June 2023

Faculty of Engineering of
University of Porto

IEEE
University of Porto - Student Branch

Unraveling the Mysteries of the Brain: Exploring Visual Event-Related Potentials (ERPs)

José Almeida

Miguel Rocha

Manuel Fortunato

Pedro Ferreira

Index

I Project Introduction

EEG inside a fMRI machine

Some studies have already been conducted to measure the degradation of the EEG inside fMRI

Our Goal

Understanding if there are differences in the cognitive process when the patient is inside the fMRI machine

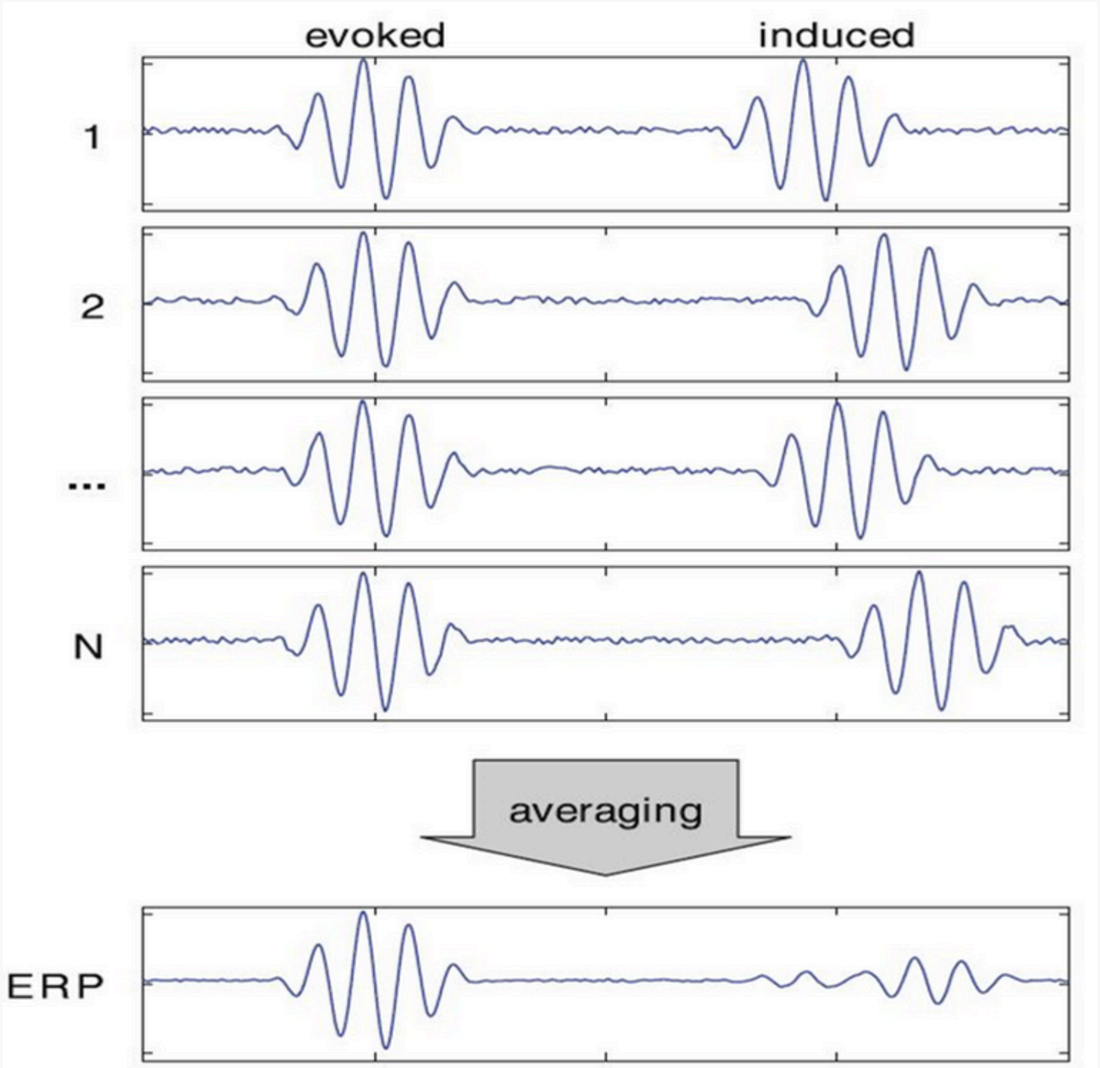
How?

