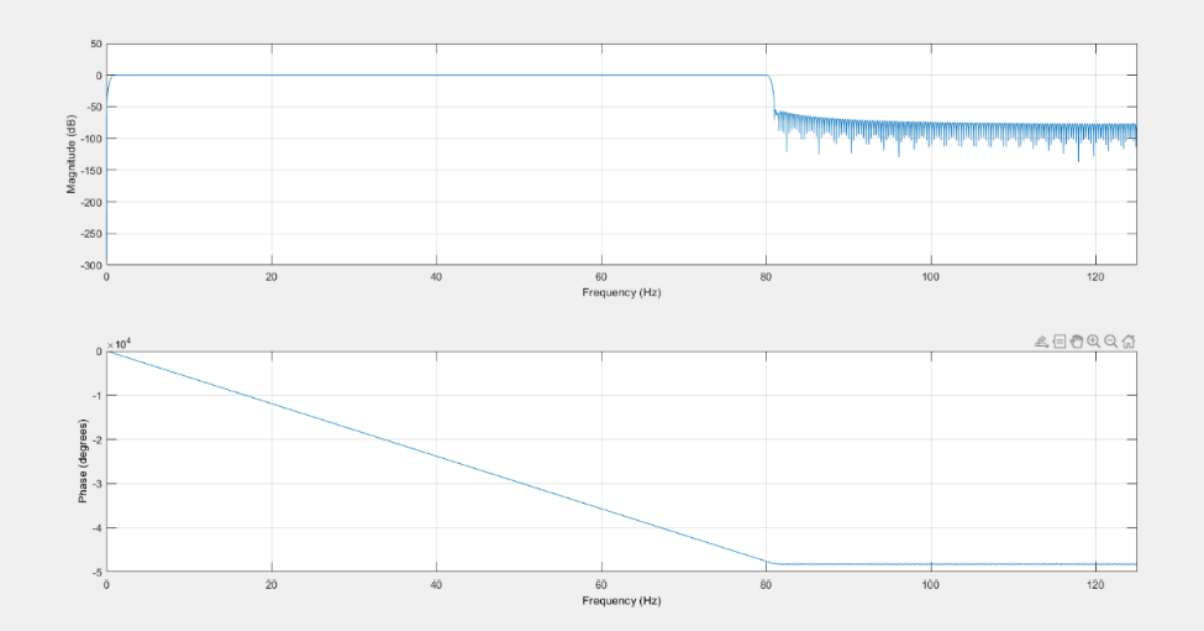
1) Download the EEG files .set and .fdt from Teams
   - To Download EEGLAB dataset
   - Unzip folder inside MATLAB folder.

2) Load the EEG file (.set) on EEGLAB
   - Open Matlab and on command window write:
     - addpath('/YOURPATHTOMATLAB/eeglab2022')
   - Then write:
     - eeglab
   - It will open the GUI.

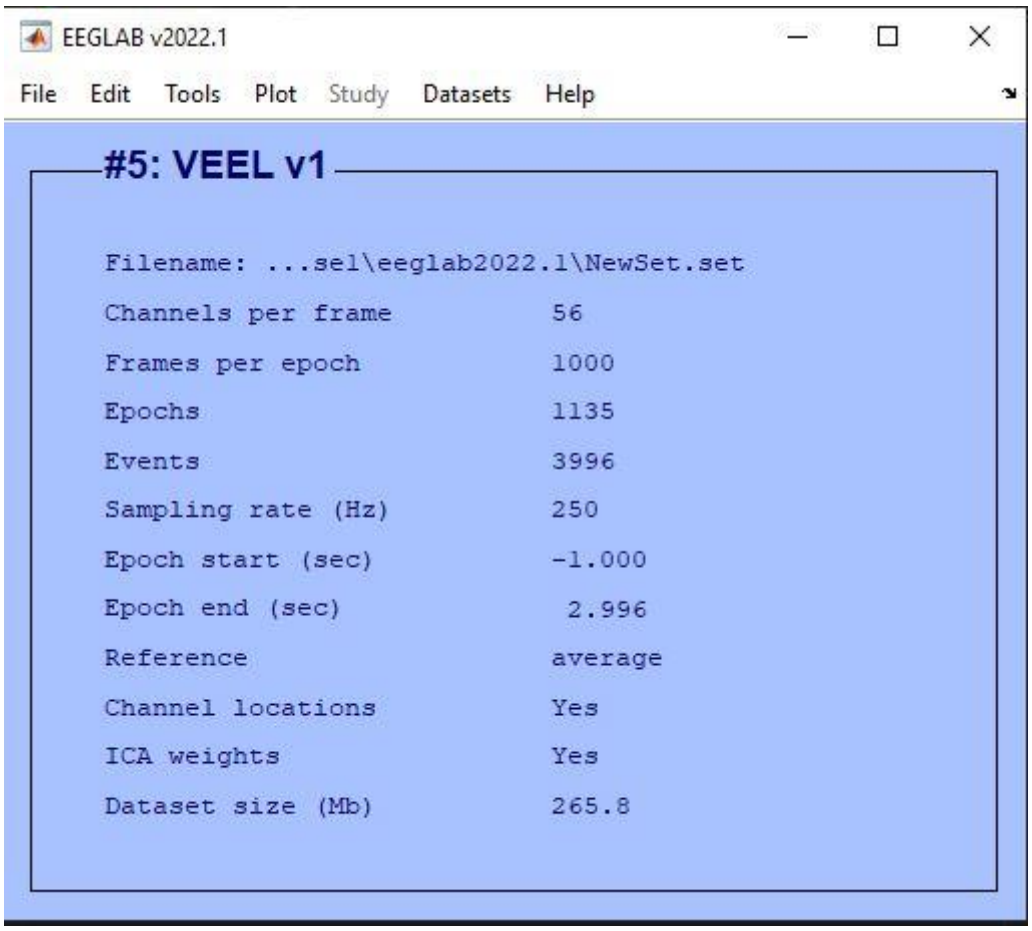
3) Using the GUI, complete the following steps:
   a) Downsampling 250 Hz
   Goto: Tools -> change sampling rate -> 250Hz



