

EEG DATA ANALYSIS THROUGH EEGLAB

To Download EEGLAB

Download eeglab <https://sccn.ucsd.edu/eeglab/download.php>

Unzip folder inside your MATLAB/toolbox folder.

Open Matlab and on command window write:

```
addpath('/YOURPATHTOMATLAB/toolbox/eeglab2020_0')
```

Then write:

eeglab

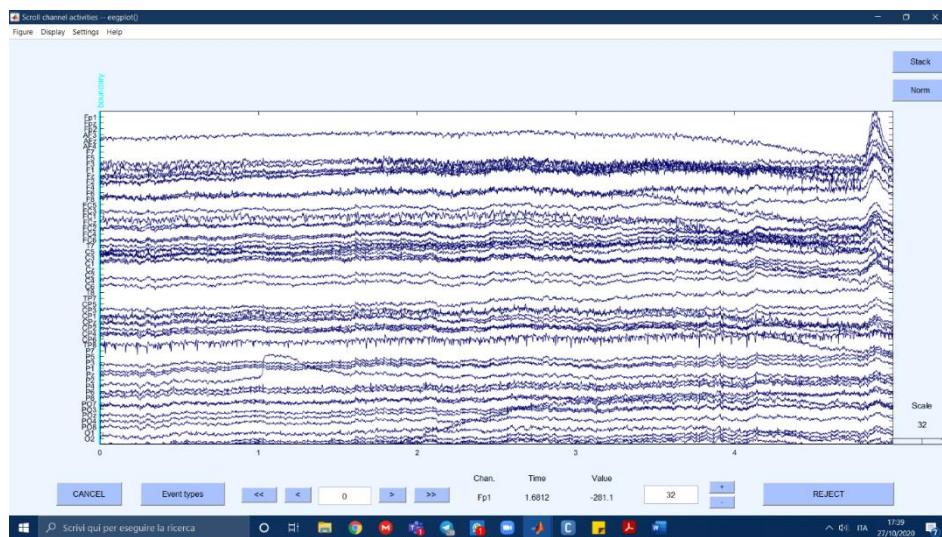
to open the GUI.

To analyze data (Notice: parts in italic are the buttons to click)

IMPORT INTO EEGLAB

file -> load existing data : load your dataset

plot -> channel data (scroll) : see your dataset



IMPORT CHANNEL LOCATIONS

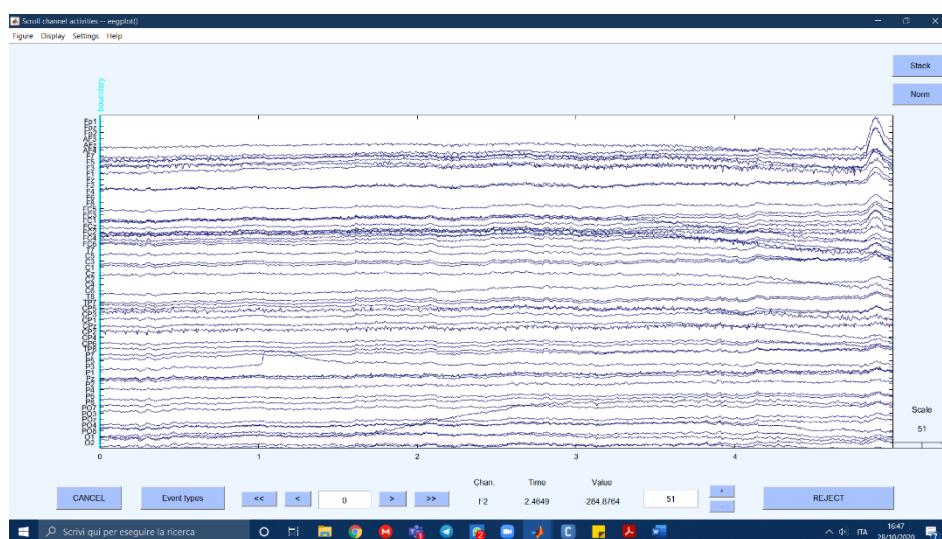
Edit -> import channel locations mni coord -> ok