Analyzing the EEG signal in different situations;

- Sitting
- Sitting with sounds
- Lying inside fMRI
- Lying inside fMRI with sounds

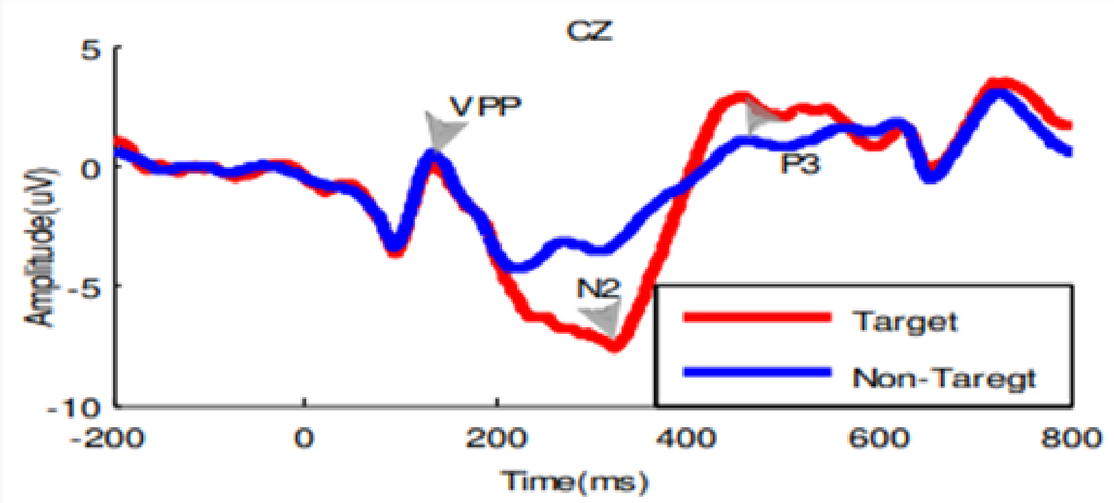
ERP : Event-Related Potentials

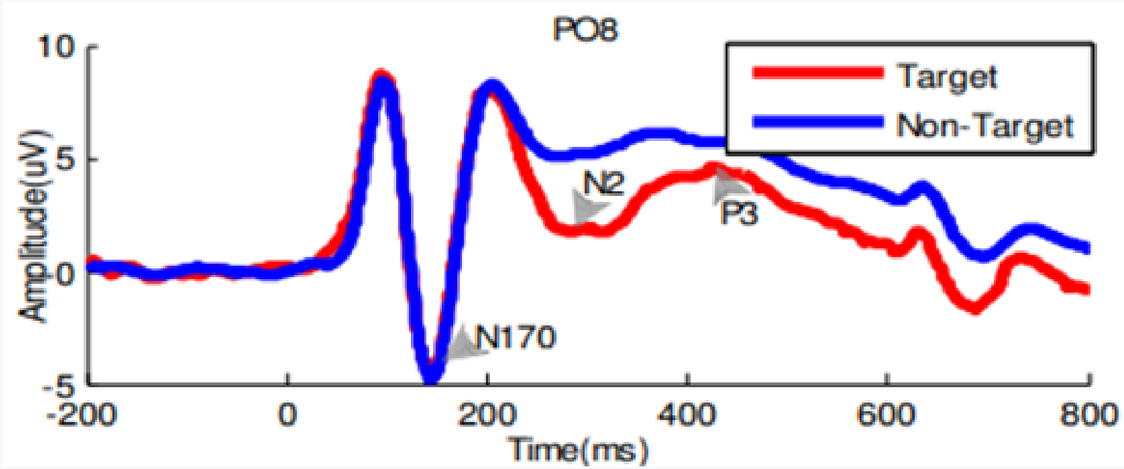
- Electrical brain responses that can be measured using EEG;
- Linked in time to specific events or stimuli;
- Used to study cognitive process and brain function;
- Labeled based on their polarity and time.