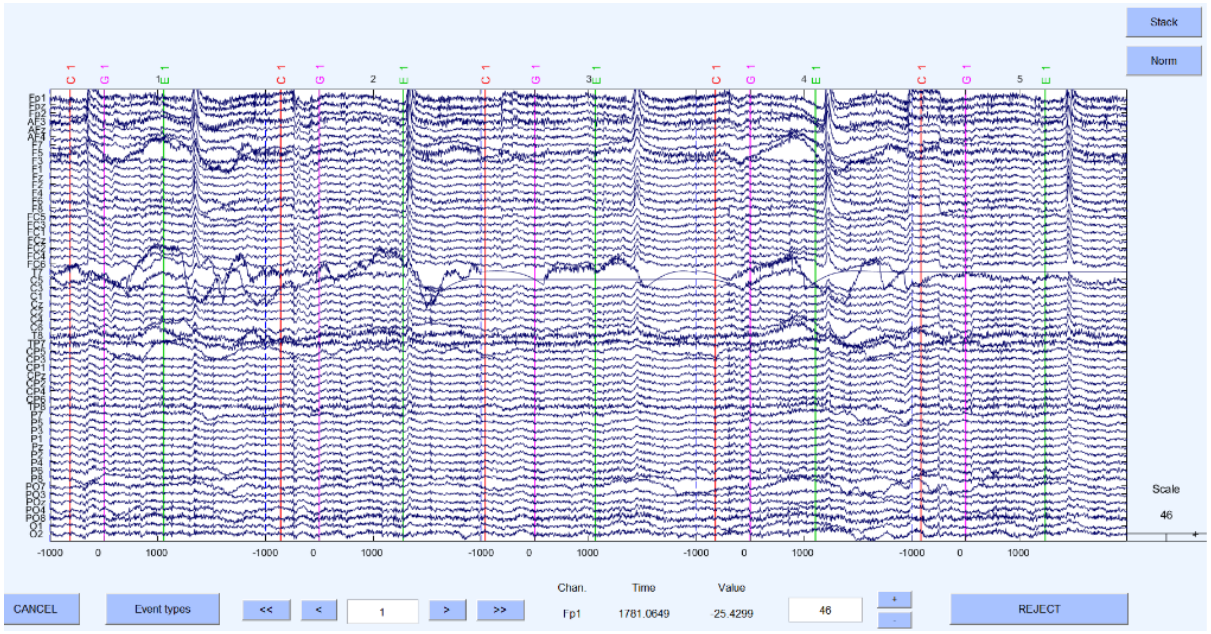
   b) Filtering [1-80Hz] + Notch filter 50 Hz
   Goto: Tools -> Filter the data -> *basic FIR filter* -> set high and low values (here: 1-80)



c) Epoching: Time locking event type: G interval: [-1 3]
Goto: Tools -> Extract Epochs



4) Visual inspection for channels and epochs: Channel Data (scroll)