->Plot 2d

->Plot 3d

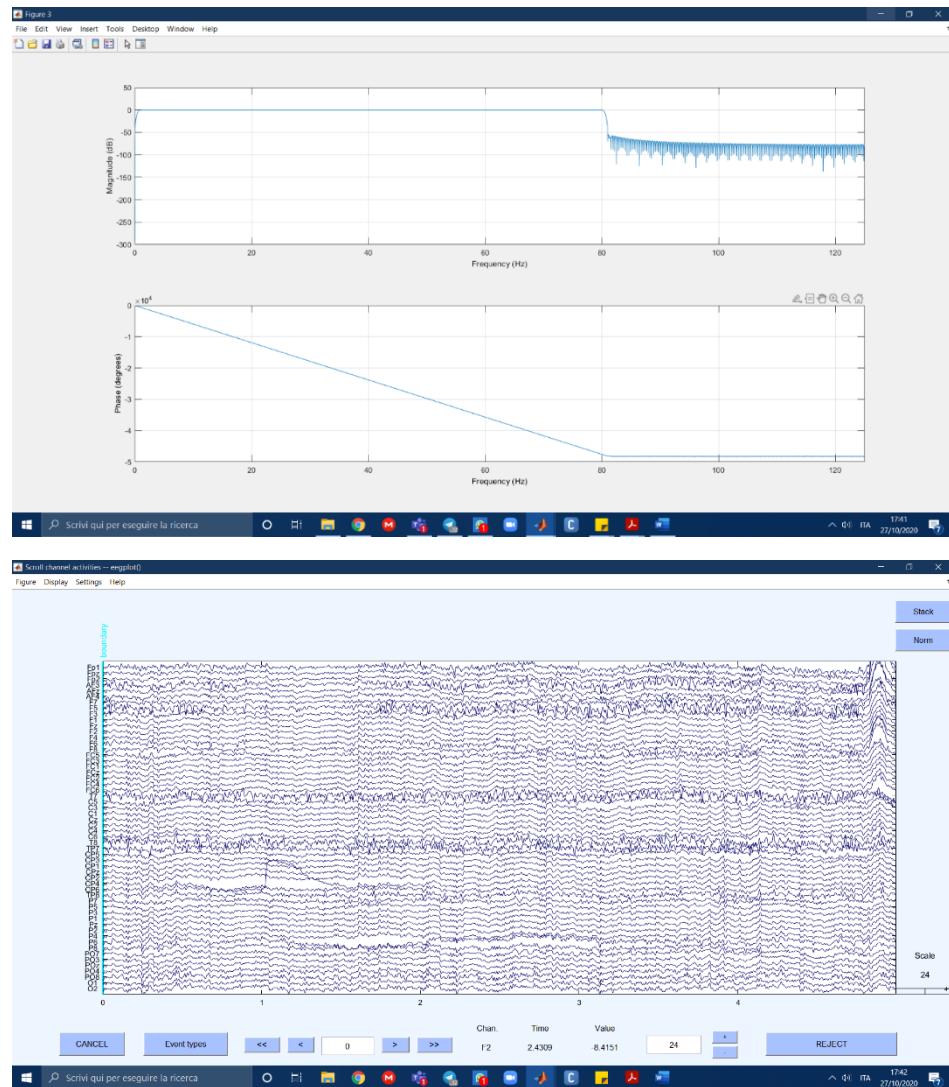
DOWN-SAMPLE

Tools -> change sampling rate -> write your rate (here 250)