ERP's components

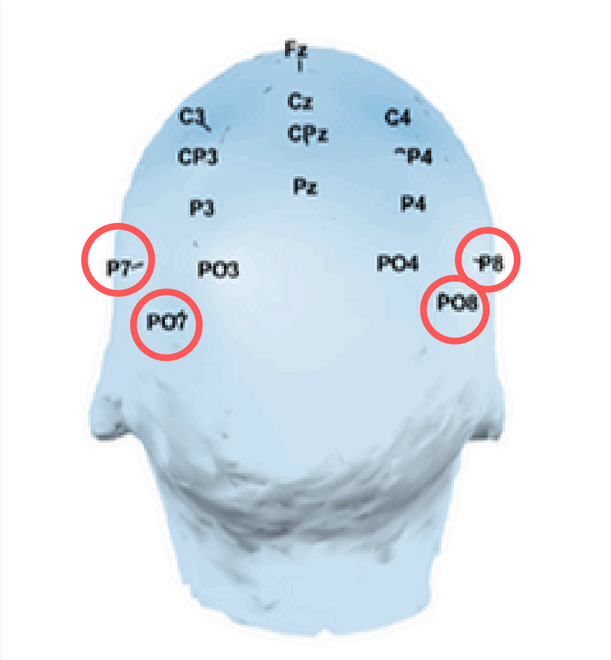
- N170
- VPP
- N2
- P300

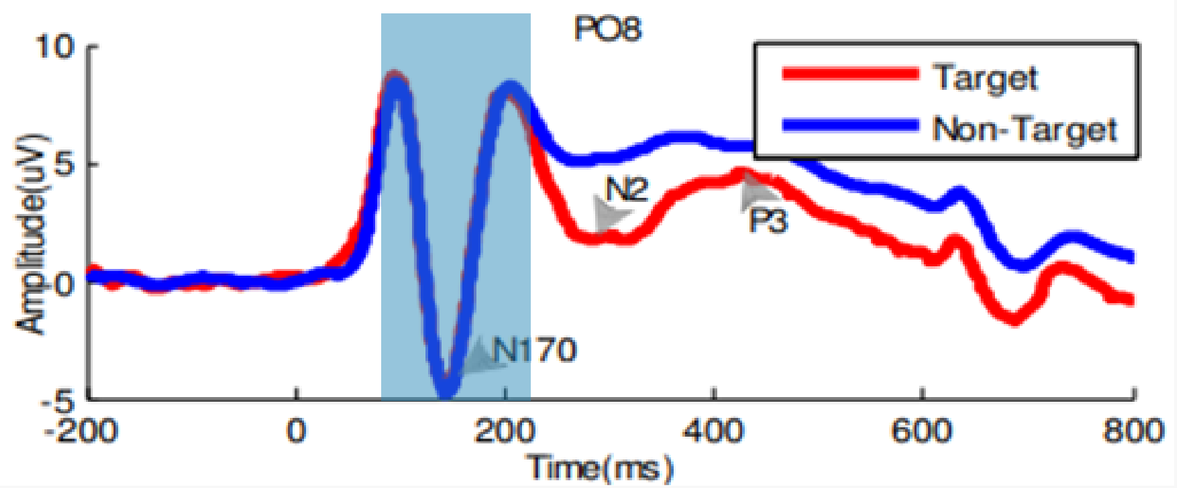




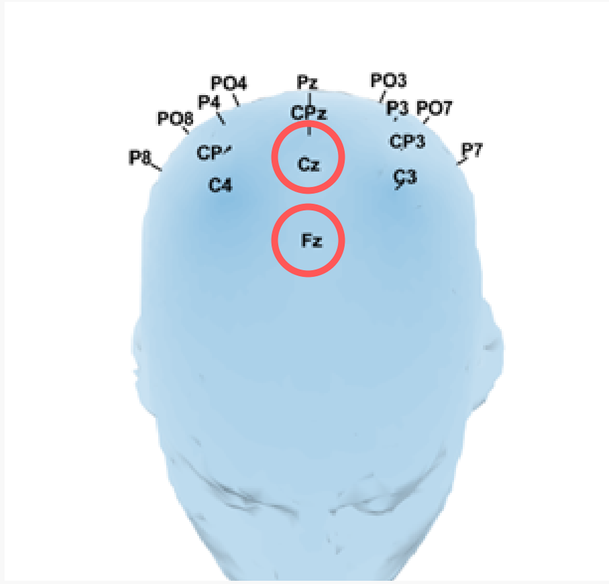
N170

- Negative waveform
- 140ms to 200ms latency
- Face-sensitive
- Higher amplitude regarding faces stimuli
- Lateral-posterior distribution