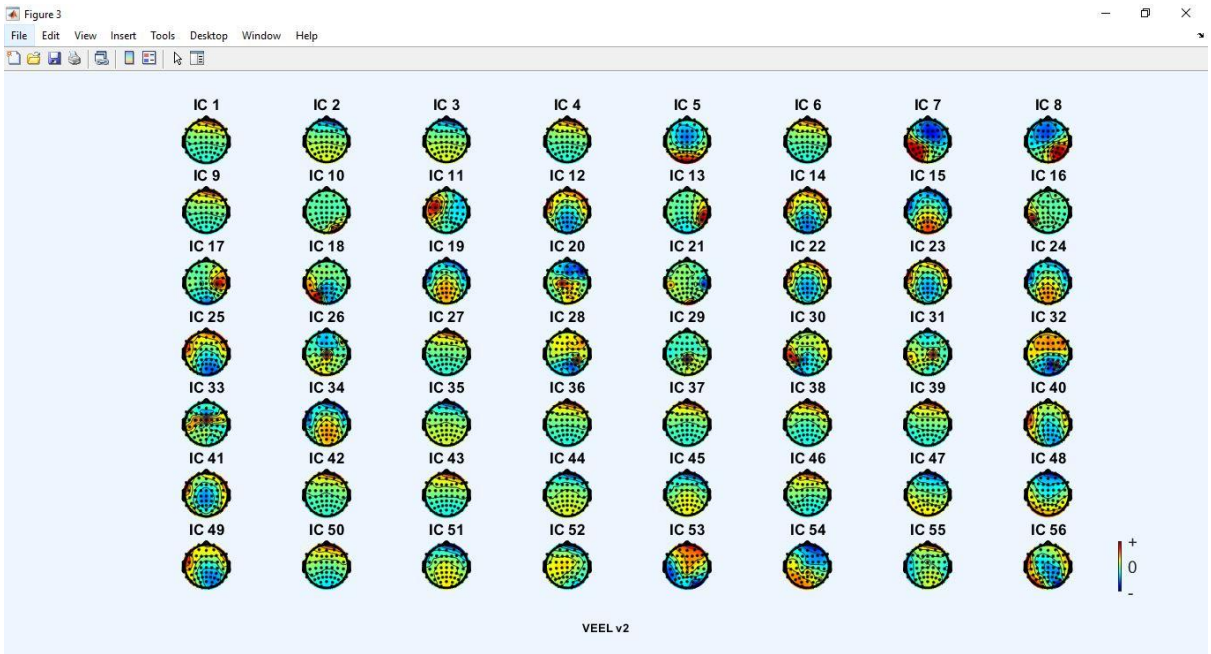
a) Remove bad epochs from the plot
Goto: *Tools -> Reject continuous data by eye*

b) Select bad channels and remove them using the GUI

5) Independent Component Analyses

a) Run ICA

Goto: Tools -> ICA decompose data by ICA (it takes a while)
And: Plot -> Component maps -> 2D



b) Manual Check of the components and mark the “bad” ones Reject Data

using ICA -> Reject components by map

First, we should know how to decide whether it's a good component or bad. For this ICA is used to distinguish between the either the component is based on the movement of eye, brain, muscle, heart, and or the noise.

Brain:

- Scalp topography often looks dipolar.
- Residual variance from dipole fit (marked RV on images) should be low. Usually below 15% unless the component is better explained with two dipoles.
- Power spectrum decreases as frequency increased (1/f)
- Power spectrum usually has peaks between 5 and 30 Hz, most often at 10 Hz.
- Epoched data will likely have a visible ERP.

Heart:

- Clear QRS complex in the data at about 1 Hz
- Near linear gradient scalp topography
- No peaks in power spectrum

Eyes:

- Scalp topographies suggest ECDs near eyes.
- Power concentrated at low frequencies (below 5 Hz)
- Vertical eye movement components will contain blinks in the data.
- Horizontal eye movement components will look like step functions.

Muscle:

- Power concentrated in higher frequencies (20 Hz and above)
- Can still be dipolar, but will be located outside the skull

Line noise:

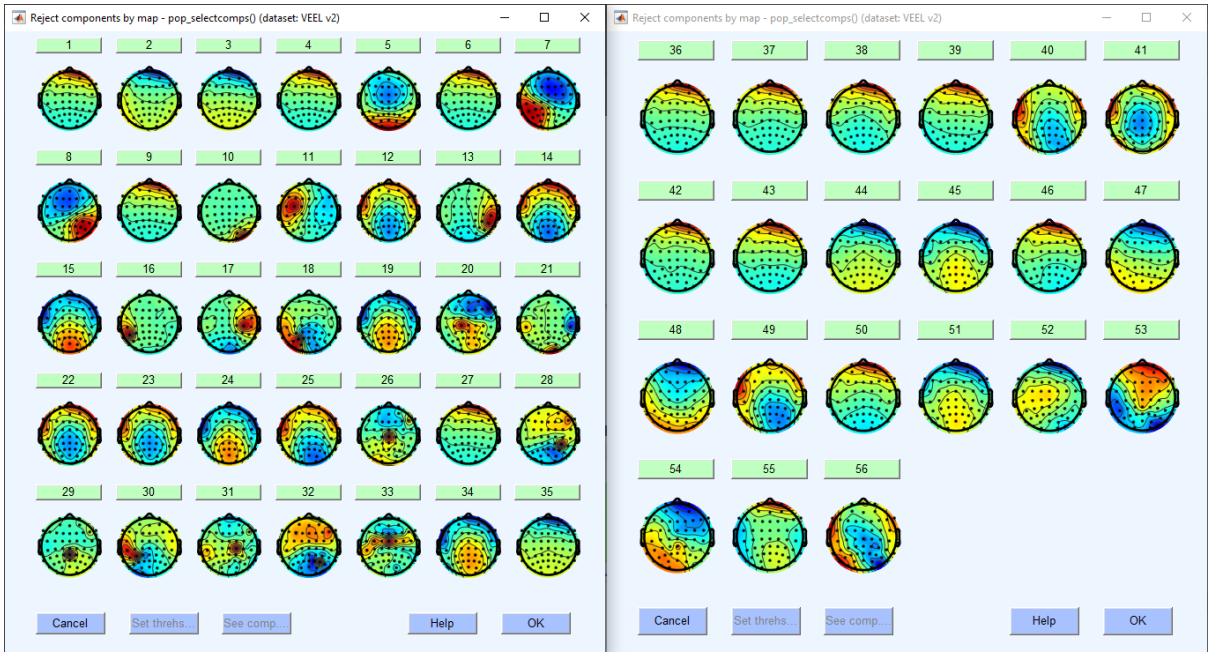
- Strong peak in power spectrum at either 50Hz or 60Hz