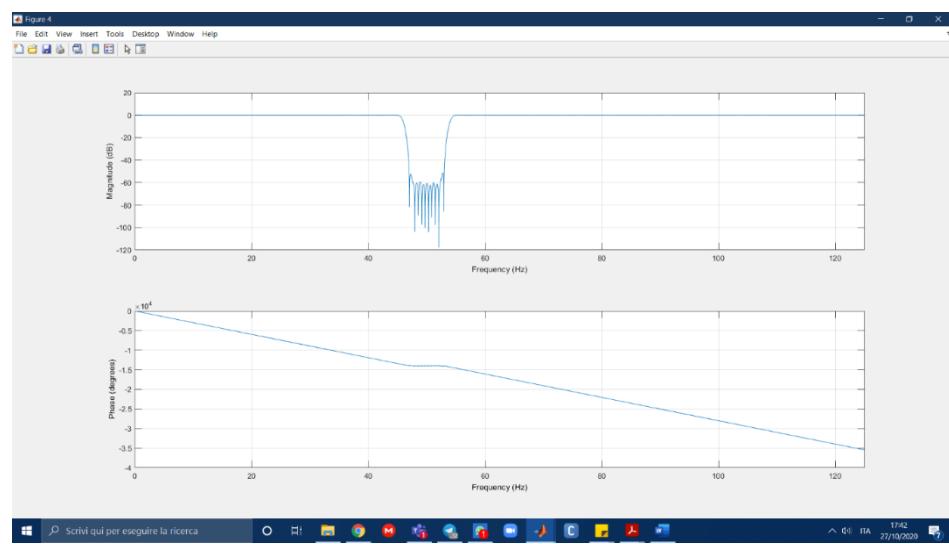


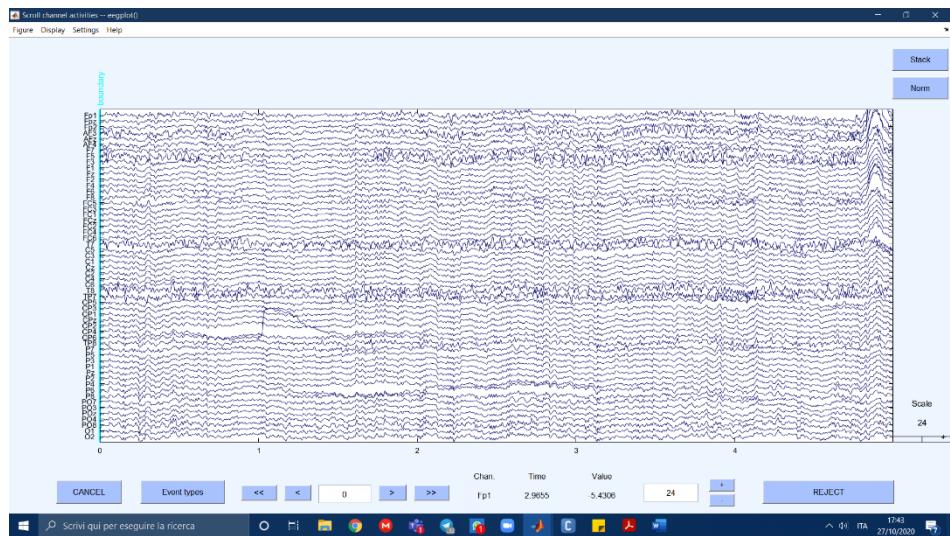
FILTER THE DATA

Tools -> filter the data -> basic FIR filter -> set high and low values (here: 1-80)



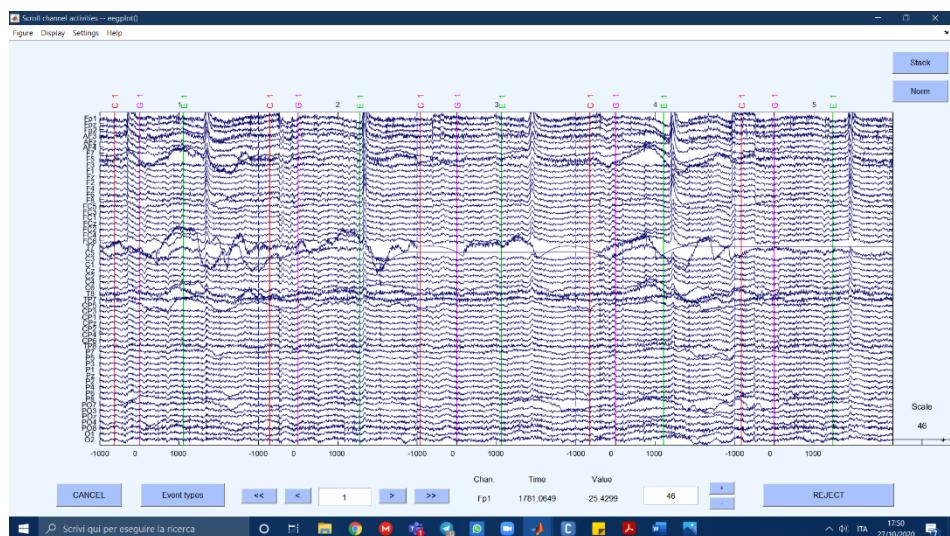
Tools -> filter the data -> notch filter -> set values around your desired value (here: 45-55)





EXTRACT EPOCHS

Tools -> extract epochs



Data set brief description: The events are of three types:

1. C: see red target.
2. G: target becomes pink: go towards it with your arm+ee.
3. E: movement finishes.

We try this multiple times then make an average of the data. Synchronization is important since we can link EEG data to real events. Data is like a matrix channels x epochs. You can remove either an entire row or an entire column, not pieces or u can't do the analysis.

EXAMINING RAW DATA (already done)

Tools -> Reject continuous data by eye

plot -> channel data (scroll)

TIME LOCKING EVENT TYPE

Tools -> extract epochs -> time-locking event type -> write the desired type (here: G).