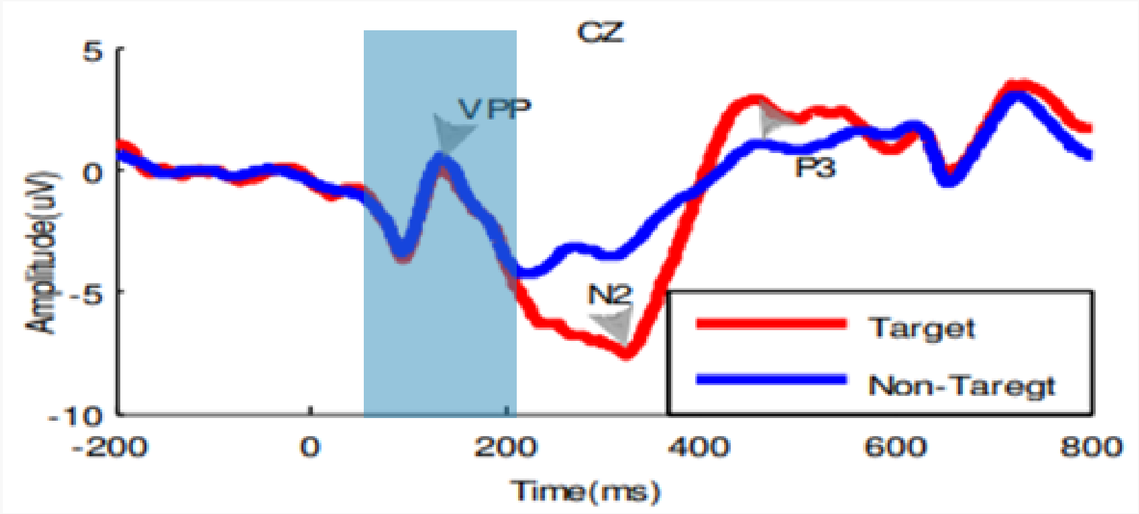




VPP

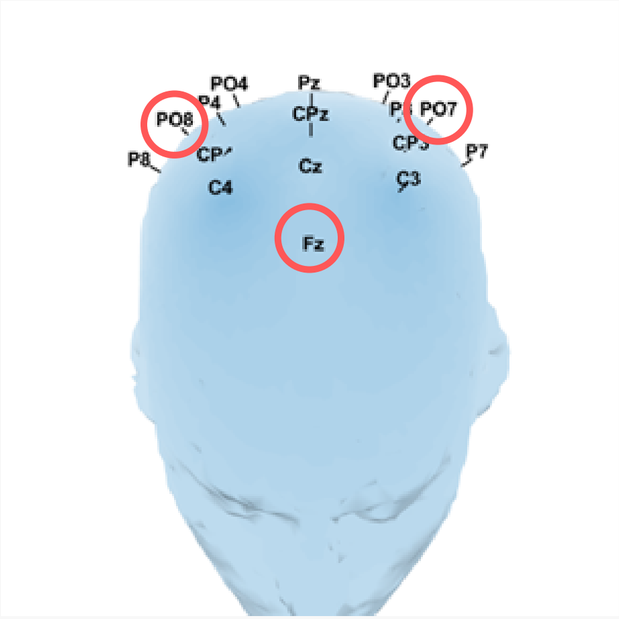


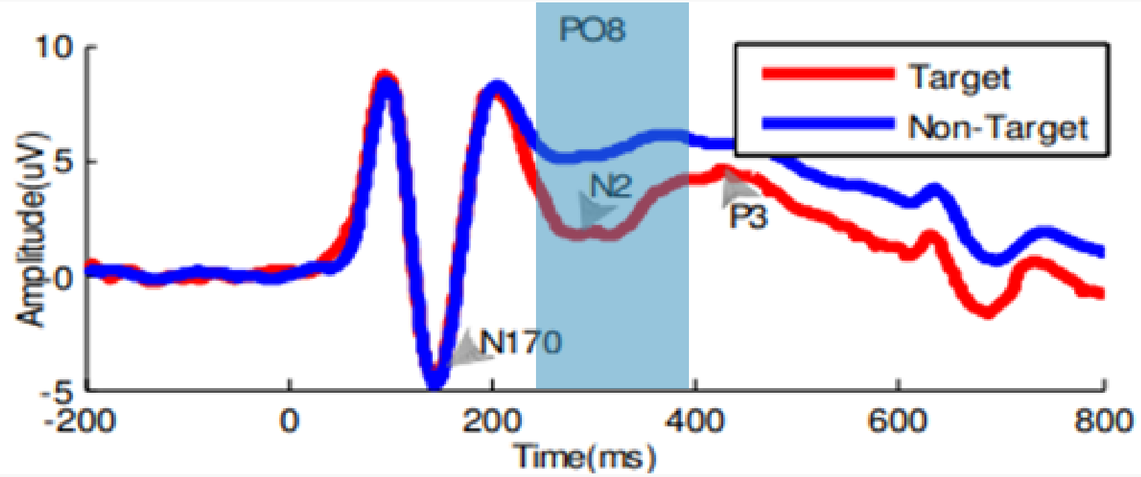
- N170 positive Counterpart
- 140ms to 200ms latency
- N170 and VPP responses are associated