Channel noise:

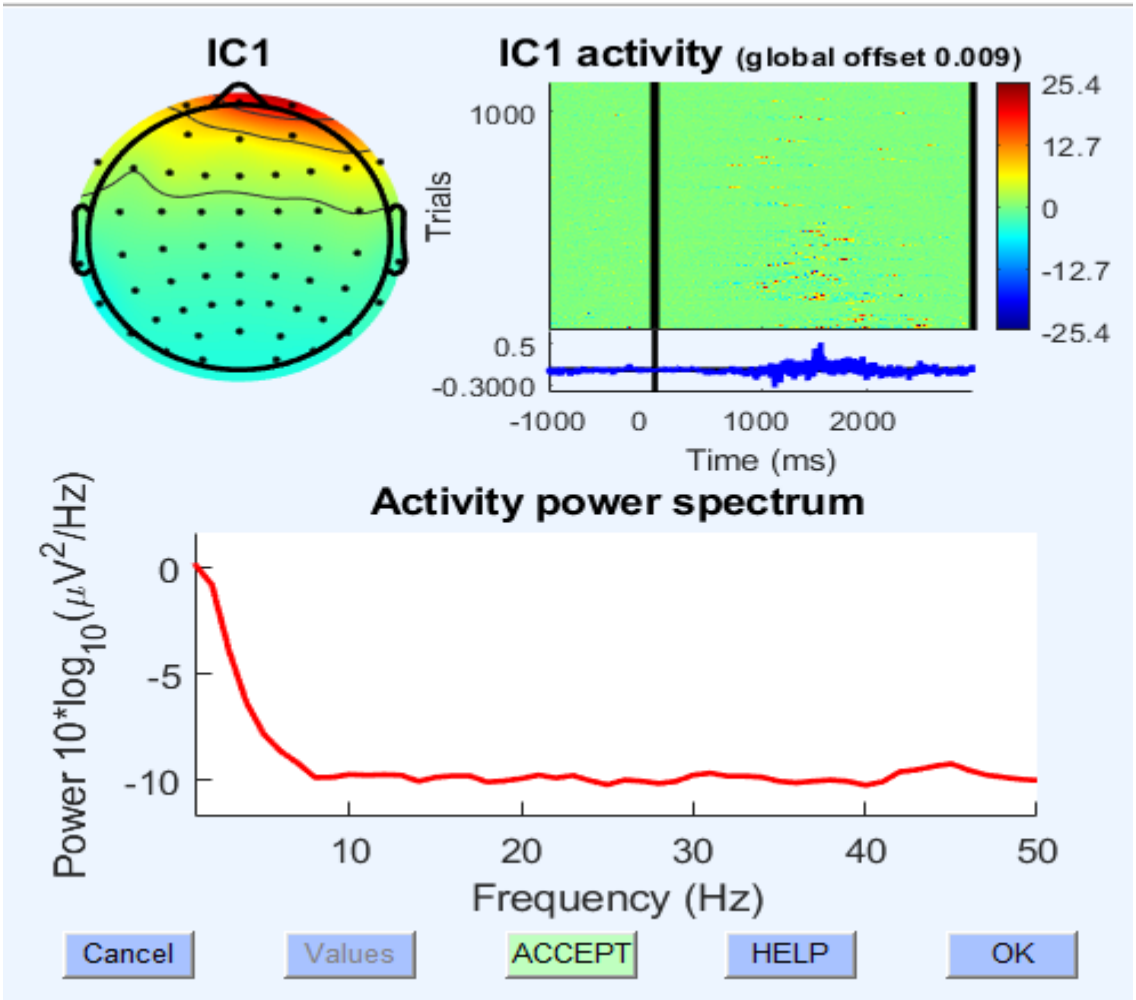
- Very focal scalp topography
- Large and/or consistent artifacts in the component activations.
- Easily confused with muscle components, but PSD is different.

Other:

- Anything that doesn't fit the above categories.
- More likely the higher the IC number (as in IC 150 of 220 is *very* likely to be "Other"
- Non-dipolar scalp maps
- Spectrum can still have weak 10 Hz peak as brain signals are likely mixed with other signals.

