University of Moratuwa

Department of Electronic and Telecommunication Engineering

BM4152

Bio-signal Processing

Laboratory Exercise 2.2

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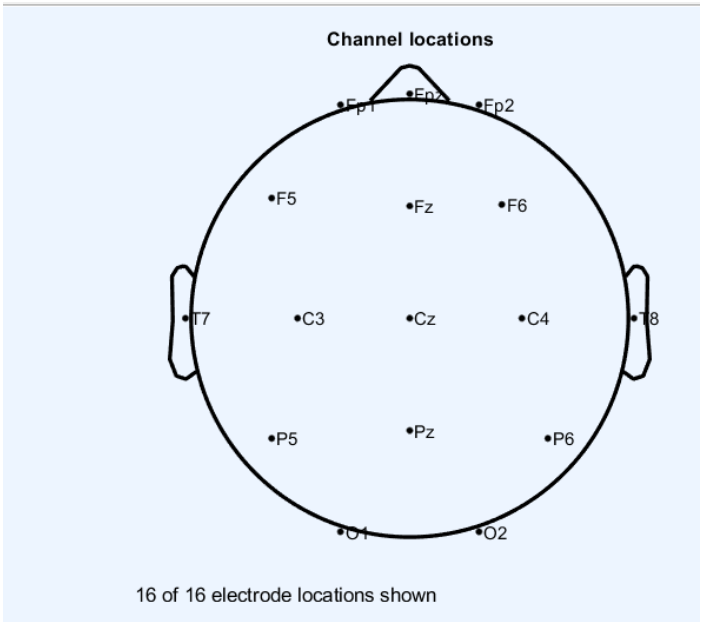
200664P

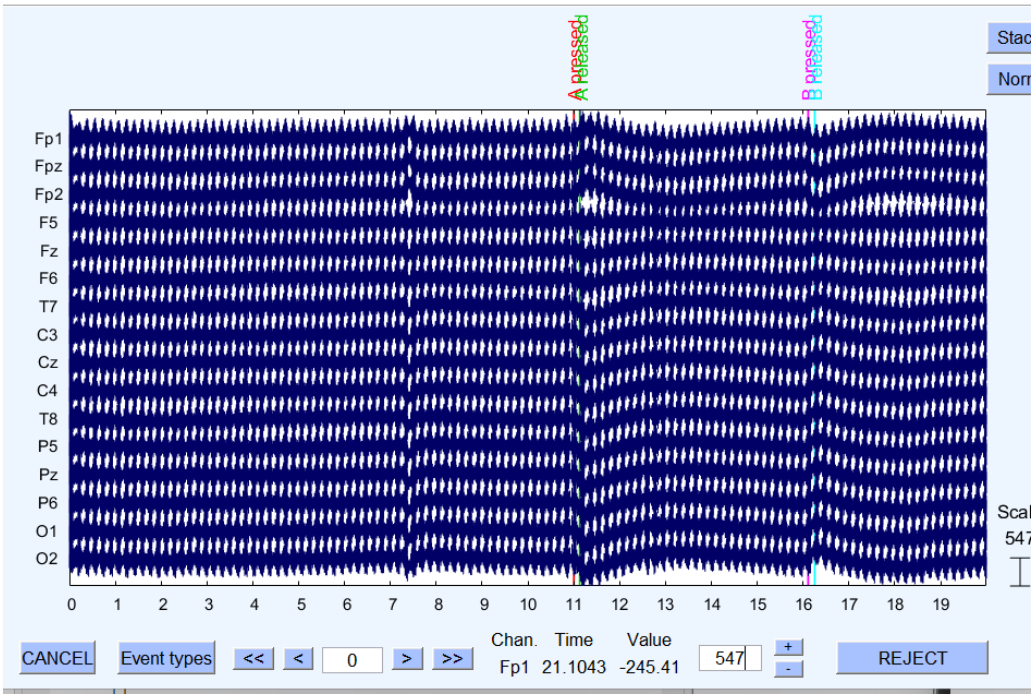
Part 2: Data preparation, time and frequency domain analysis

3.3

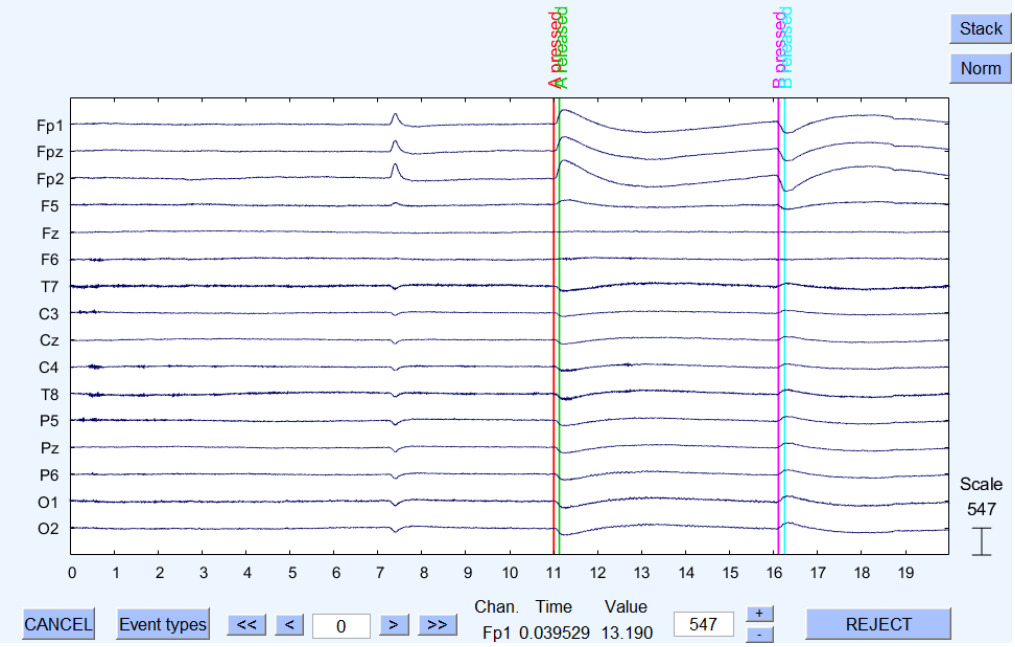


5.3

Raw:

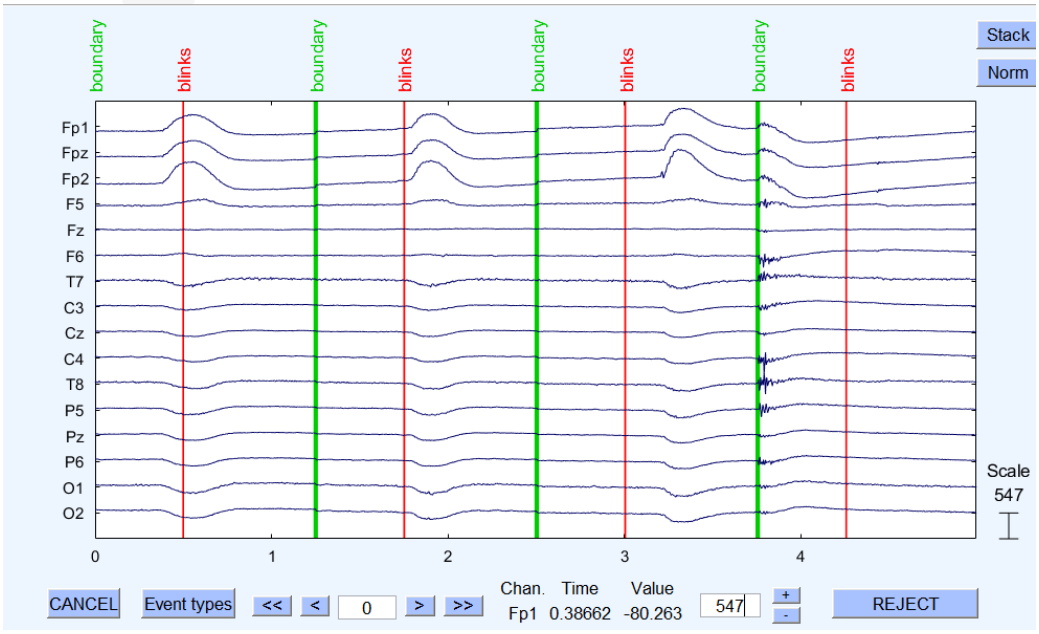


Referenced:



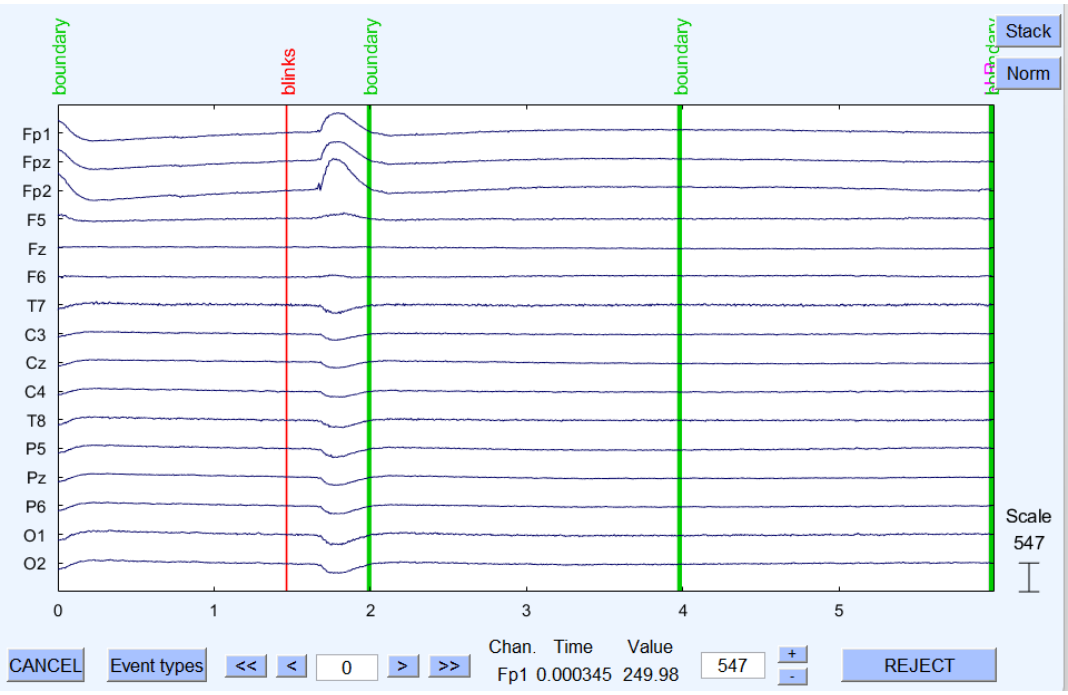
Noise is captured through all channels. When we set the reference, only changes compared to that are depicted. Therefore, eliminating common noise of all EEG electrodes.

7.1.4

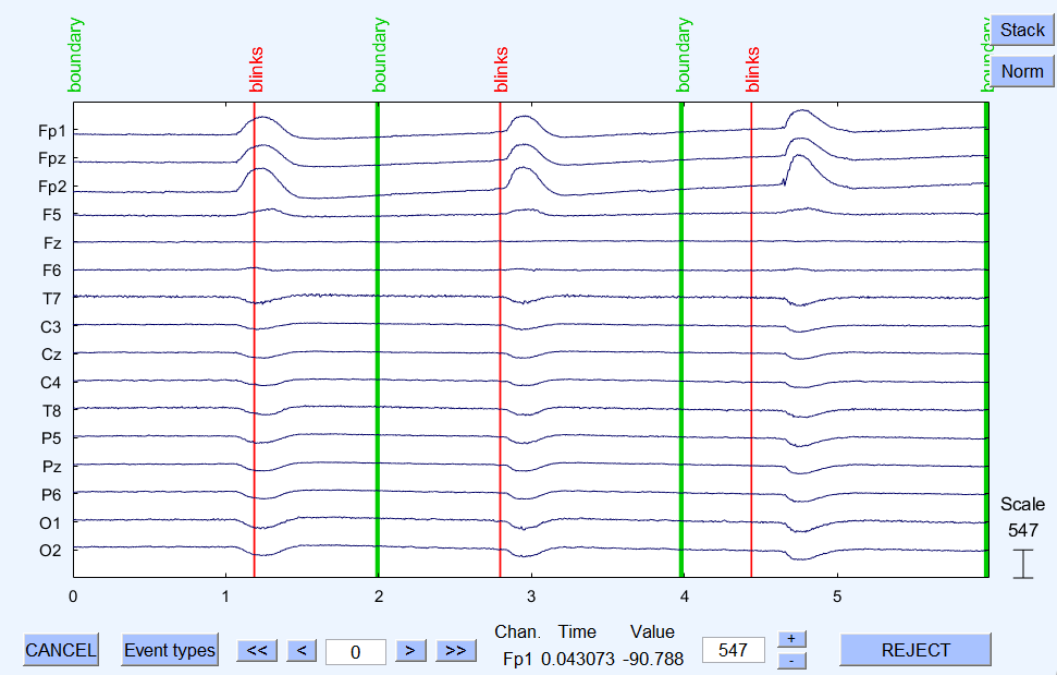


The events being marked at different instances of the blink makes it difficult to only extract the event, by taking a constant range around the marked event.