- Medial zone distribution



N2

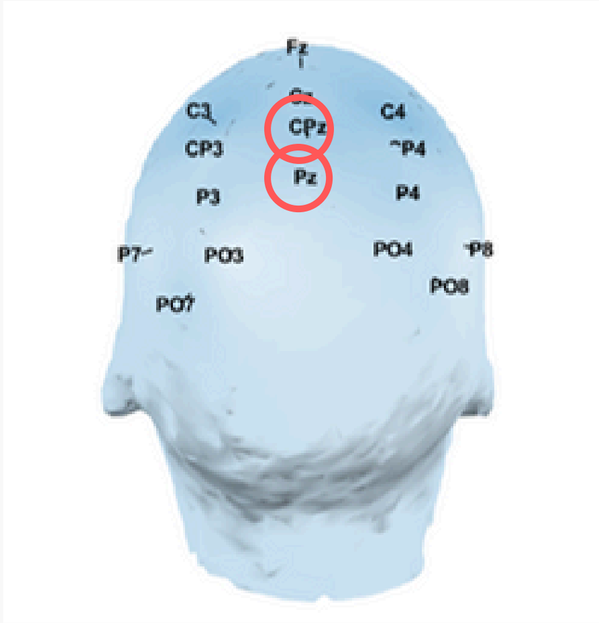
- Negative waveform
- 200ms to 350ms latency
- Studied in oddball paradigm
- Rare, inexpected or deviant stimuli
- Ocipital/frontocentral distribution