Epoch limits -> write limits (here -1,3)

REMOVING BAD CHANNELS (check chapter Examples of bad channels/epochs):

Plot -> channel data (scroll) -> choose "bad channels". Here: see images

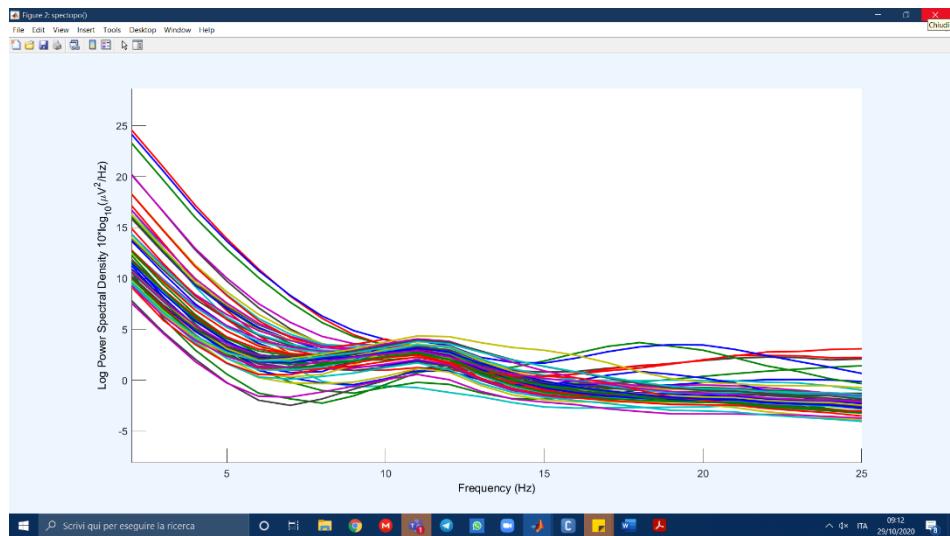
Plot -> channel spectra and map -> if there's any line which completely doesn't match the rest: bad channel

Edit -> select data -> select the unwanted channels and check box!

Here: T7, C5 create big problems in the first data, we removed them.



From spectra plotting, instead, we didn't notice many anomalies:



REMOVING BAD EPOCHS

Don't remove eye blinks: they will be removed by ICA. Remove high frequency epochs that don't make sense. Remove electrode artifacts.

Plot -> Channel data scroll -> Settings -> Time range to display -> set a higher time range to have a better view -> stack -> norm -> the channels that don't match with the others are outliers

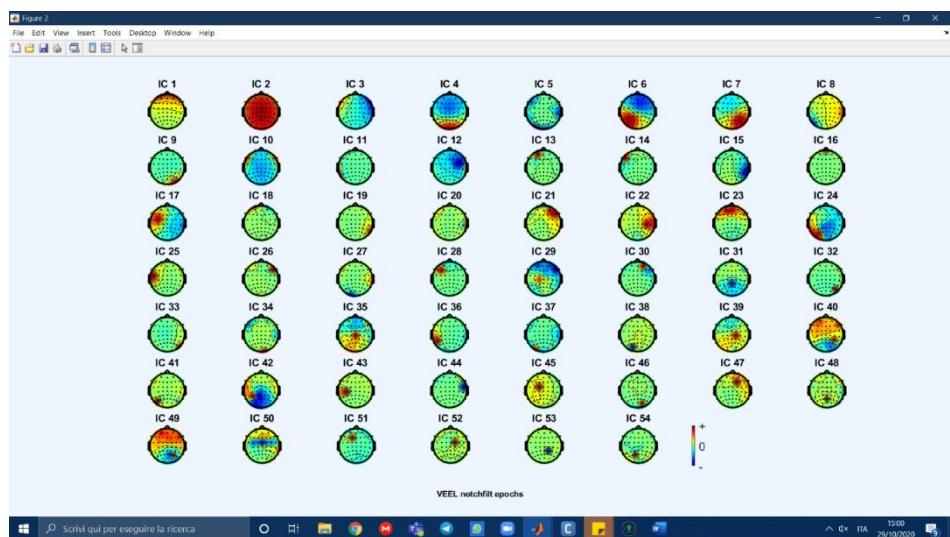
Here: we removed 37 epochs: the ones with removed electrodes, the ones with high frequency muscular data,...