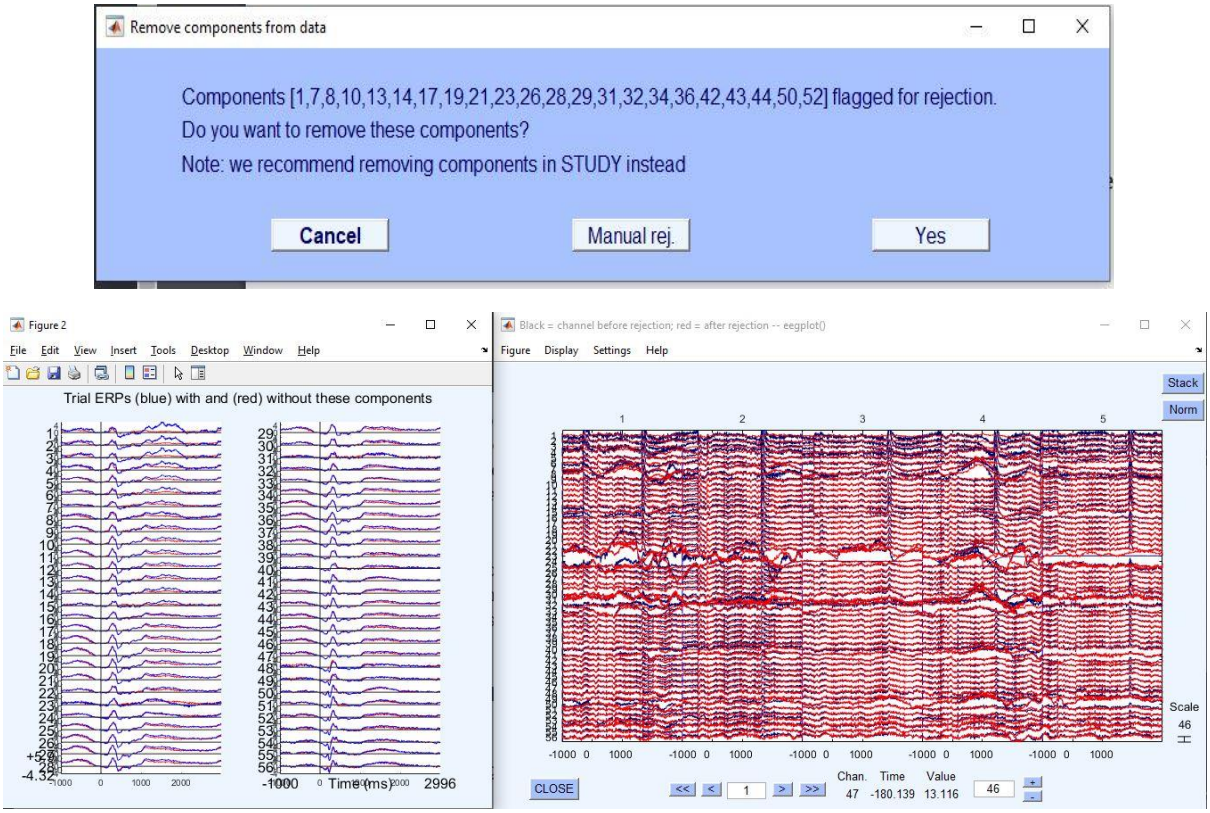


Now click on each component to reject or not.



Once finished with deciding:

Tools -> Remove components from data (the ones you rejected are already there).



6) Channels Interpolation

On the GUI select “Interpolate Electrodes” and “Use specific channels of other dataset”

File -> Load existing dataset -> Pre-processed dataset

Datasets -> select (current) Dataset.

Tools -> interpolate electrodes -> use specific channels from other dataset -> write the index of the pre-processed dataset -> choose the channels you previously removed.