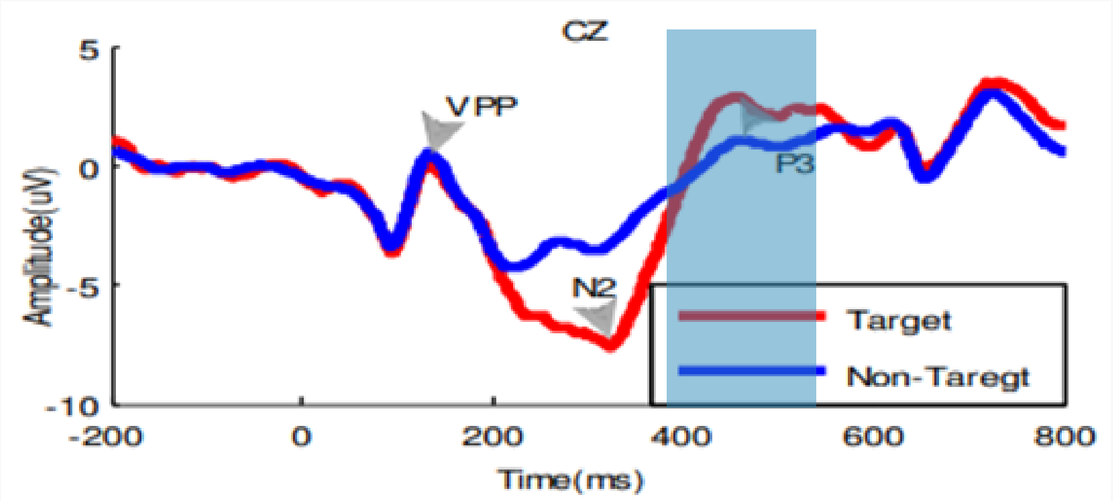




P300

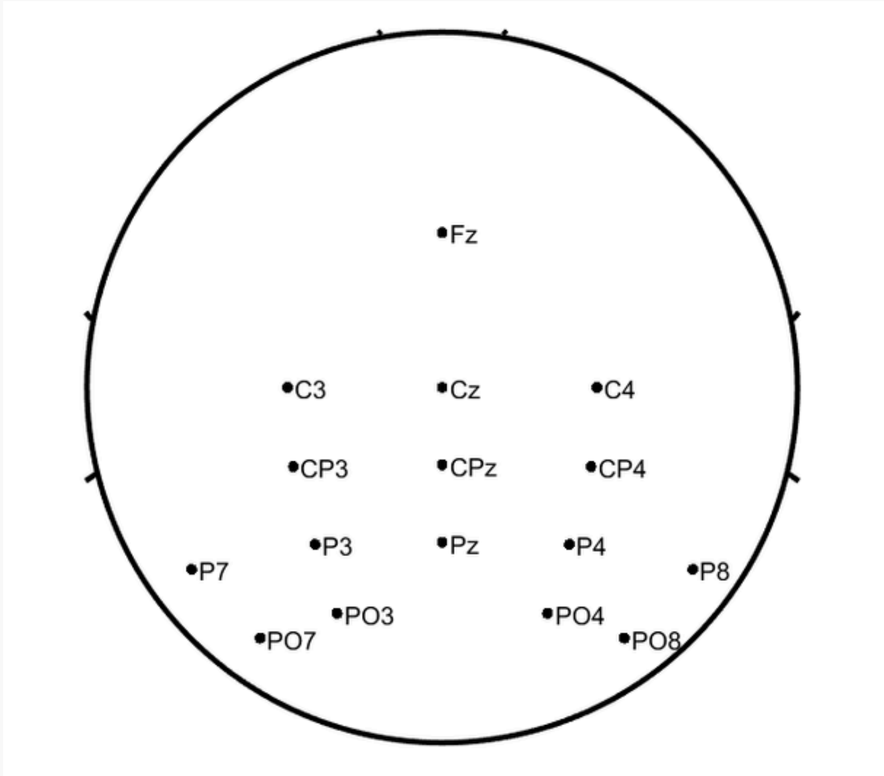
- Positive waveform
- 220ms to 380ms latency
- Studied in oddball paradigm
- Amplitude and latency vary with stimuli' salience, attention, task demands
- Parietal/centroparietal distribution