RUN ICA

Edit -> Channel locations -> Use MNI coordinates for the BEM Dipfit model

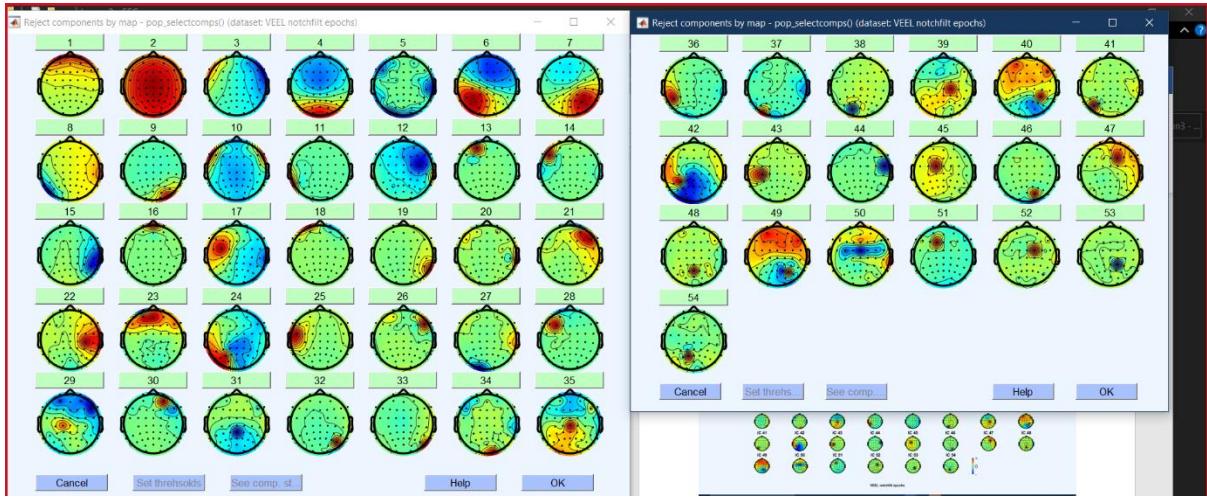
Tools -> ICA decompose data by ICA (it takes a while)

Plot -> Component maps -> 2D

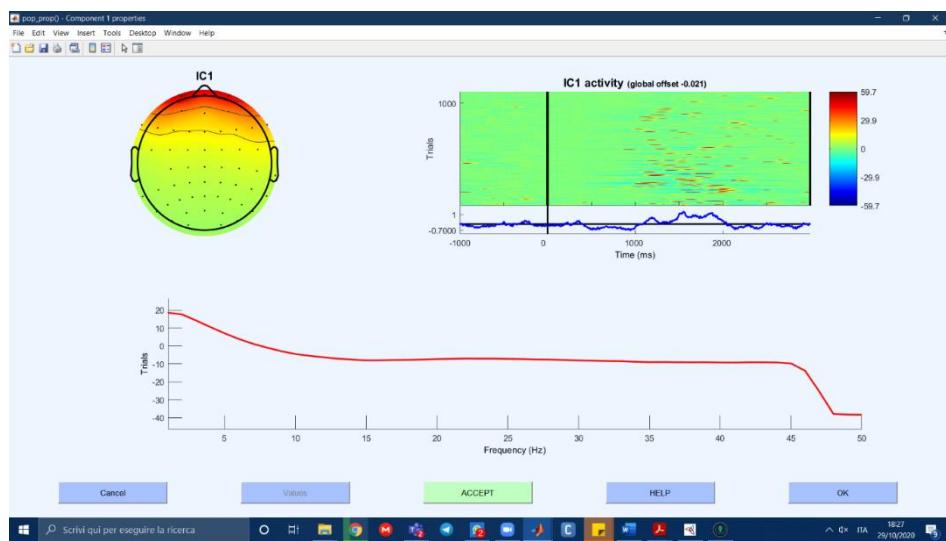


REJECT DATA USING ICA:

Tools -> Inspect/label components by map



Click on each and choose to keep it or not. Ex:



HOW TO DECIDE WHETHER TO KEEP OR NOT:

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

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

Heart:

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

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:

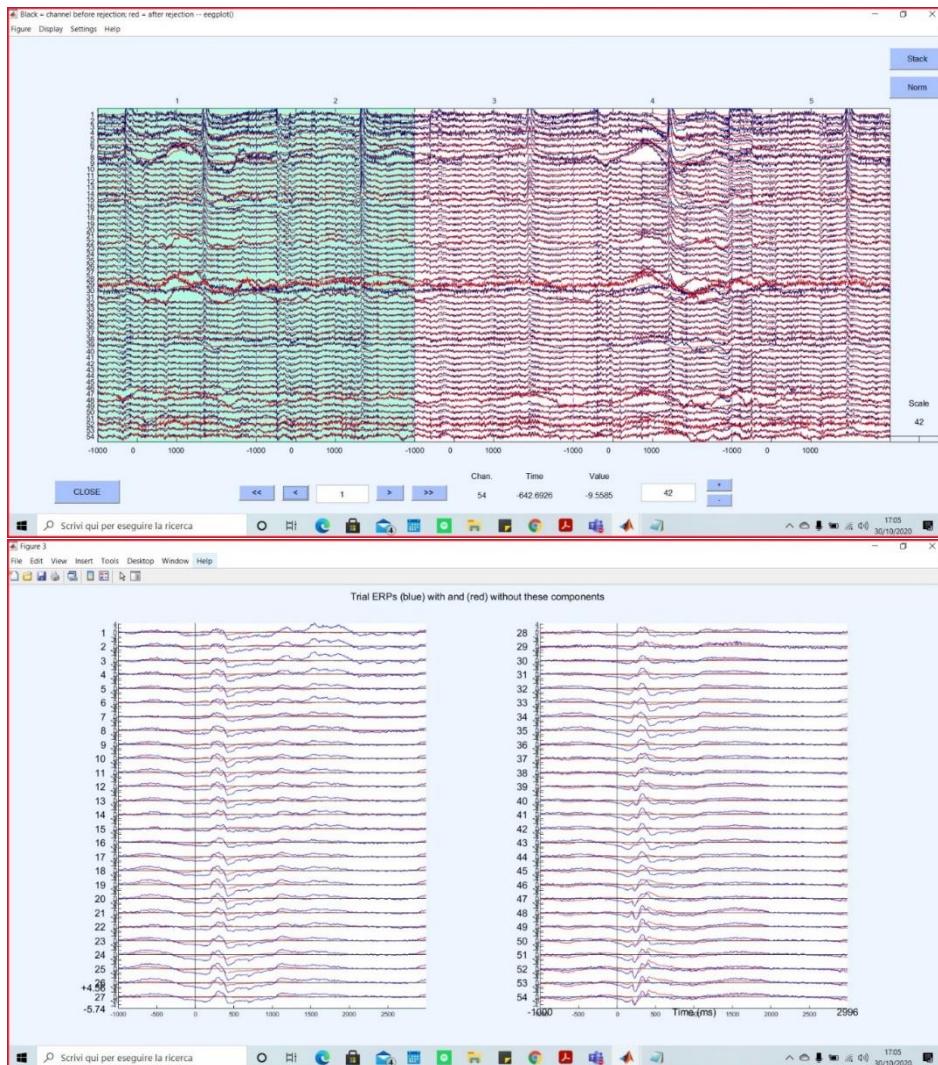
- Anything that doesn't fit the above categories.
- More likely the higher the IC number (as in IC 150 of 220 is *very* likely to be "Other")
- Non-dipolar scalp maps
- Spectrum can still have weak 10 Hz peak as brain signals are likely mixed with other signals

When you are finished deciding:

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

-> *Plot single trials*: how channels change after rejection.

-> *Plot ERP*: check if it looks good.



INTERPOLATE CHANNELS

File -> Load existing dataset -> Preprocessed_dataset

Datasets -> select Dataset(1) (the current)

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

REFERENCE AVERAGE

Tools -> re-reference the data

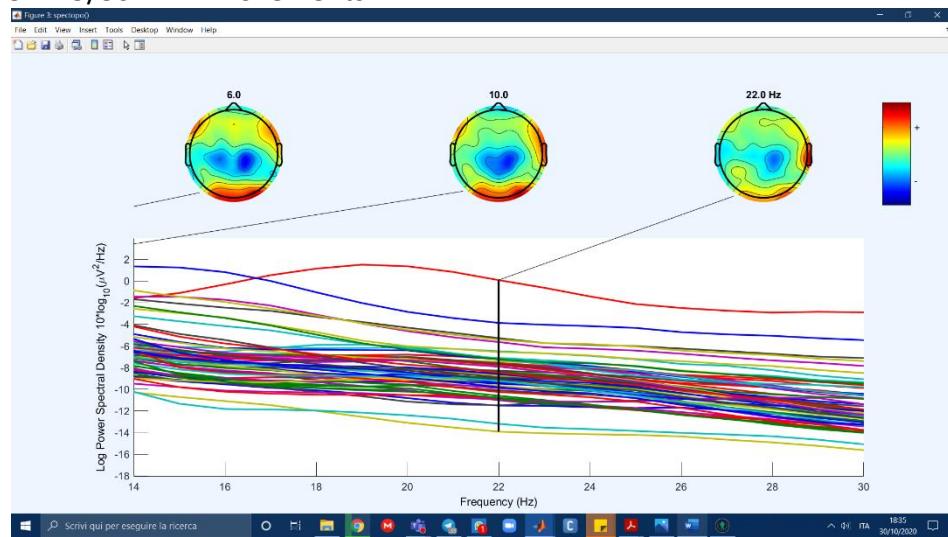
DIVIDE BY FREQUENCY

Plot -> channel spectra and map -> Plotting frequency range: write the desired frequency.
Percent data to sample: write 100