7) On the “clean” dataset Perform Average Reference

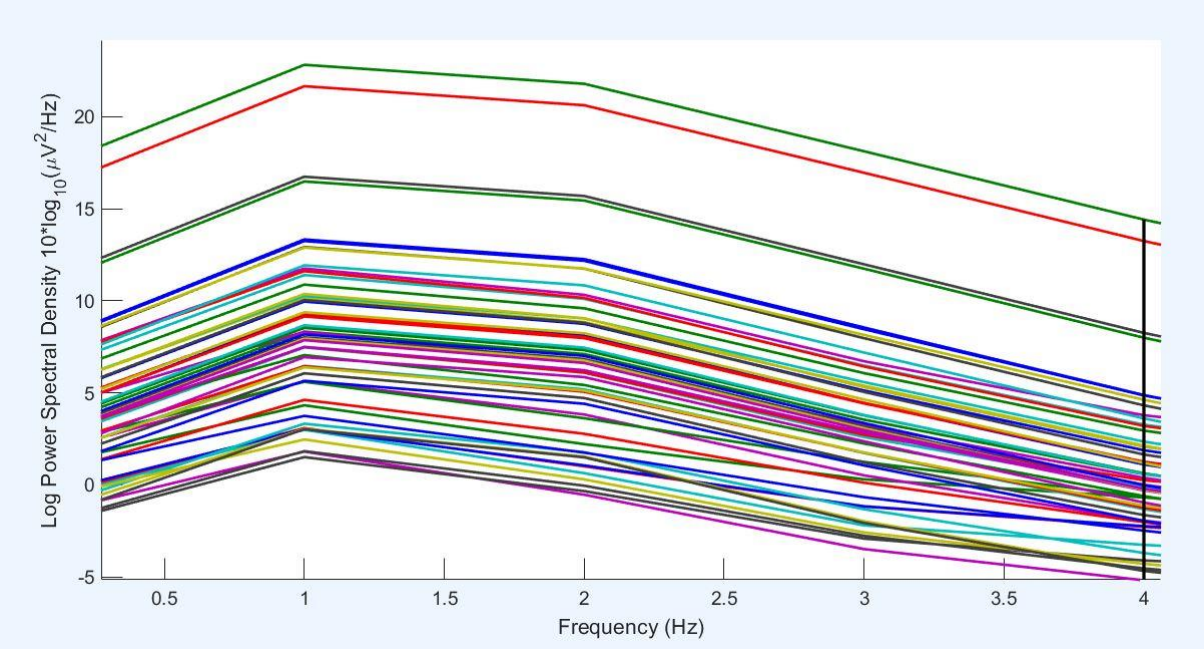
REFERENCE AVERAGE

Tools -> re-reference the data

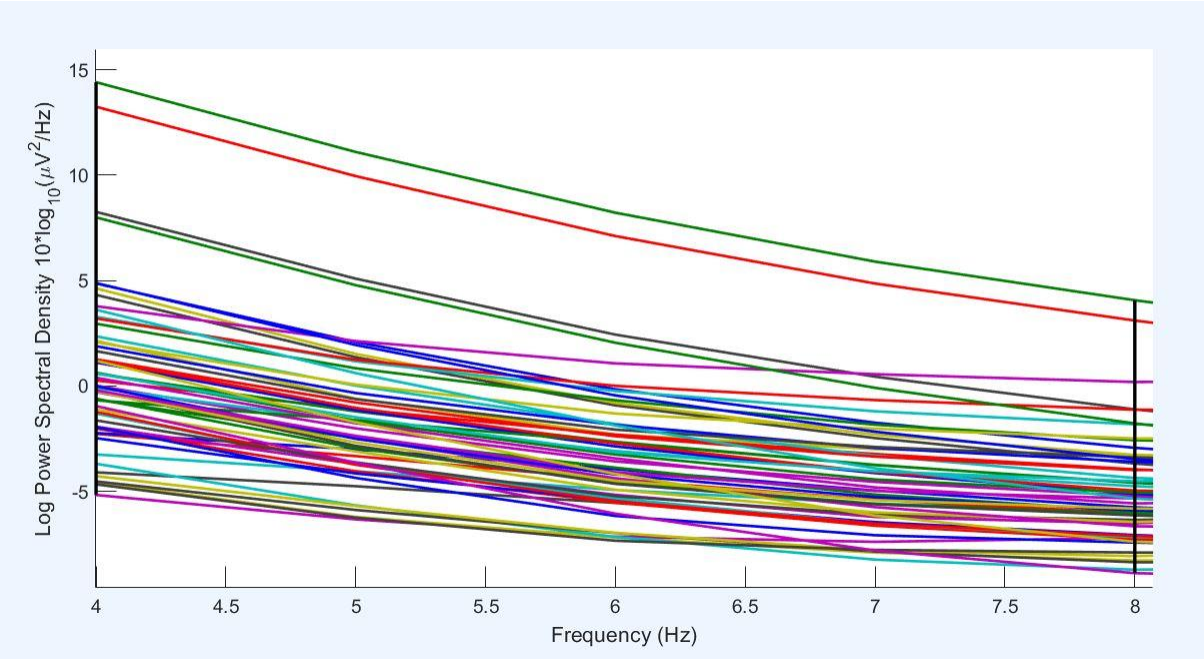
8) Plot Spectra and Maps

Plot -> channel spectra and map -> Plotting frequency range: delta 1-4Hz, theta 4-8Hz, alpha 8-13Hz, beta 15-25Hz
Percent data to sample: 100%