Selecting blinks manually from From 36th second →

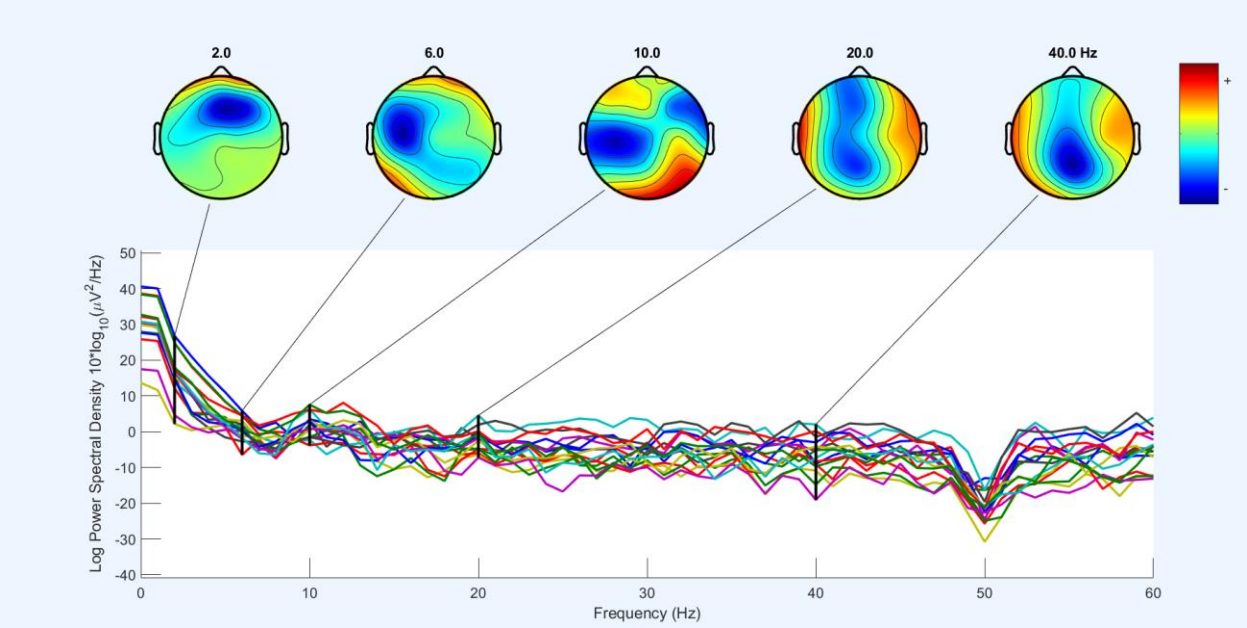


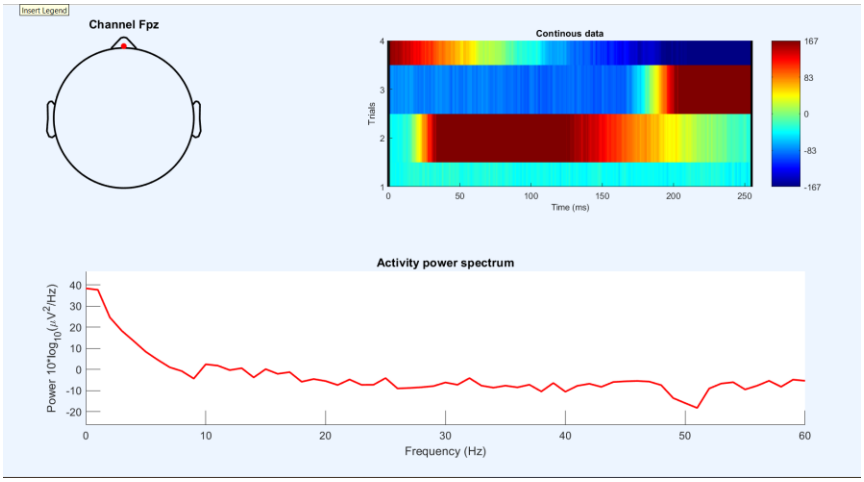
Selecting blinks manually from 33rd second →

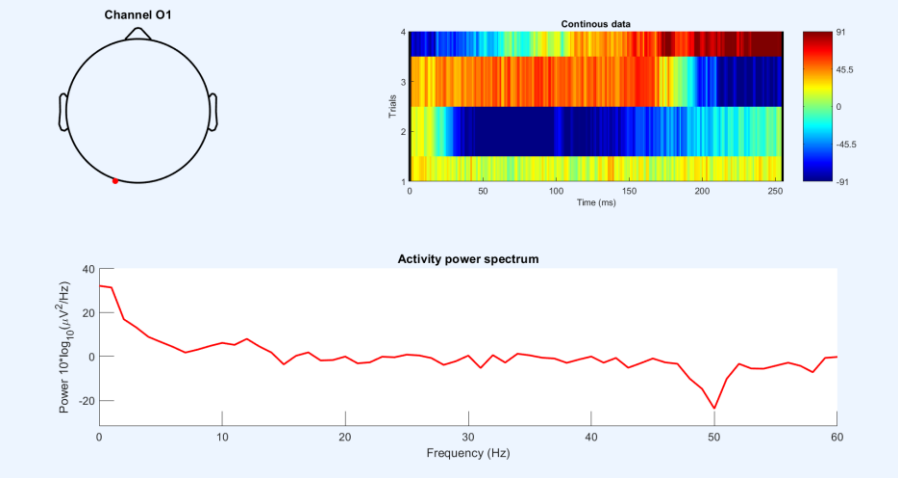


10.6

i_closed

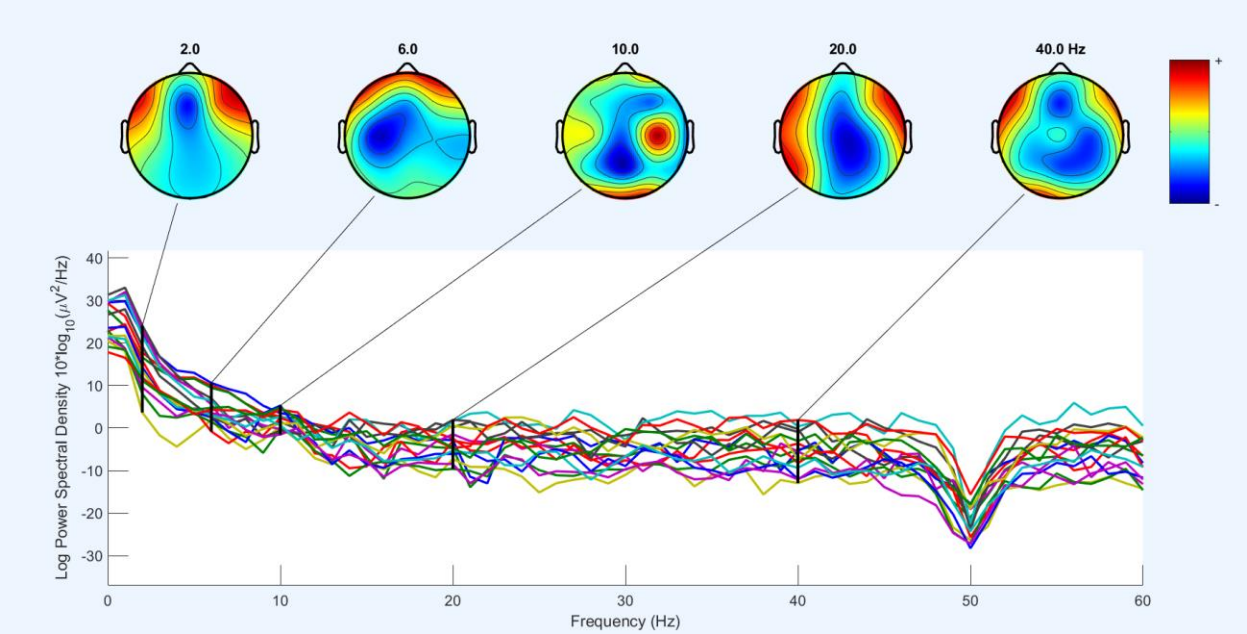

2.0
6.0
10.0
20.0
40.0 Hz
+
-
Log Power Spectral Density 10*log10 (μV^2/Hz)
Frequency (Hz)

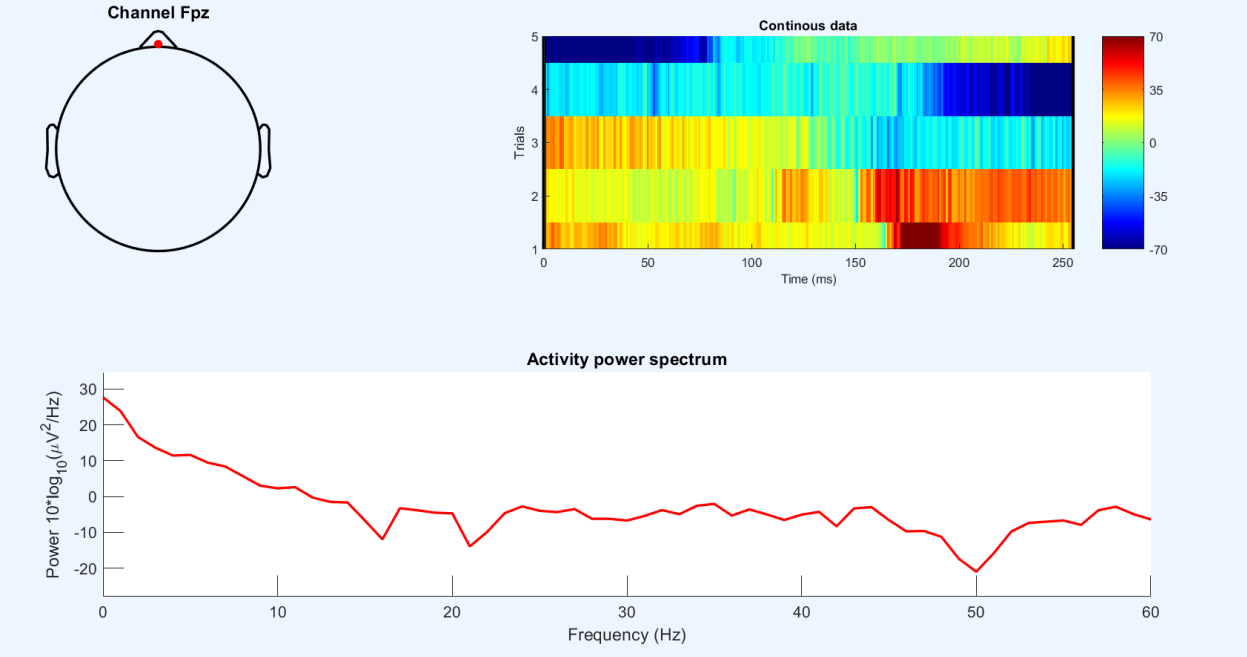

Insert Legend
Channel Fpz
Continous data
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV^2/Hz)
Frequency (Hz)

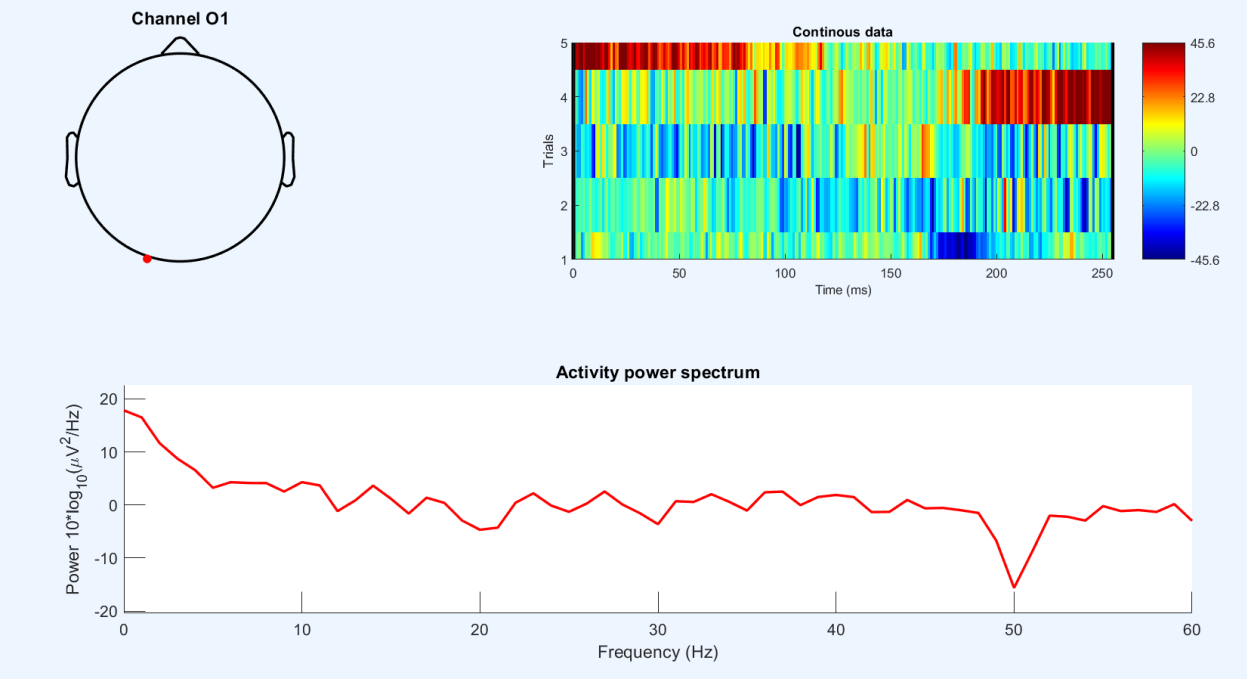


Eye closure is typically associated with an increase in alpha waves (8-12 Hz), can be observed here, in the back of the head, near the occipital region as well. Reduces beta wave high frequency activity. Low frequency in frontal channels is due to the physical movement of eyelids and associated muscle activity.