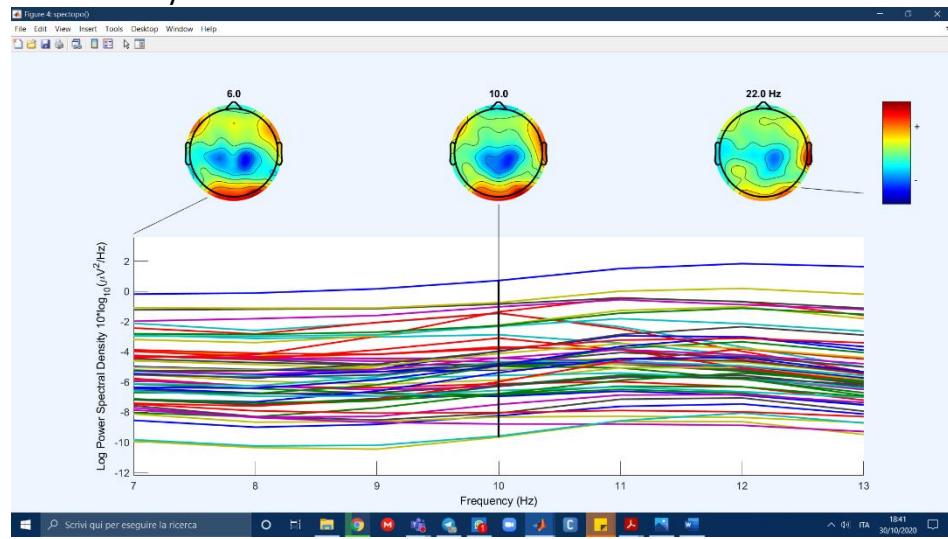
Frequencies:

(Gamma 30 – 100 Hz → higher cognitive functions, i.e. memory/learning)