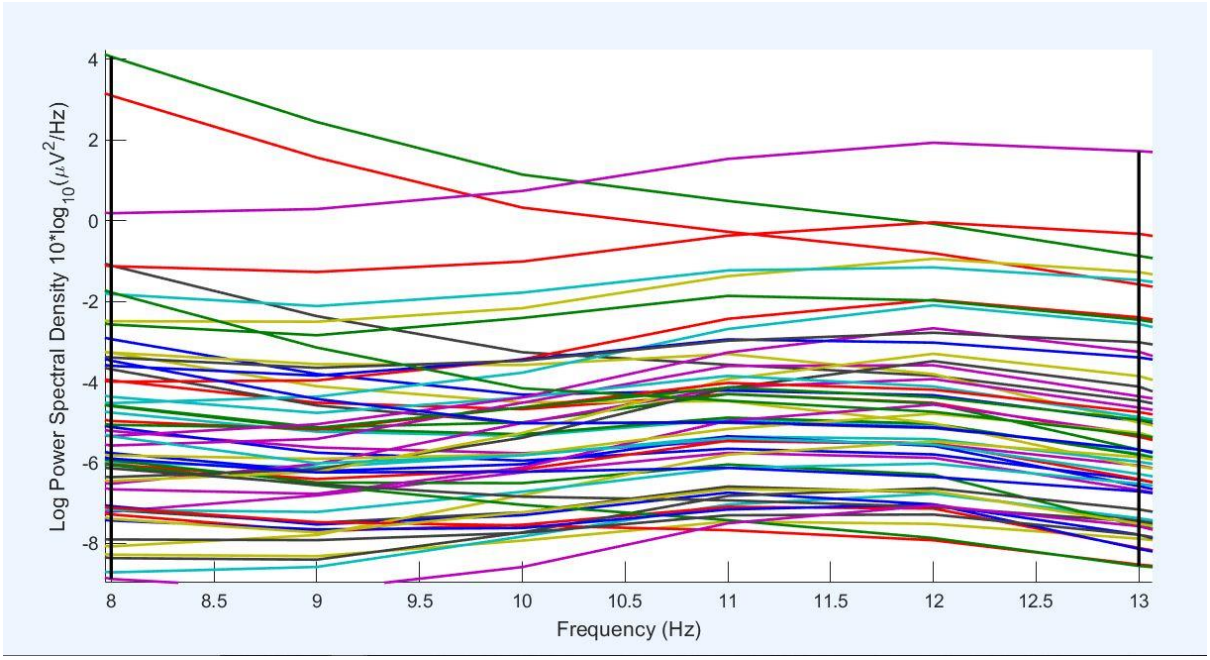
Frequencies:
Delta: 1 – 4 Hz -> sleep



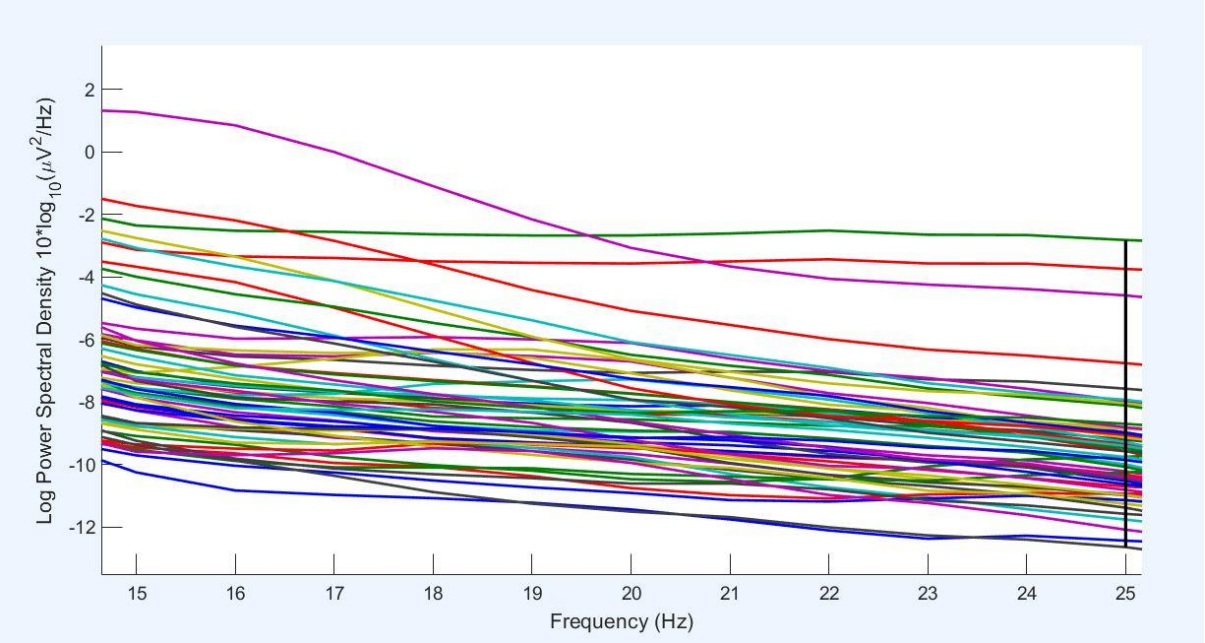
Theta: 4 – 8 Hz -> attention



Alpha: 8 – 13 Hz -> eyes closed

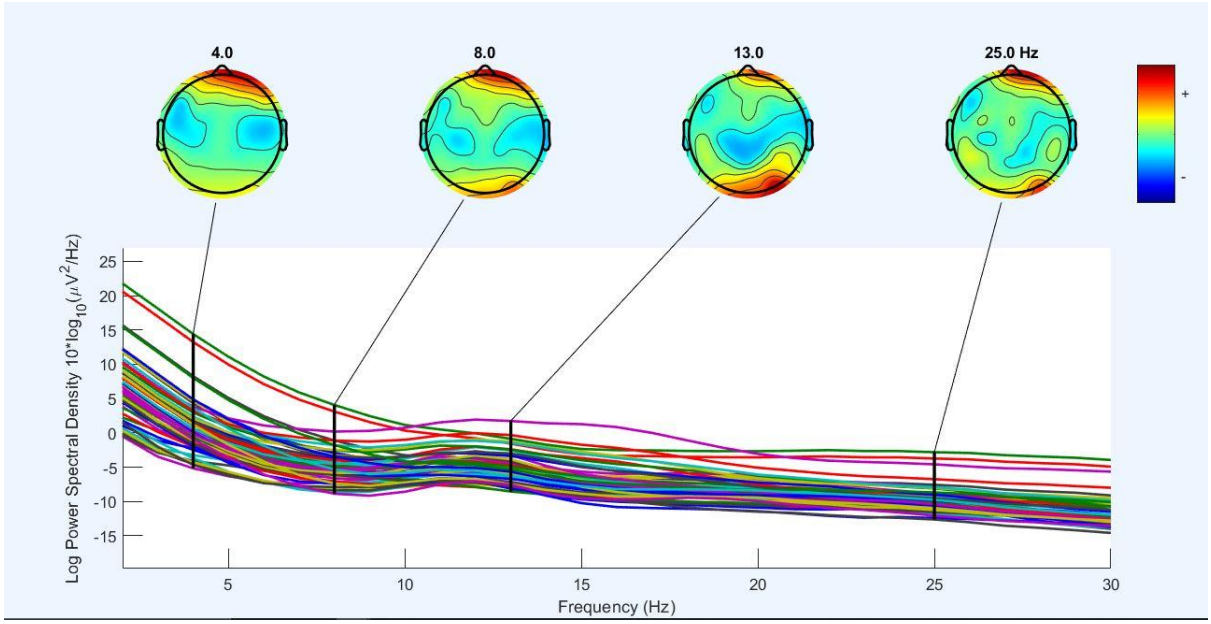


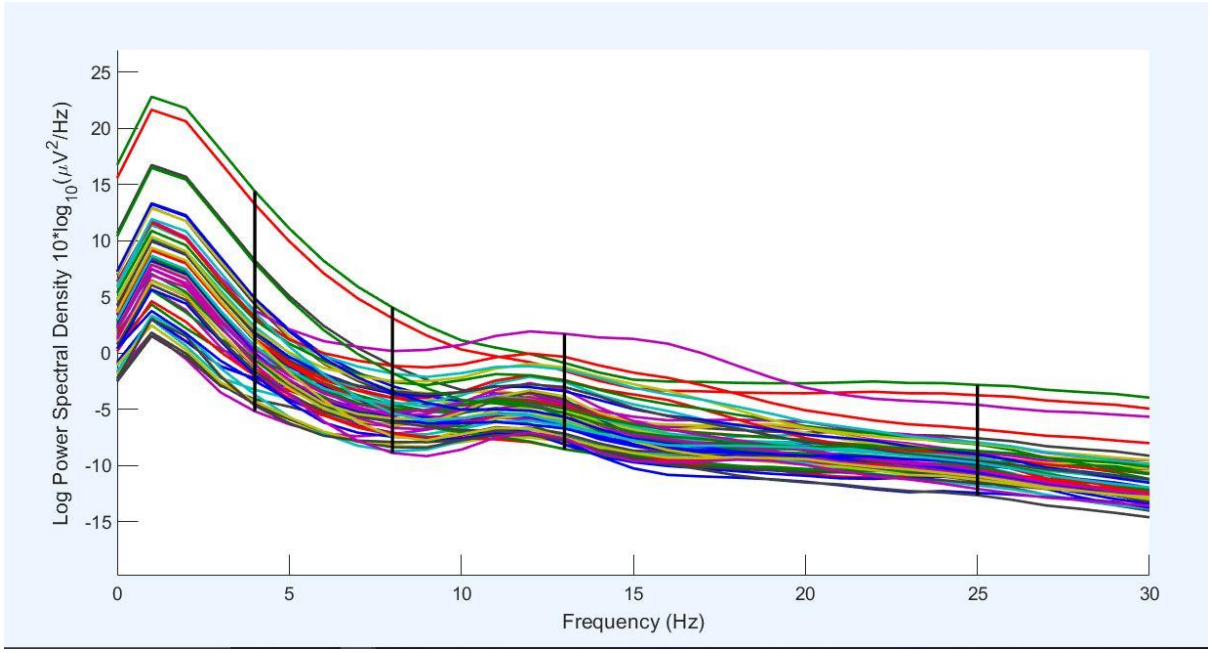
Beta: 15 – 25 Hz -> movements



From 30-100 Hz are Gamma waves which facilitate higher cognitive functions, such as memory and learning, by synchronizing neural activity across different brain regions.

All Together:





The concentration of peaks around 11-17Hz in the occipital area indicates activity related to both eyes-closed relaxation and movement, as these frequencies are respectively within the alpha and beta ranges.