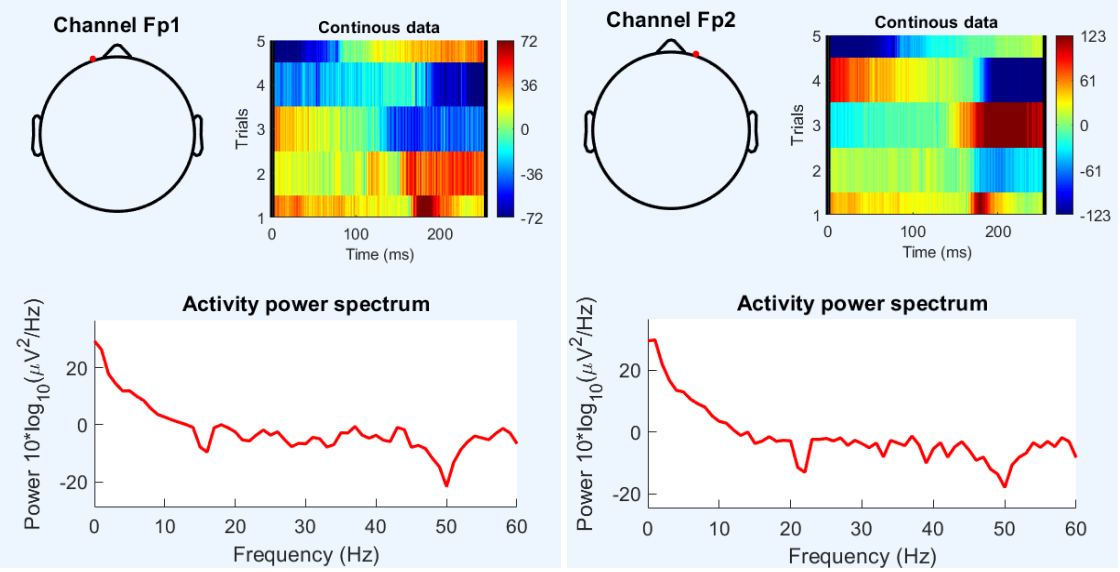
i_LR





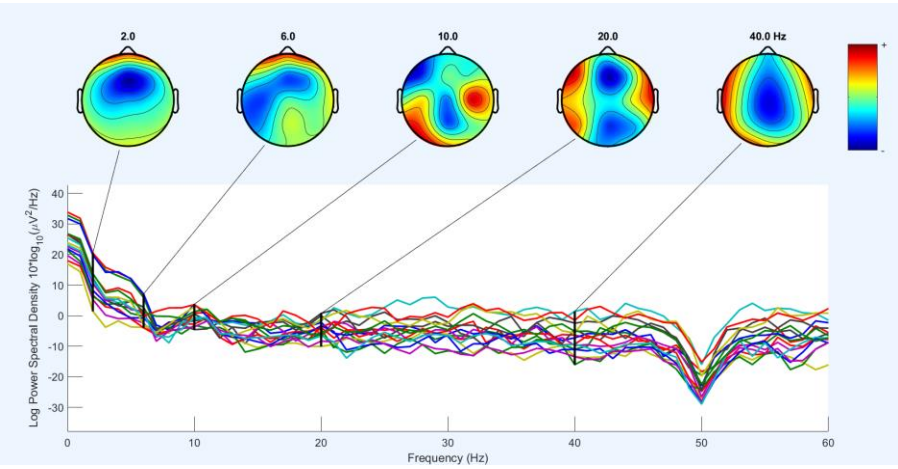


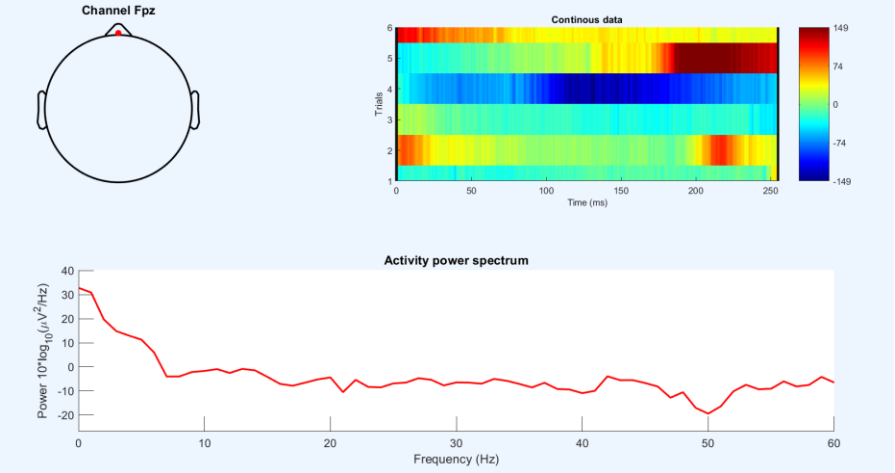
These artifacts are called the EOG artifacts. Low-frequency components (delta range) dominate these signals. Most significant deflections occur in the frontal channels, these artifacts can sometimes spread to the central and parietal channels though at a lower amplitude. This is observed by the lower amplitudes comparatively of electrodes at the back of the head. Also these lower frequencies are from the frontal regions as seen in the 2 Hz, and 6 Hz maps.

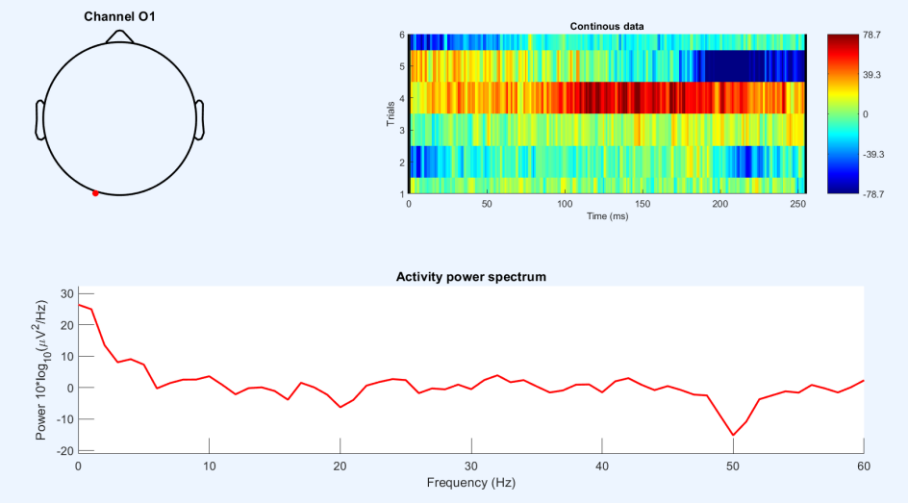

Channel Fp1
Continous data
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV²/Hz)
Frequency (Hz)
Channel Fp2
Continous data
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV²/Hz)
Frequency (Hz)

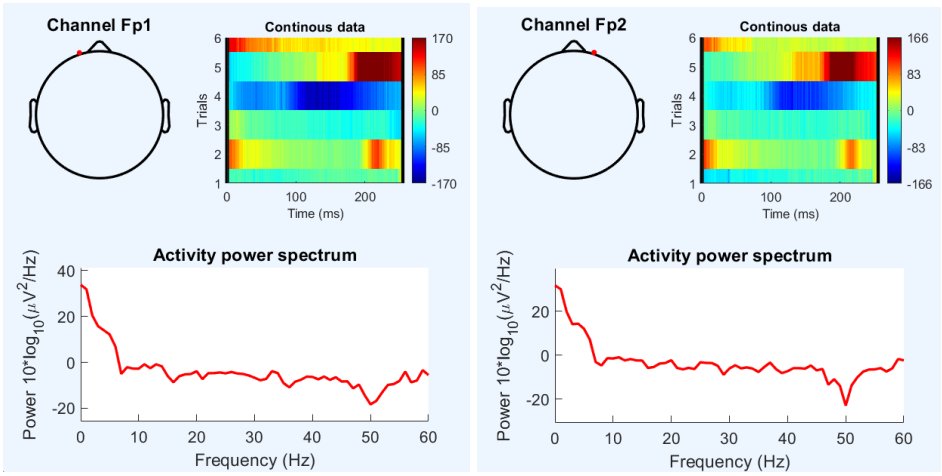
When the

i_UD


2.0
6.0
10.0
20.0
40.0 Hz
Log Power Spectral Density 10*log10(μV²/Hz)
Frequency (Hz)

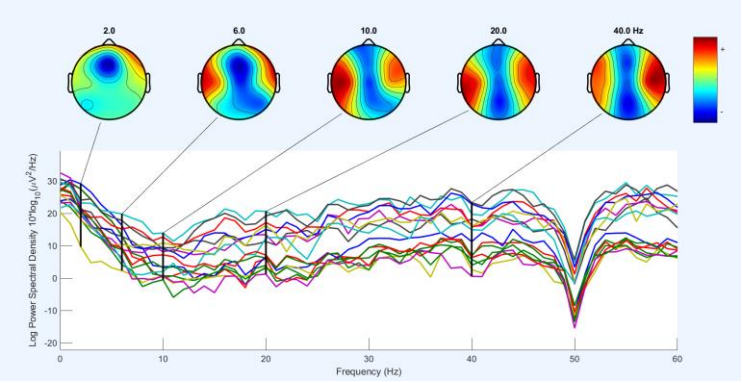

Channel Fpz
Continous data
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV²/Hz)
Frequency (Hz)

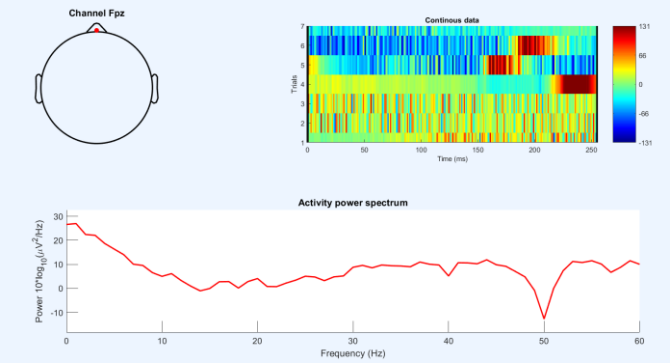


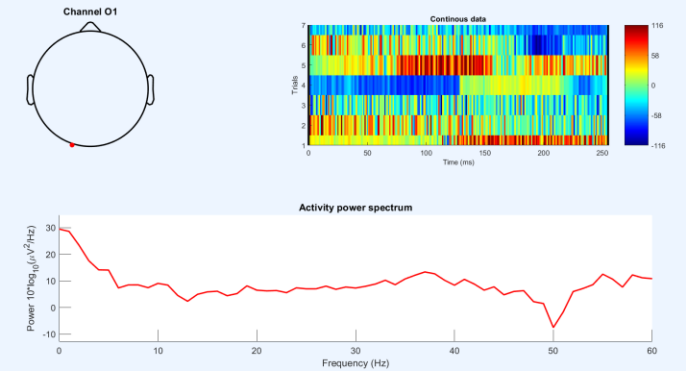


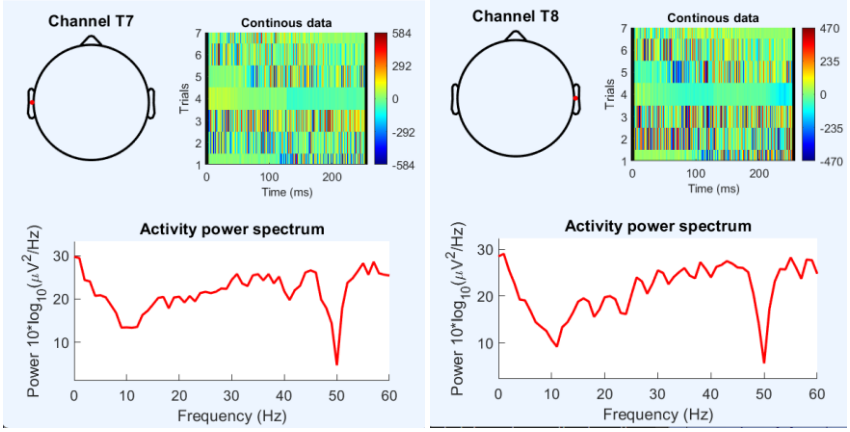
As the eyes move up and down, the changes in orientation generate artifacts in the frontal electrodes. As we can see the lower frequencies are generated from the frontal regions. Some residual eye movement artifacts can still be present in the theta range (4–8 Hz), though less pronounced than in the delta band. The 20 Hz map reflects more cognitive and motor activity, with minimal contamination from eye movement artifacts.

Teeth



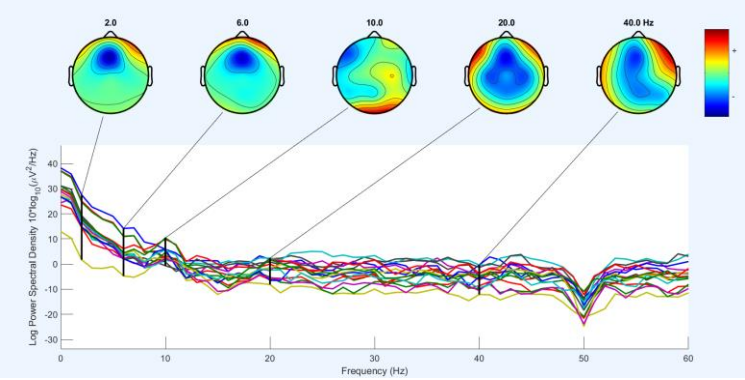


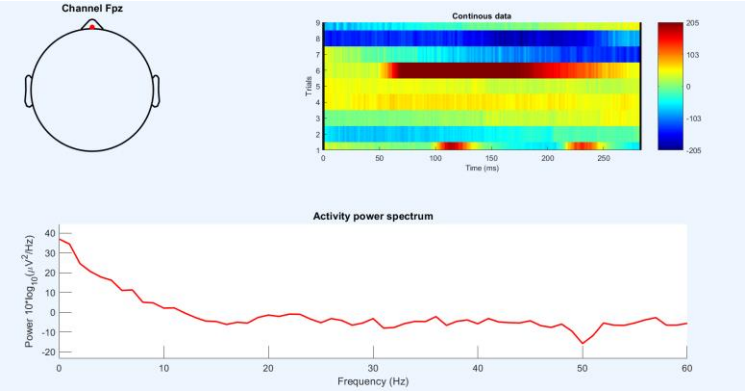


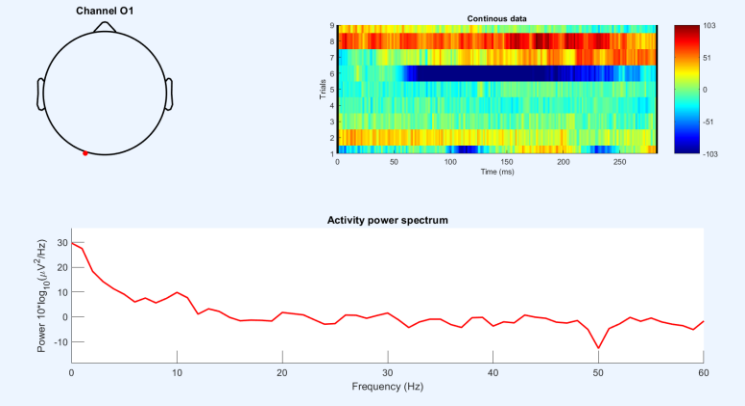


Now we can see that high frequencies have become more prominent. It is because of the muscle artefacts/ EMG artefacts. Temporal and frontal regions are mostly affected since they are closer to jaw muscles. In contrast to previous cases, we can see the high frequency noise mostly concentrated on those areas. Temporal – T7, T8.