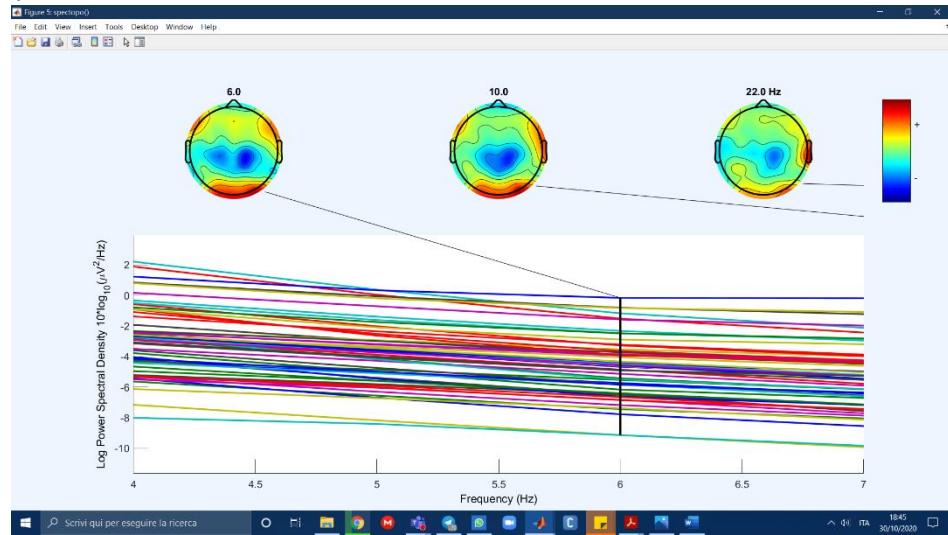
Beta 14/15 – 25/30 Hz → movements



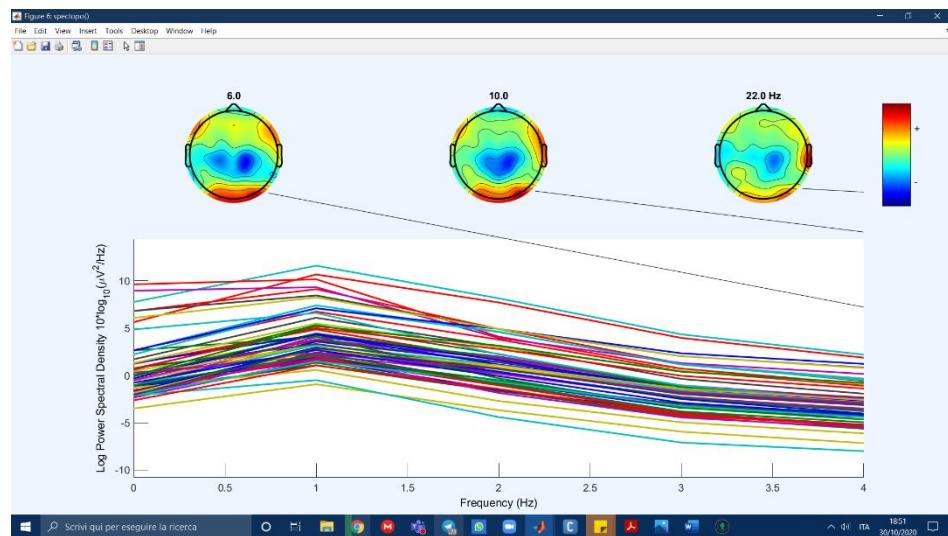
Alpha 7/8 – 13 Hz → eyes closed



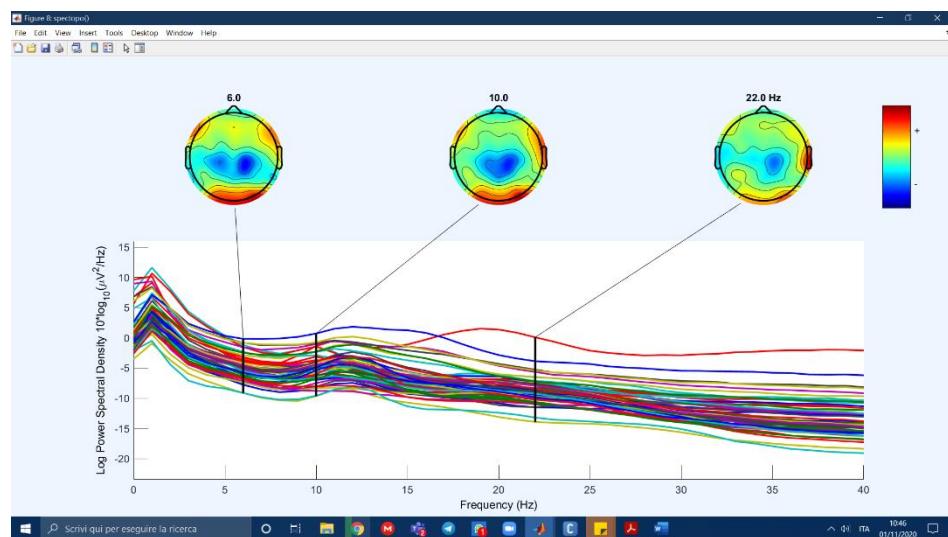
Theta 4– 7/8 Hz -> attention

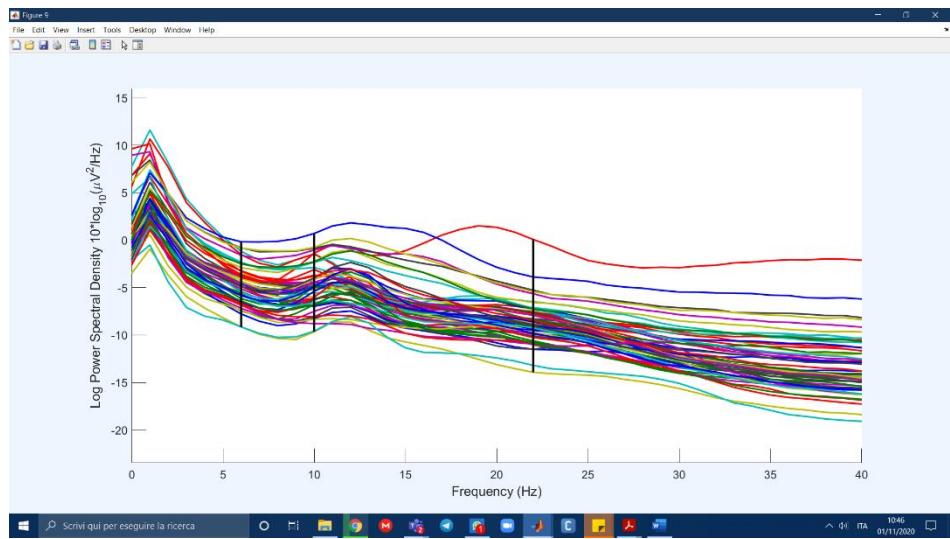


Delta: 0.5 – 4 Hz -> sleep



Together:





The peaks are around 11-16Hz and 19-21Hz, which are respectively in the eyes closed and movement frequency ranges. The areas in which they are concentrated are the occipital area.