Electrode Selection

2D Channel Location



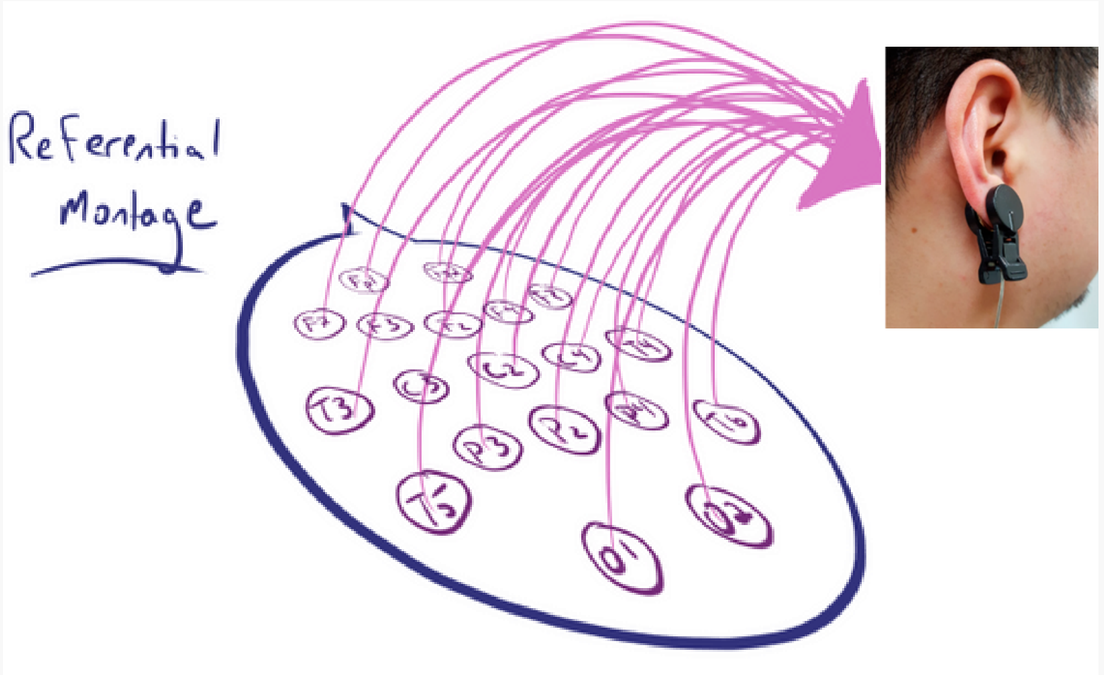
16 Electrodes with special focus on the Parietal-Occipital region, associated to the visual paradigm.

EEG Montage

Common Reference: all electrodes are compared to a **reference electrode**

Advantages

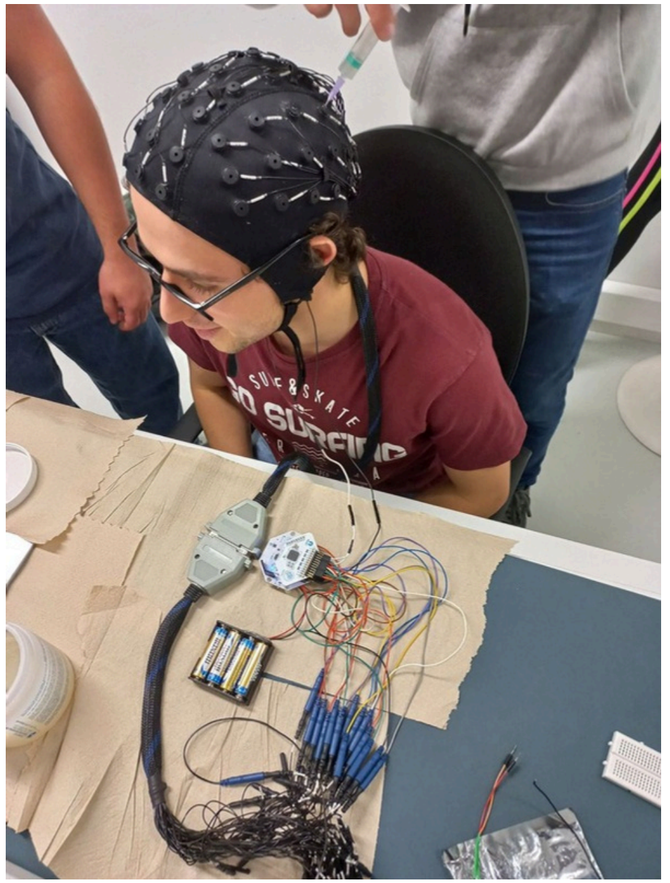
- Simpler
- No phase reversals
- Easier to find maximum amplitude electrodes
- Minimizes abnormalities from distributed brain potentials