noise_ON





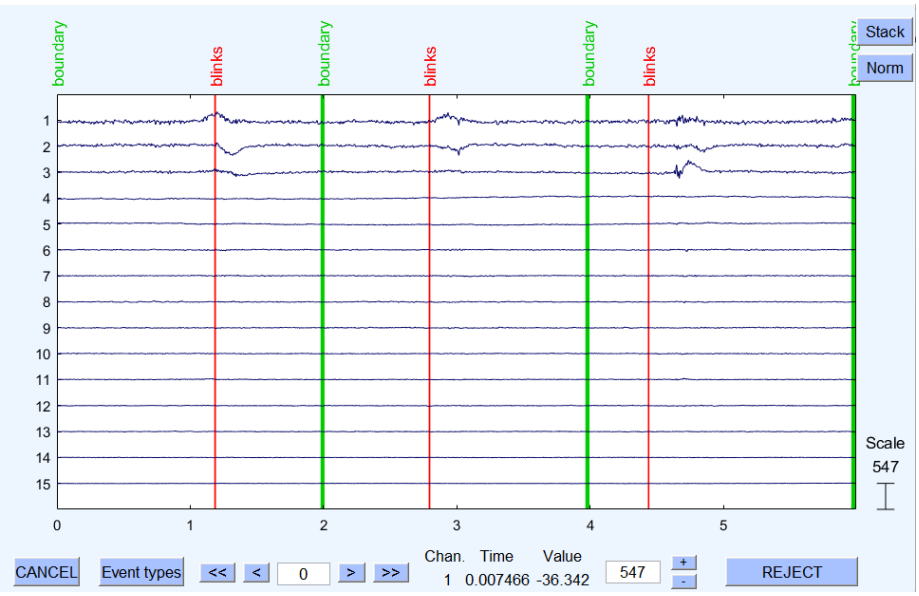


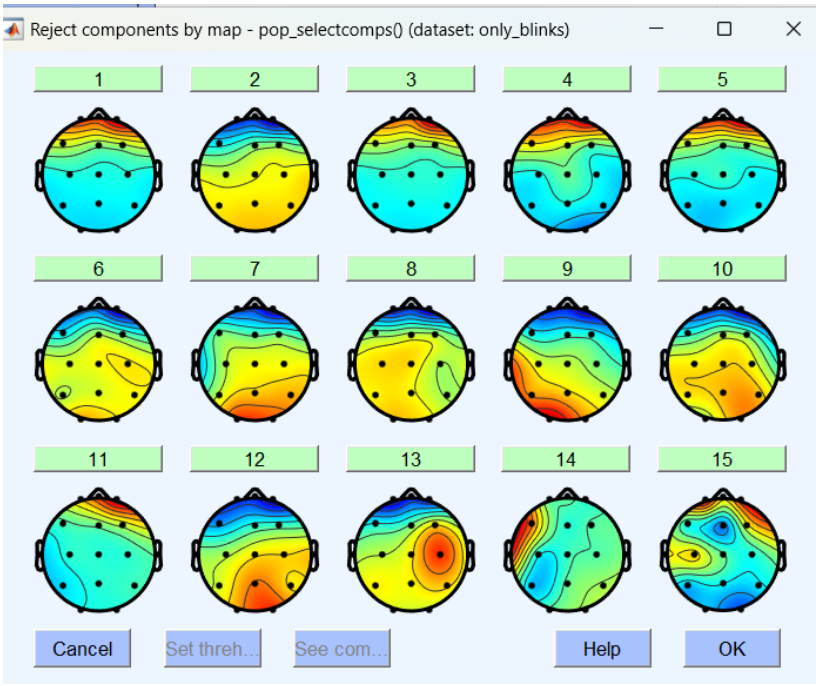
Some jitters are available in the signal due to the added noise. There are slight peaks in the 10 Hz region indicating that the noise may be in that region.

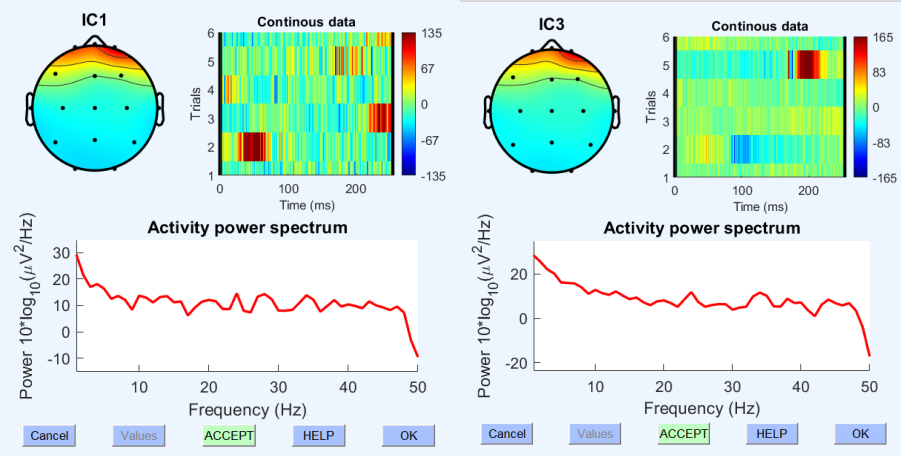
Part 3: Using independent component analysis (ICA) of EEG data

Only Blinks

ICA components:

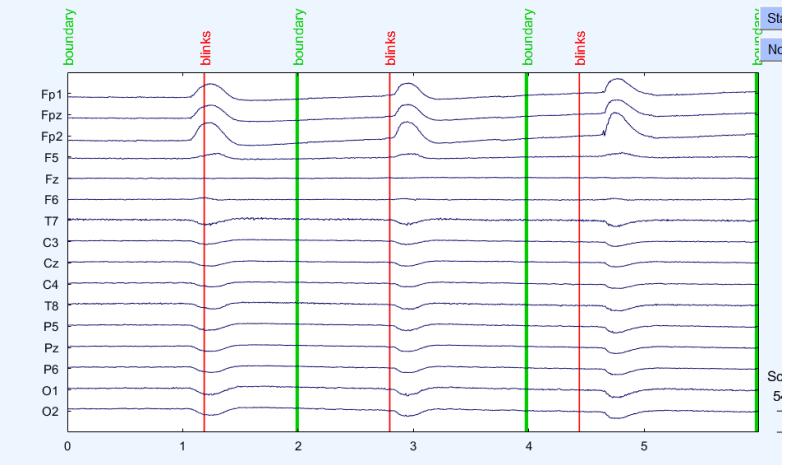




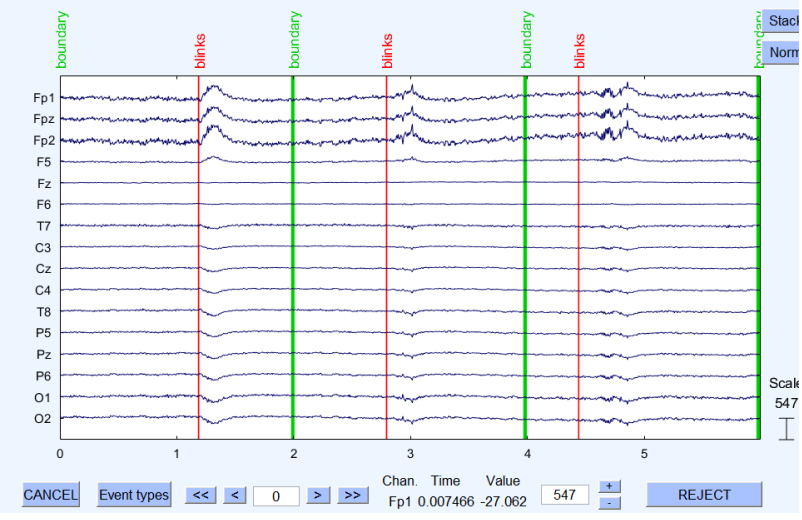


Only removed 1st and 3rd ICA components since the magnitudes were considerable higher and were localized in the front. Eye movement magnitudes are comparatively higher.

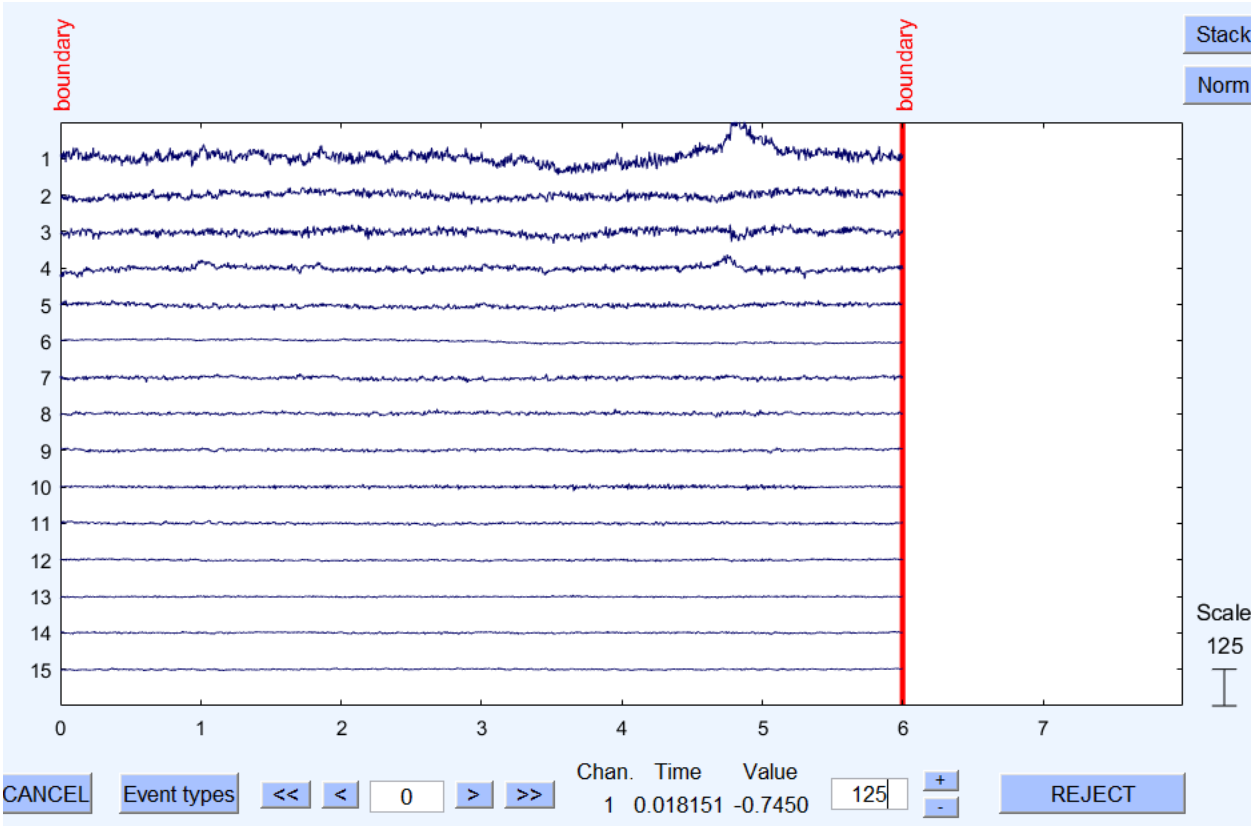
Before removal:

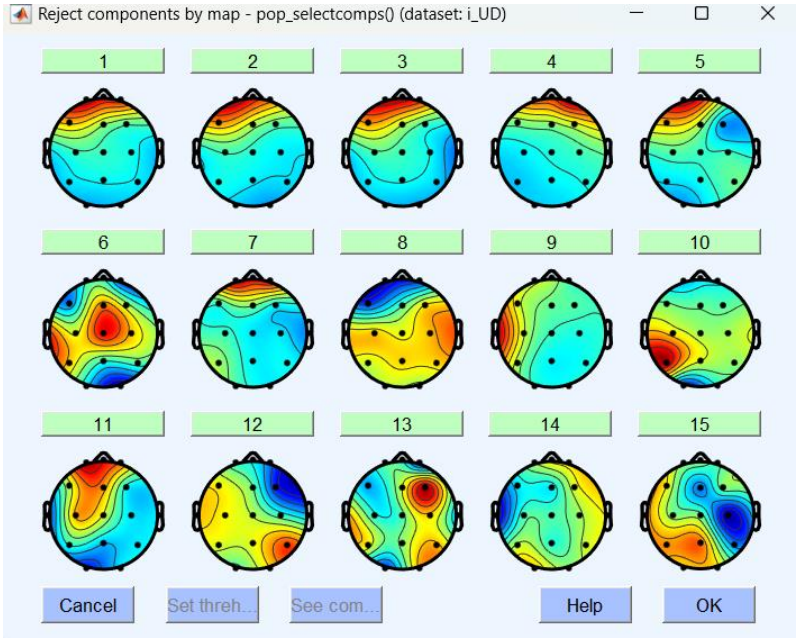


After removal:



i_UD

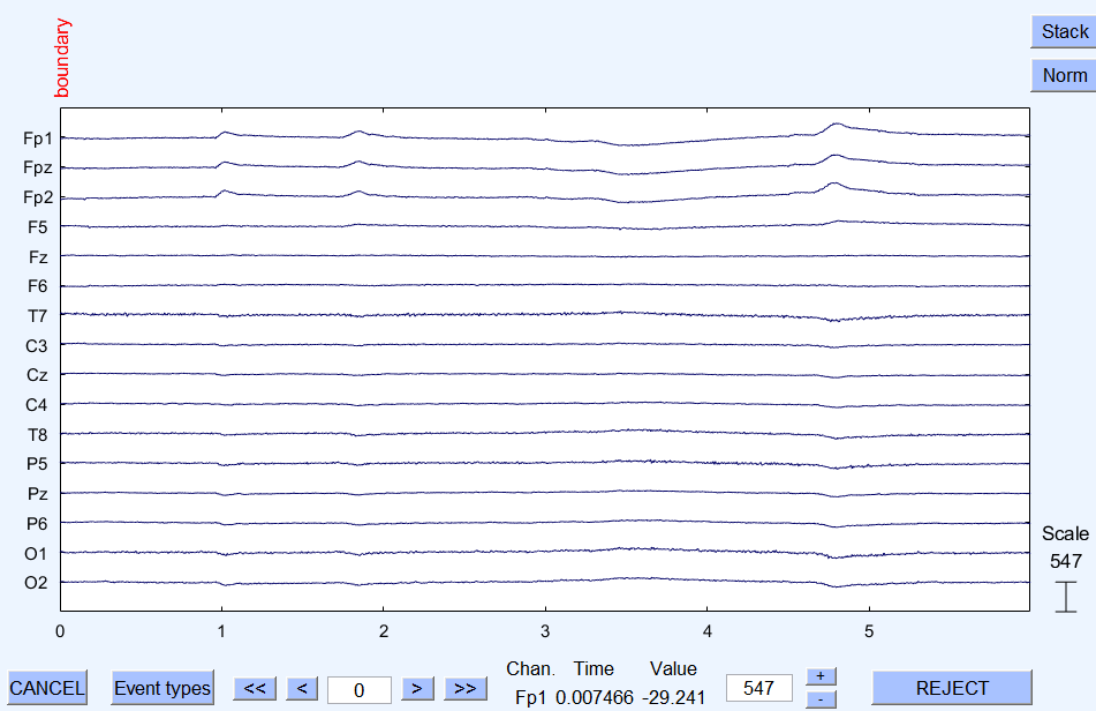




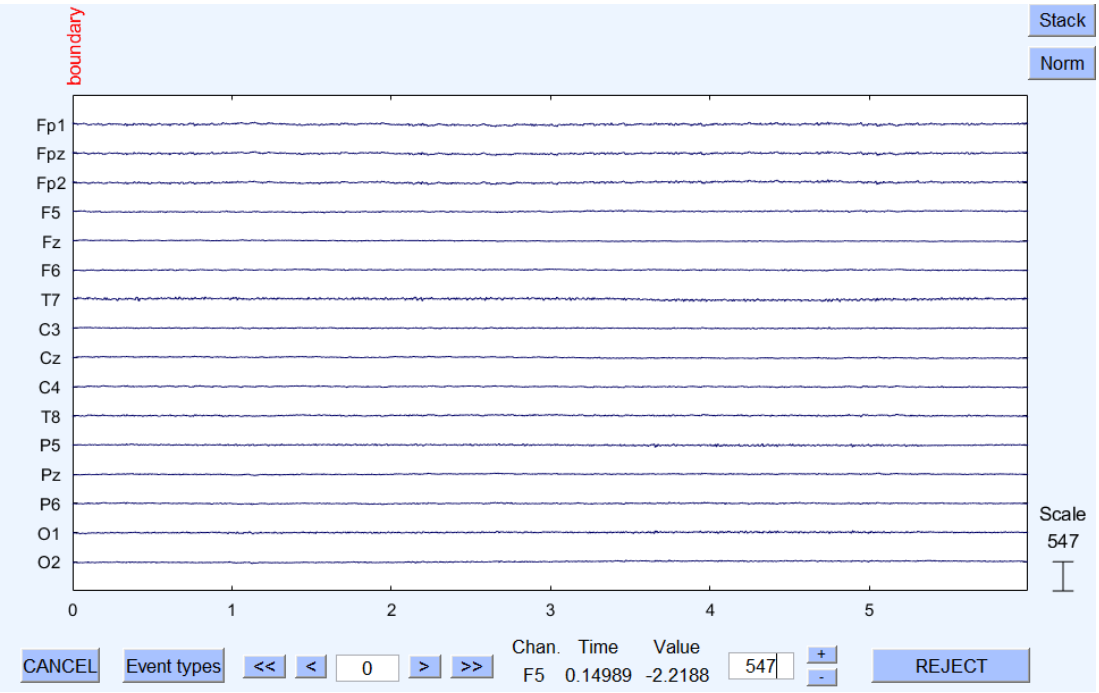
Removed 1-5

Because eye movement noise has higher magnitudes and are localized at the front. These components were identified so.

Before removal:

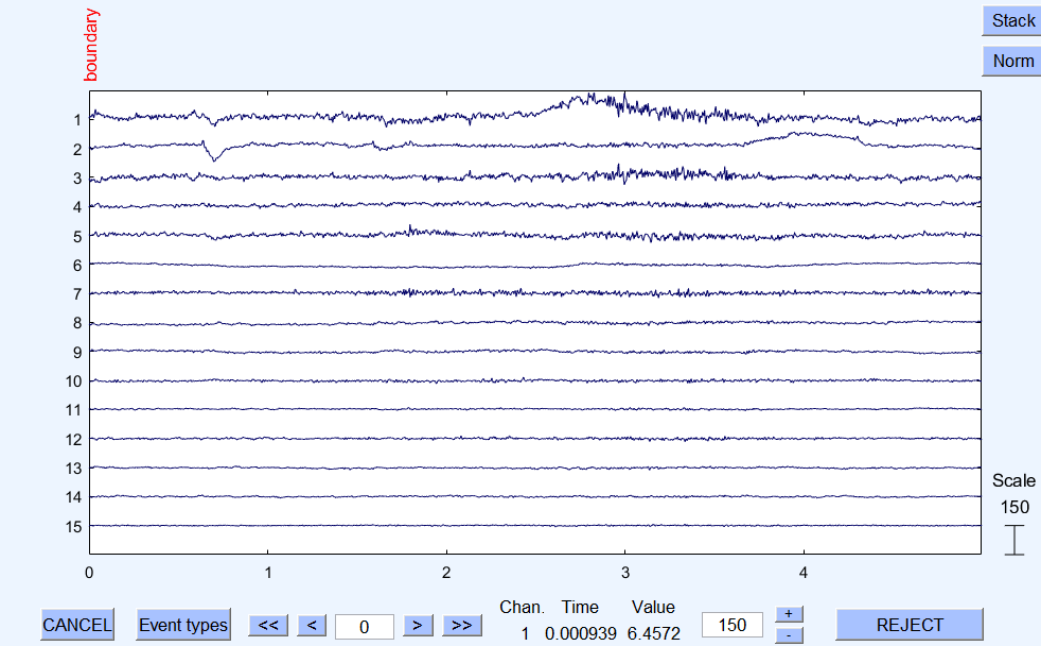


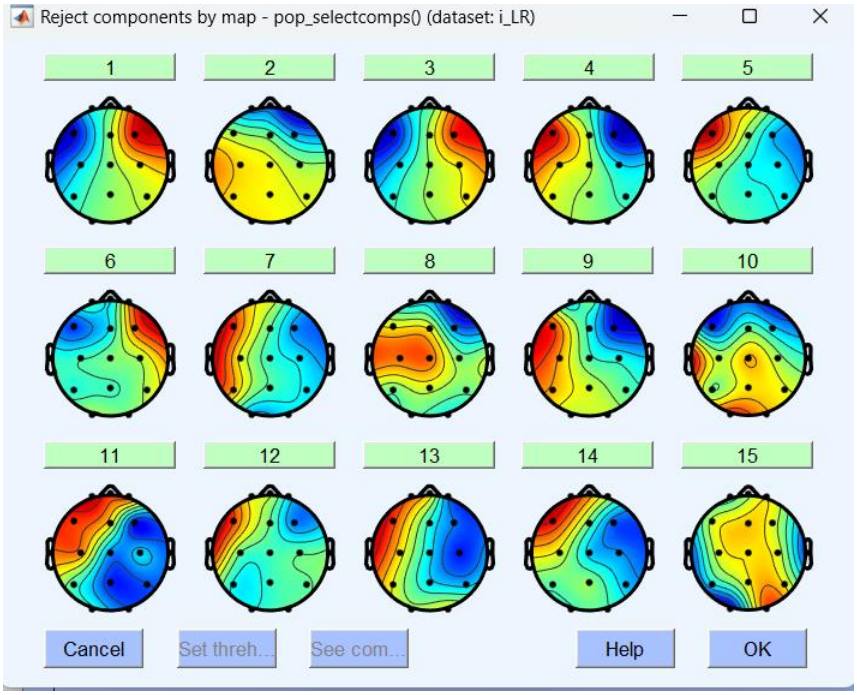
After removal:



i_LR

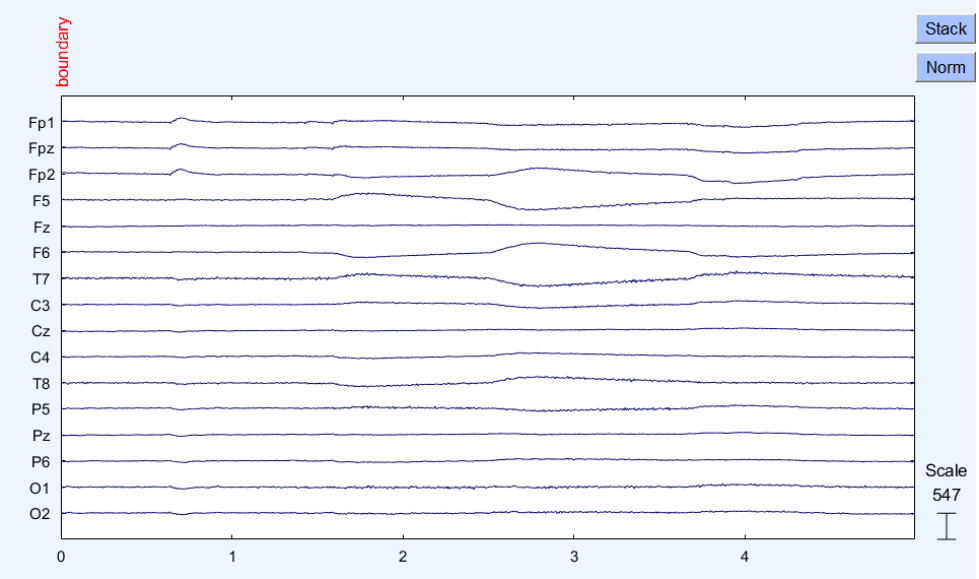
ICA Components



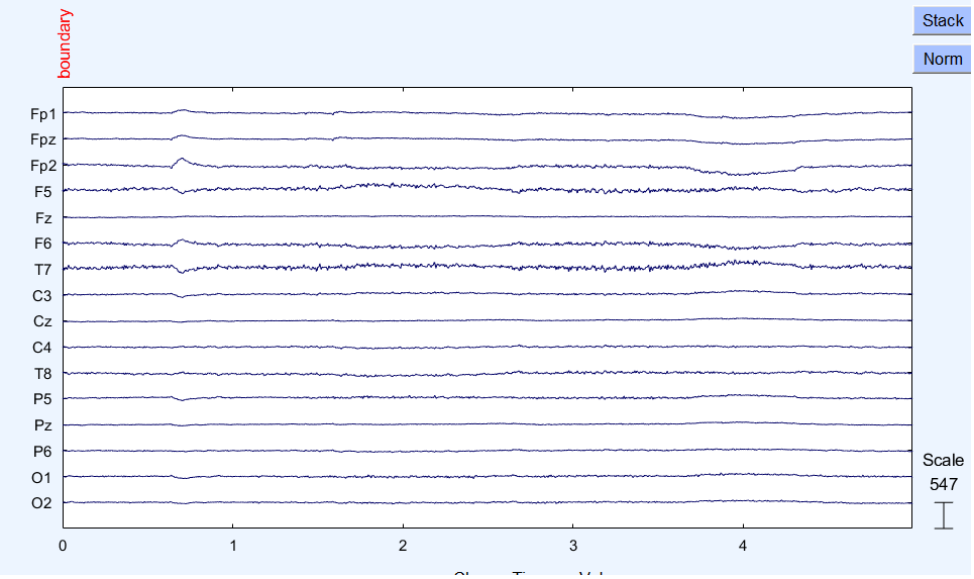


First and third ICA components were removed as they were localized at the front with higher magnitudes. These were identified as eye movement artefacts.

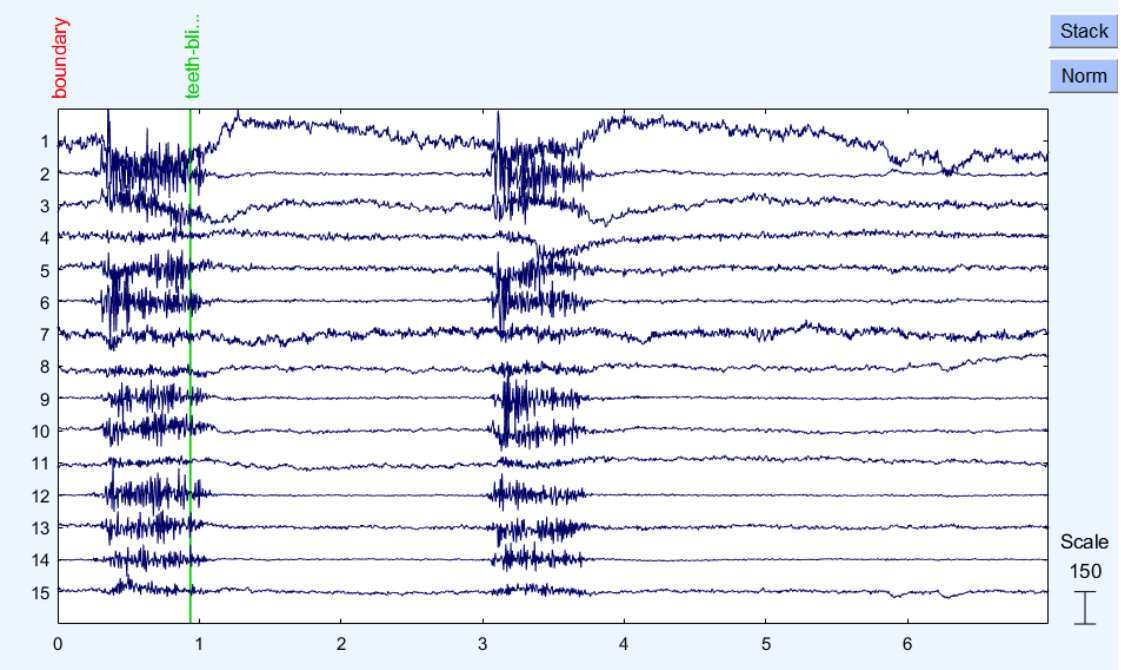
Before removing:

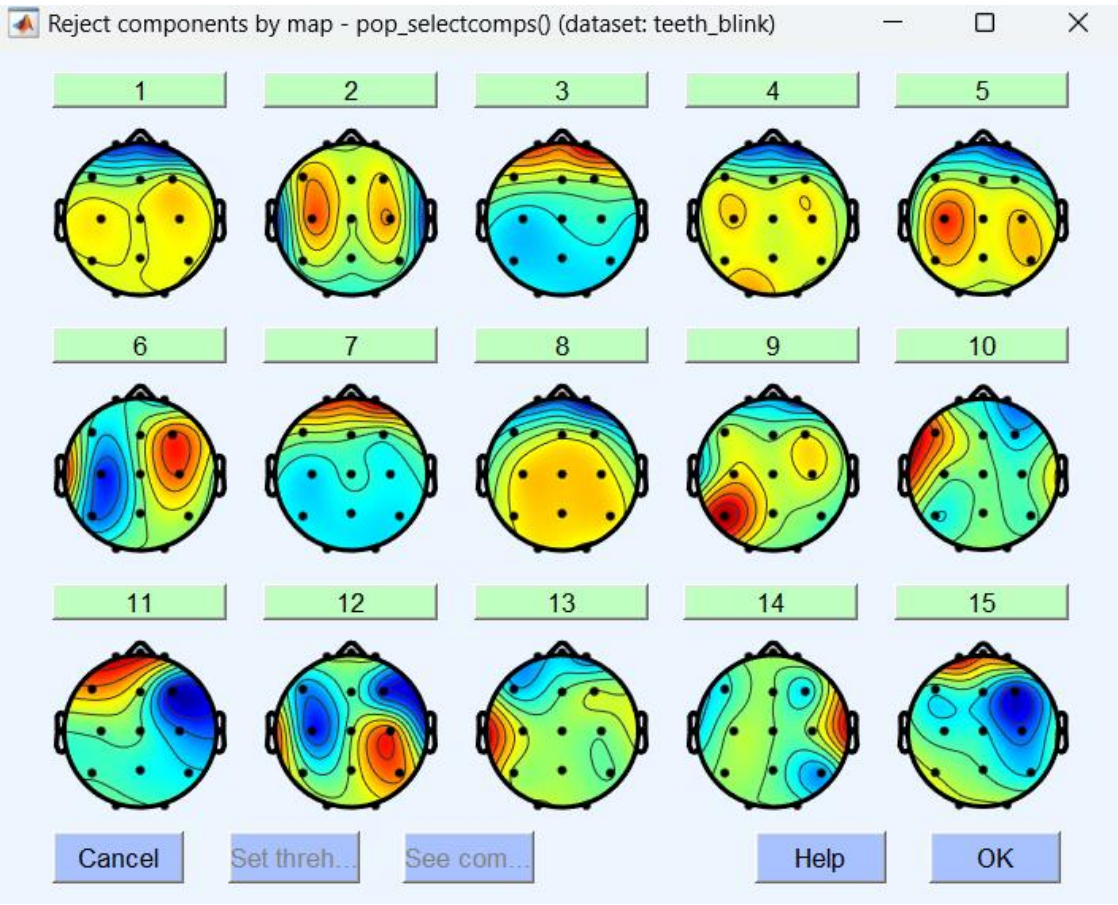


After removing:



Teeth_blink


boundary
teeth-bli...
Stack
Norm
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
1
2
3
4
5
6
Scale
150


Reject components by map - pop_selectcomps() (dataset: teeth_blink)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Cancel
Set threh...
See com...
Help
OK

Components to remove:

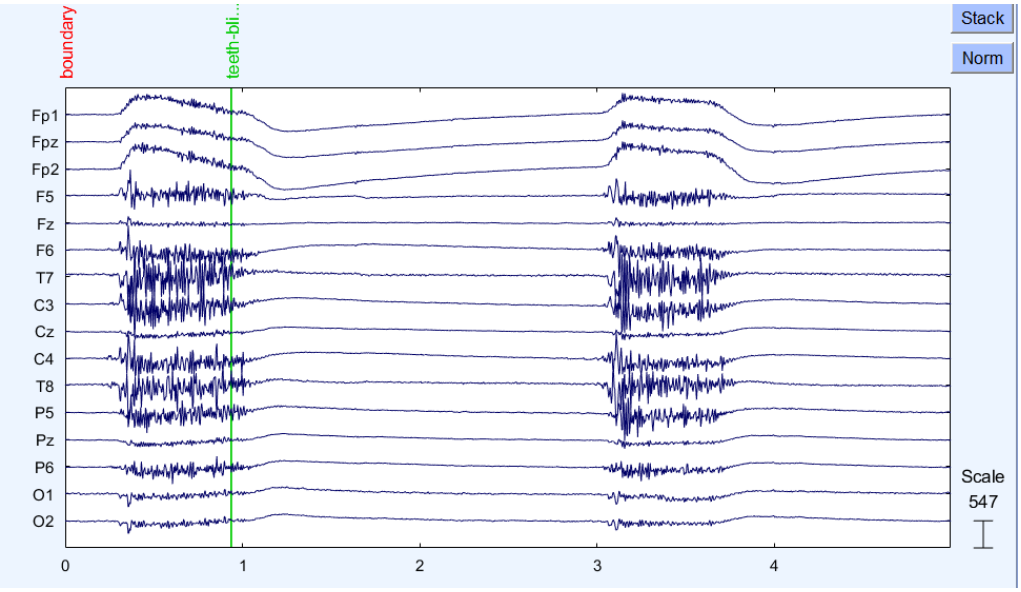
1: Power at lower frequencies indicating EOG artifacts

2,5,6: Power at high frequencies indicating muscle movements

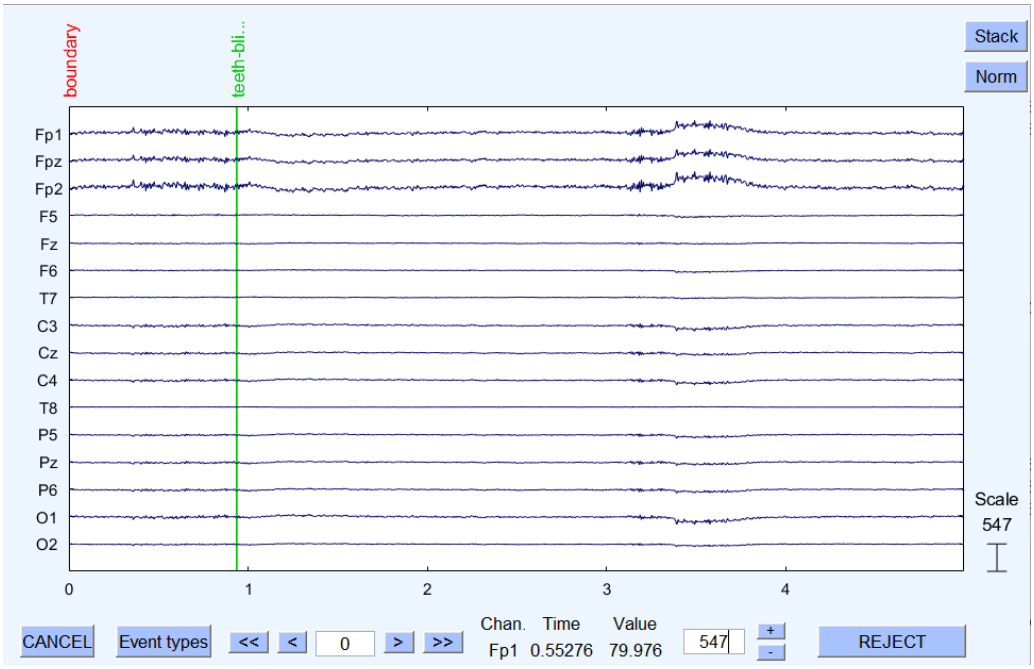
3,7,11, 15: Localized at the frontal lobe indicating EOG or muscle noise.

9, 10, 12, 13, 14: Localized and has high frequency indicating muscle noise (also temporal except 12)

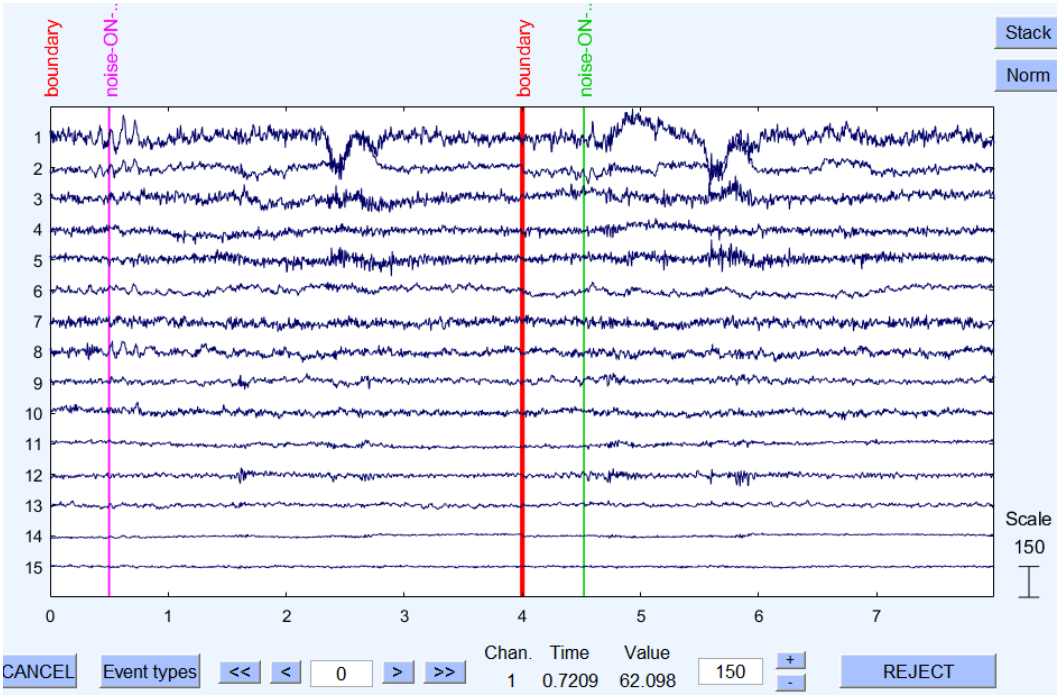
Before removing:

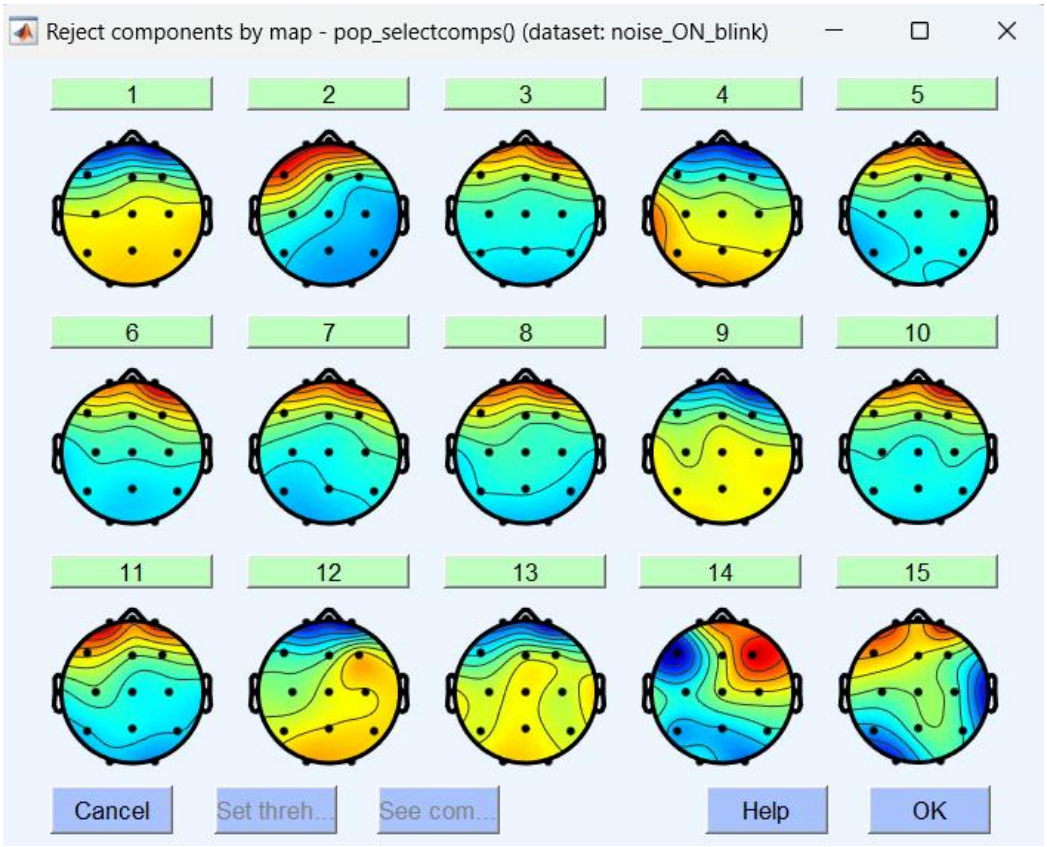


After removing:



noise_ON_blink



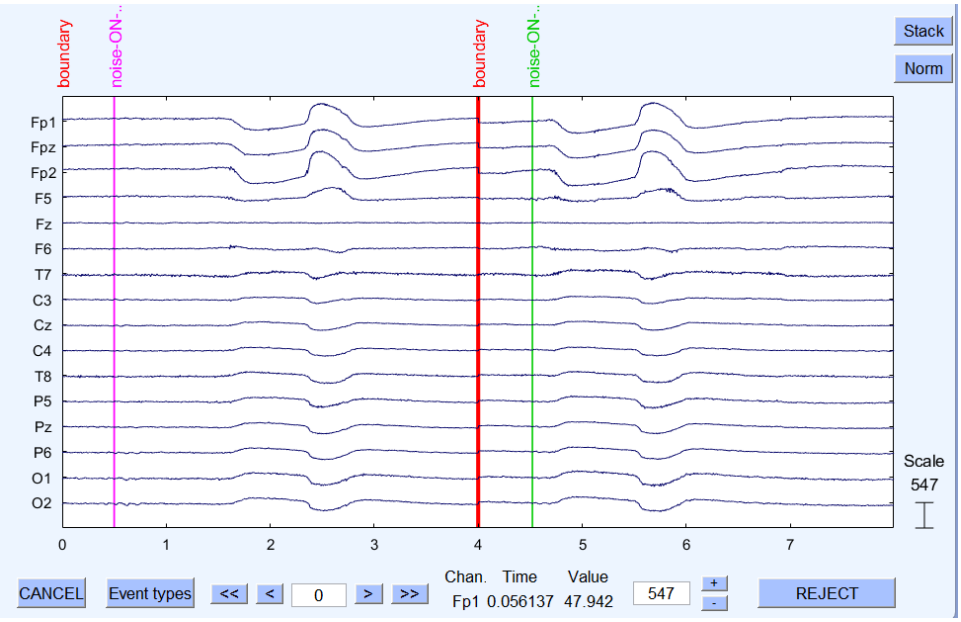


Components to remove:

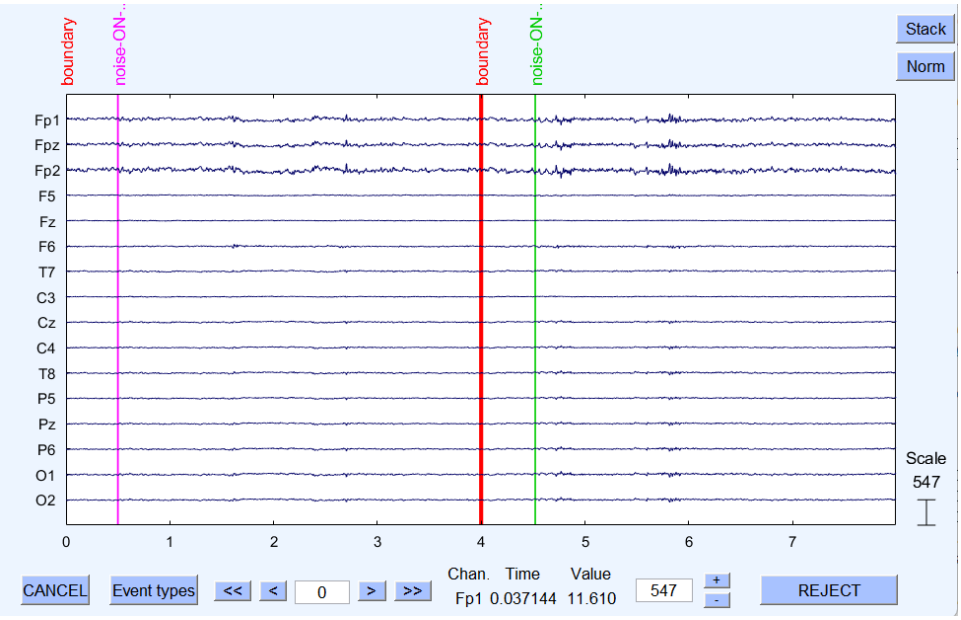
1, 4: Activity concentrated on lower frequencies indicating EOG artifacts

2,3, 5,6,7, 8,10,11,14,15. Localized at front; EOG artifacts.

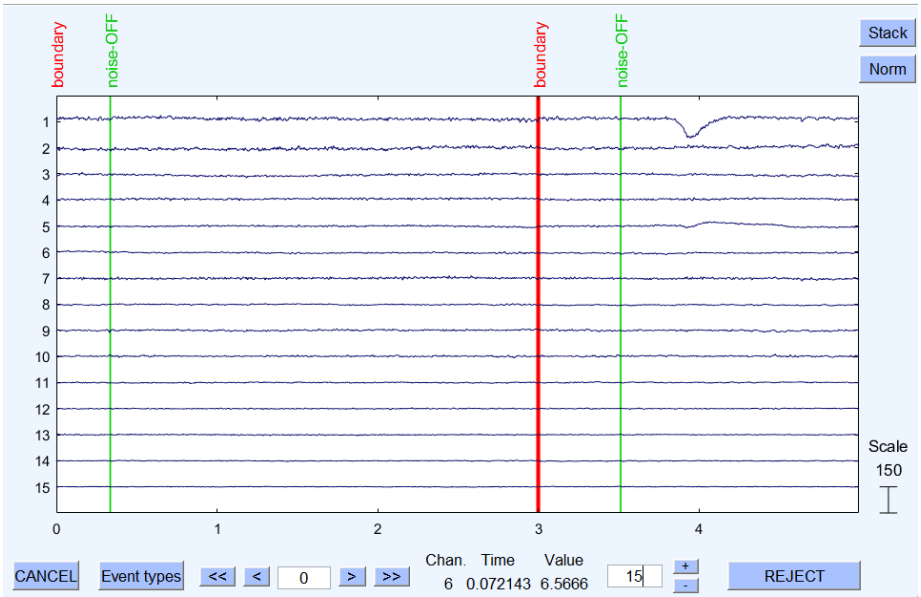
Without removal:

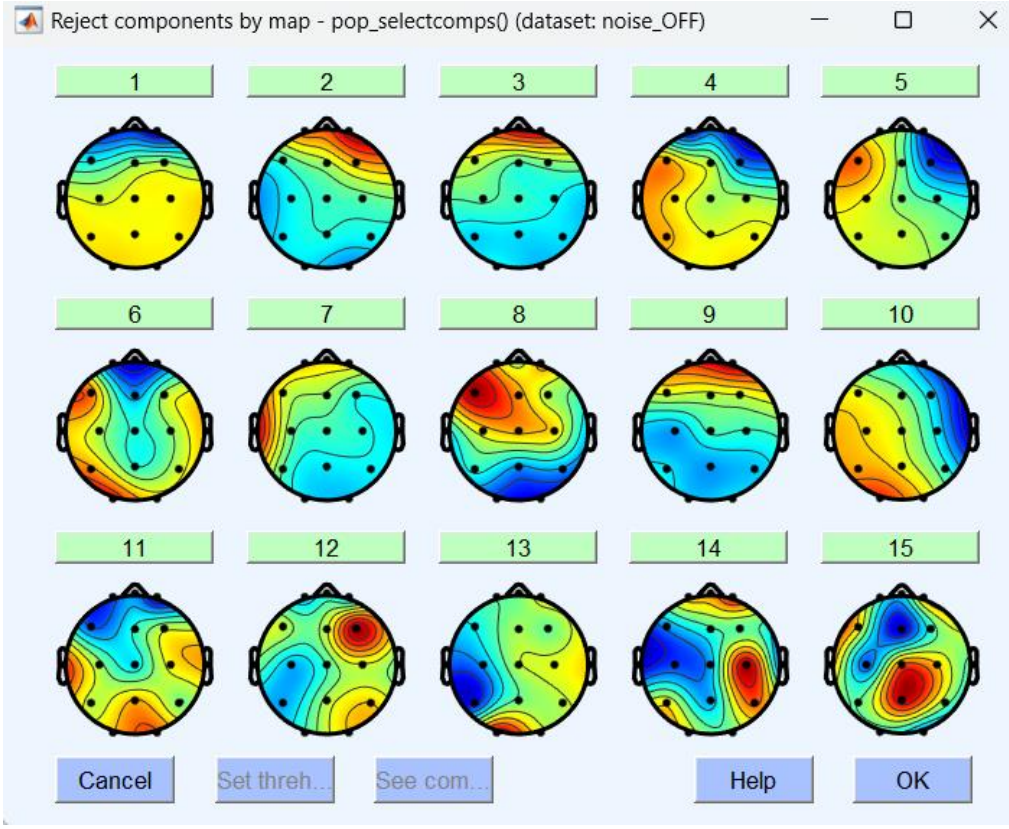


After removal:



Noise_OFF





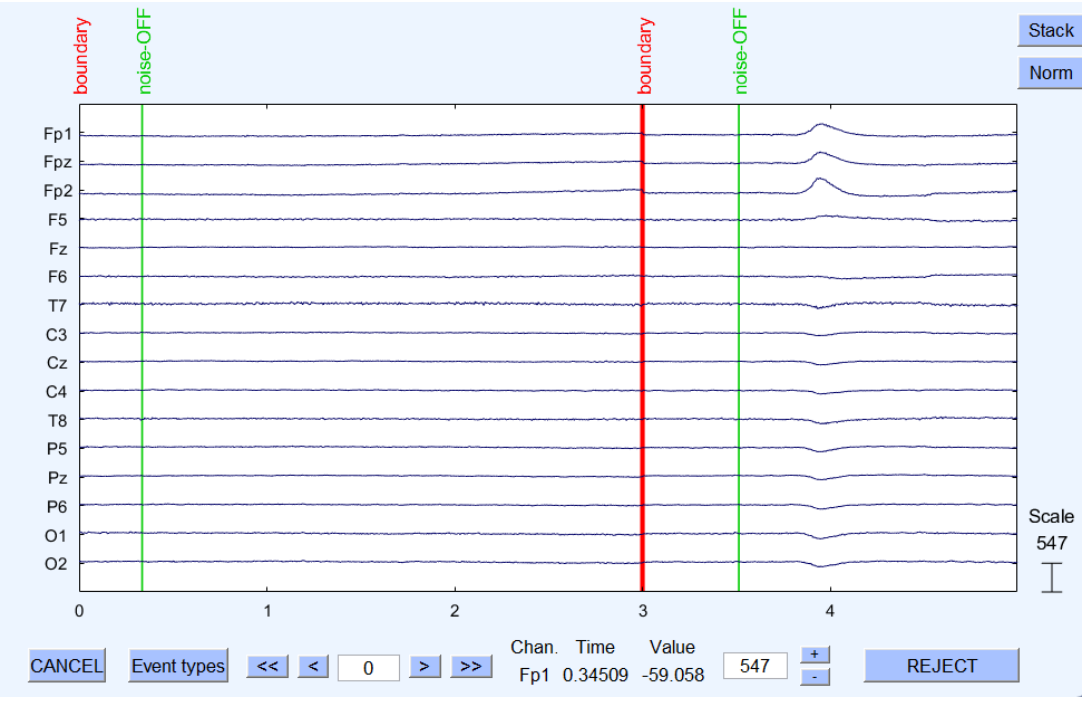
Components to remove:

1: High magnitude at lower frequencies

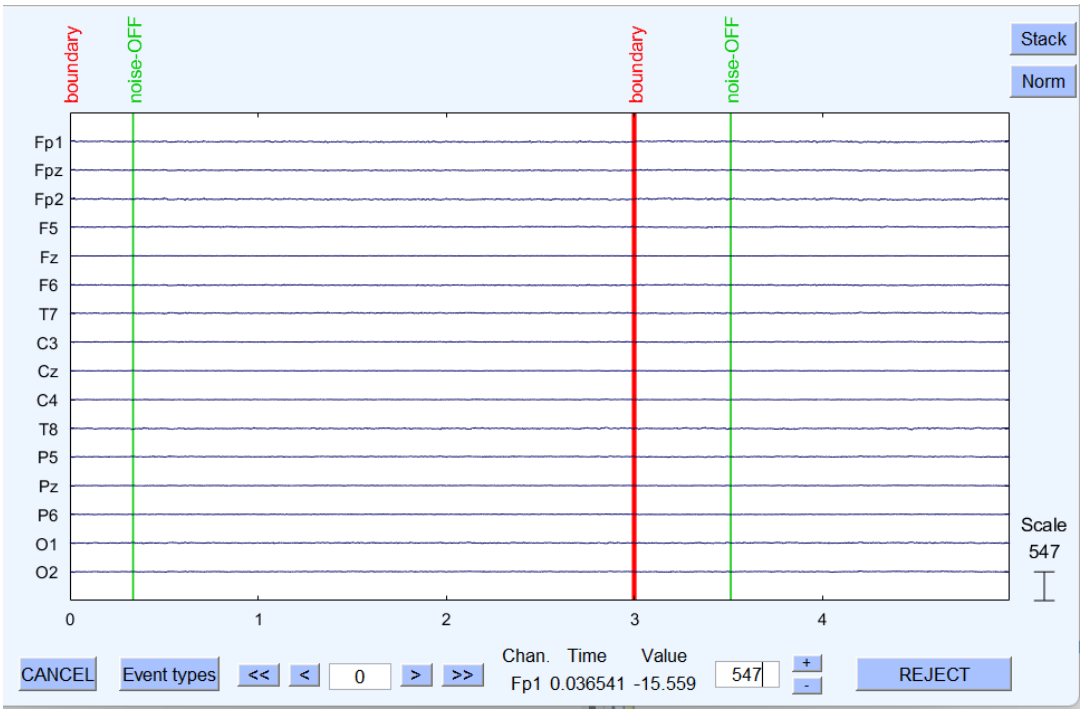
2,3, 9 : Localized at front, possible EOG noise

5,6,7,8,12,13,14,15: Localized noise

Without removing:



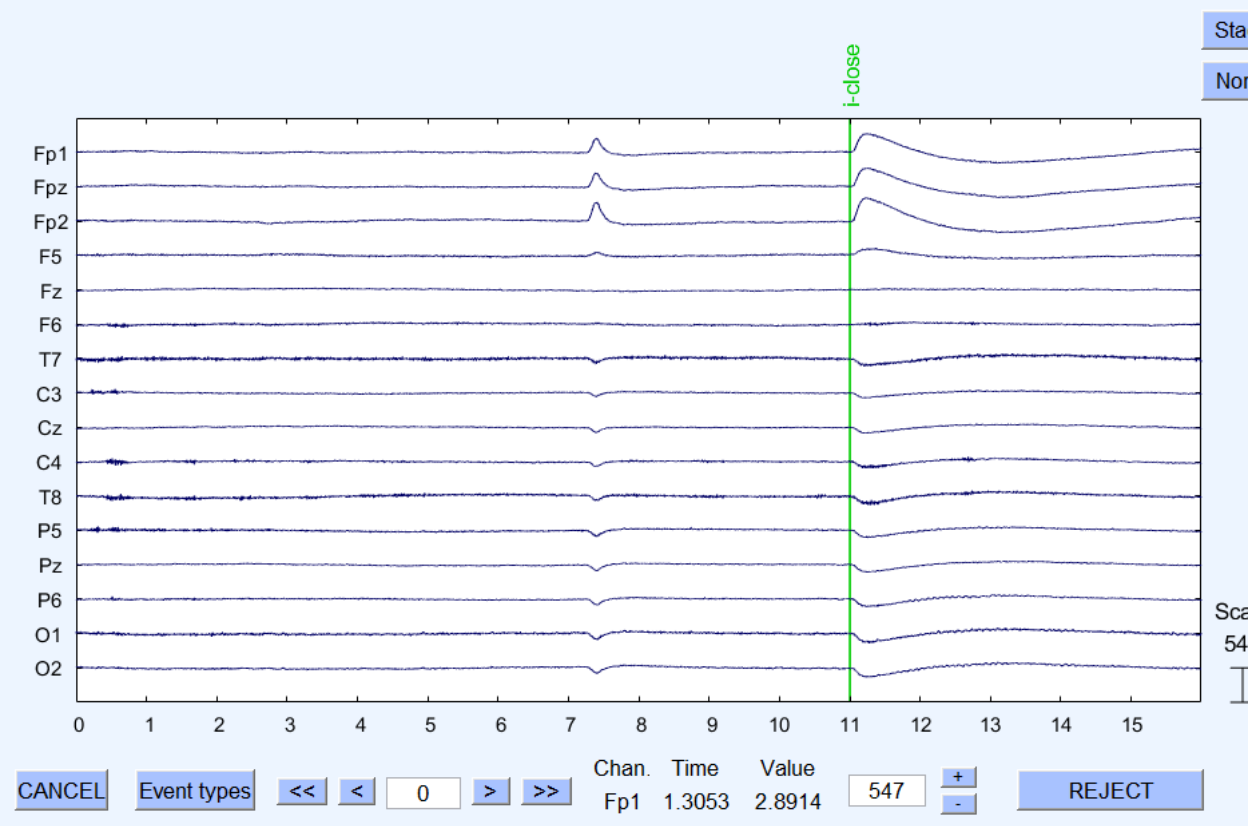
After removal:



ICA preprocessing using MARA (Extended Work)

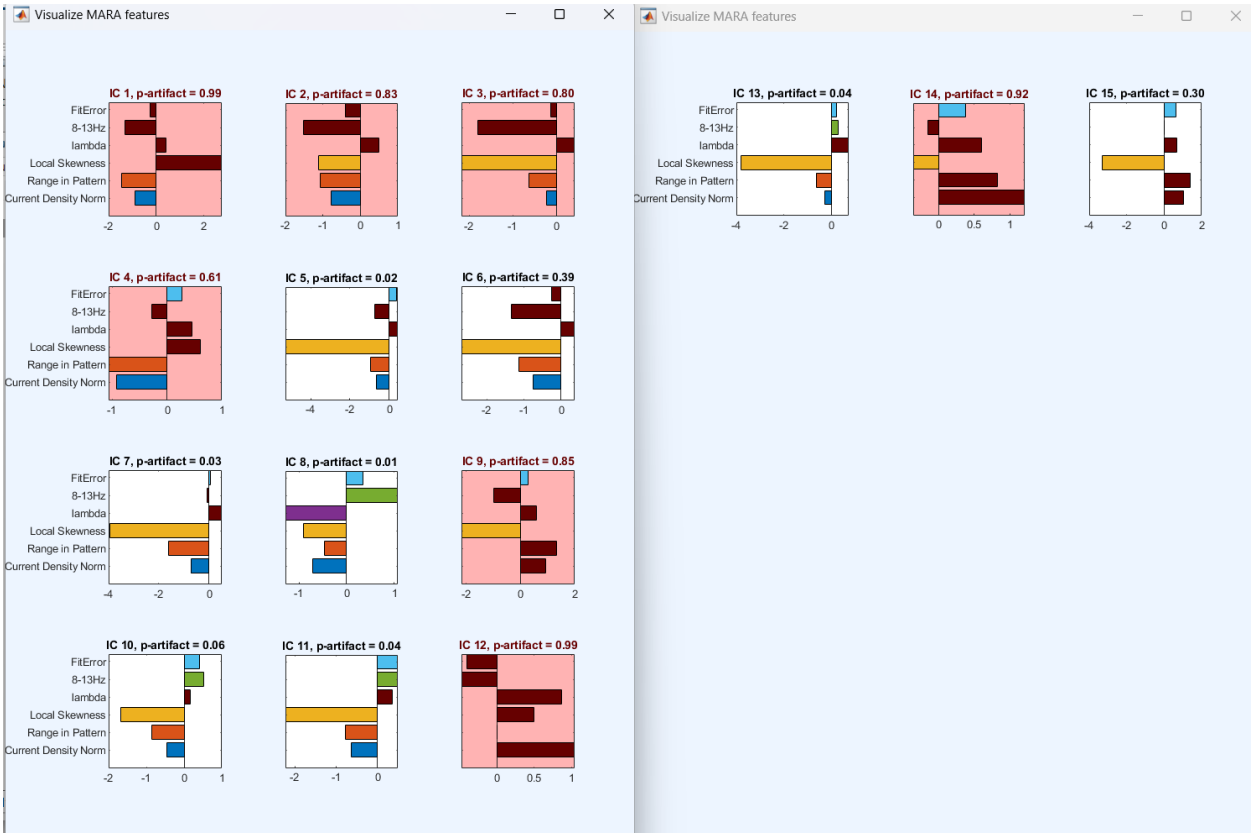
Using a 15 s window as per the requirements of MARA:

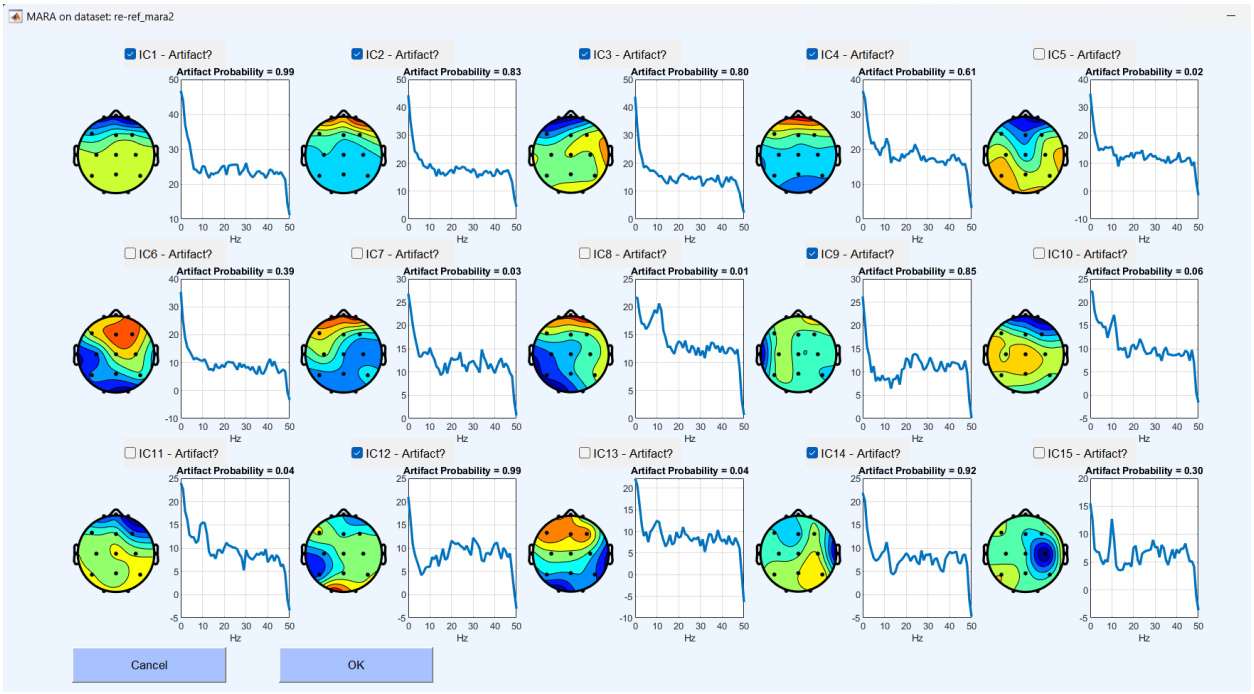
Before:



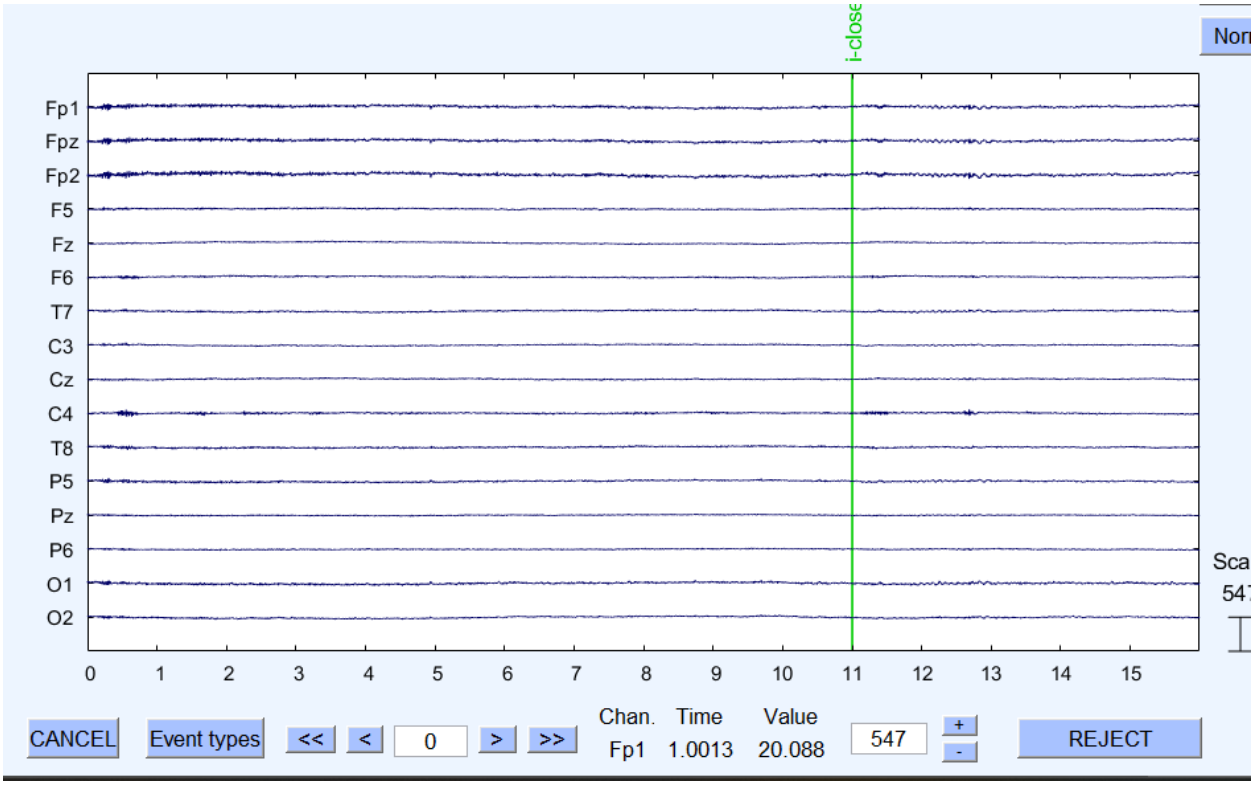
Components marked for rejection

1 2 3 4 9 12 14


Visualize MARA features
IC 1, p-artifact = 0.99
IC 2, p-artifact = 0.83
IC 3, p-artifact = 0.80
IC 4, p-artifact = 0.61
IC 5, p-artifact = 0.02
IC 6, p-artifact = 0.39
IC 7, p-artifact = 0.03
IC 8, p-artifact = 0.01
IC 9, p-artifact = 0.85
IC 10, p-artifact = 0.06
IC 11, p-artifact = 0.04
IC 12, p-artifact = 0.99
FitError
8-13Hz
lambda
Local Skewness
Range in Pattern
Current Density Norm
Visualize MARA features
IC 13, p-artifact = 0.04
IC 14, p-artifact = 0.92
IC 15, p-artifact = 0.30


MARA on dataset: re-ref_mara2
IC1 - Artifact?
IC2 - Artifact?
IC3 - Artifact?
IC4 - Artifact?
IC5 - Artifact?
IC6 - Artifact?
IC7 - Artifact?
IC8 - Artifact?
IC9 - Artifact?
IC10 - Artifact?
IC11 - Artifact?
IC12 - Artifact?
IC13 - Artifact?
IC14 - Artifact?
IC15 - Artifact?
Artifact Probability = 0.99
Artifact Probability = 0.83
Artifact Probability = 0.80
Artifact Probability = 0.61
Artifact Probability = 0.02
Artifact Probability = 0.39
Artifact Probability = 0.03
Artifact Probability = 0.01
Artifact Probability = 0.85
Artifact Probability = 0.06
Artifact Probability = 0.04
Artifact Probability = 0.99
Artifact Probability = 0.04
Artifact Probability = 0.92
Artifact Probability = 0.30
Hz
Cancel
OK

After removal:



Different types of artefacts in the first 16 seconds are identified as noise and has been removed. This is more faster and easier noise identification with more support.