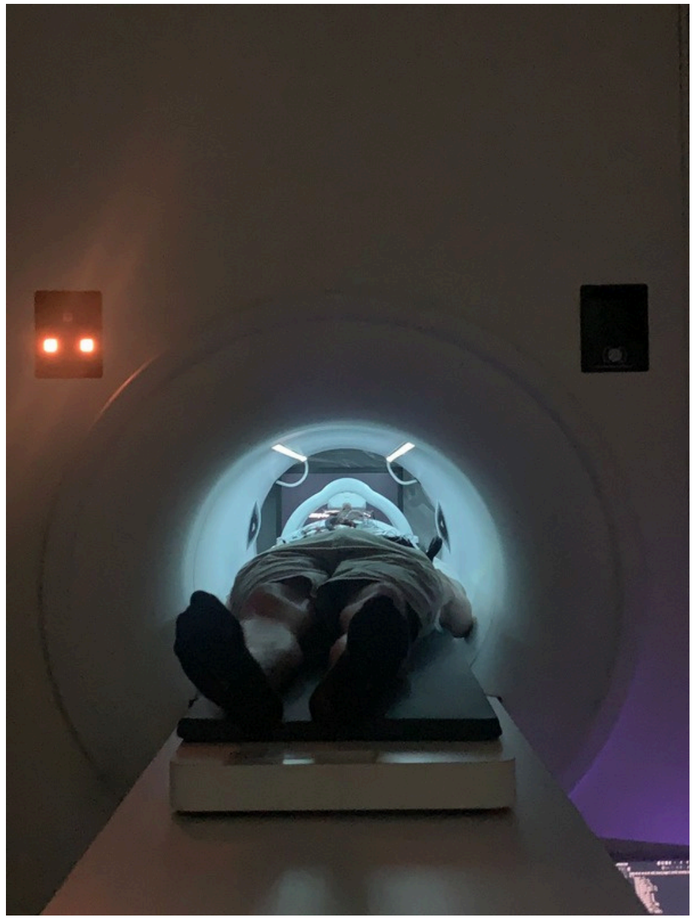
Setup

Materials:

- fMRI simulator
- 64 electrode cap
- Adaptor cables
- Cyton + Daisy
- Dongle
- Photoresistor (+ breadboard circuit)
- Seringe + Electrode gel



fMRI simulator



OpenBCI

OPENBCI

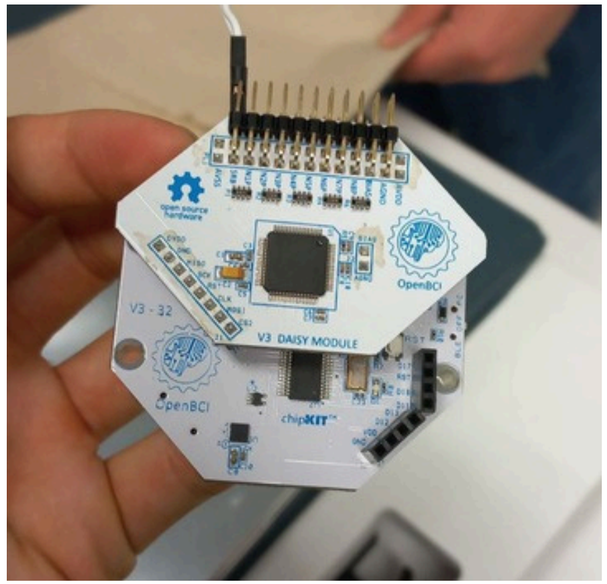
OPENBCI

MISSION

OpenBCI creates open-source tools for biosensing and neuroscience. OpenBCI's mission is to lower the barrier to entry for brain-computer interfacing, while ensuring that these technologies are adopted into the consumer landscape in an ethical way that protects user agency and mental health.

https://openbci.com/about

OpenBCI

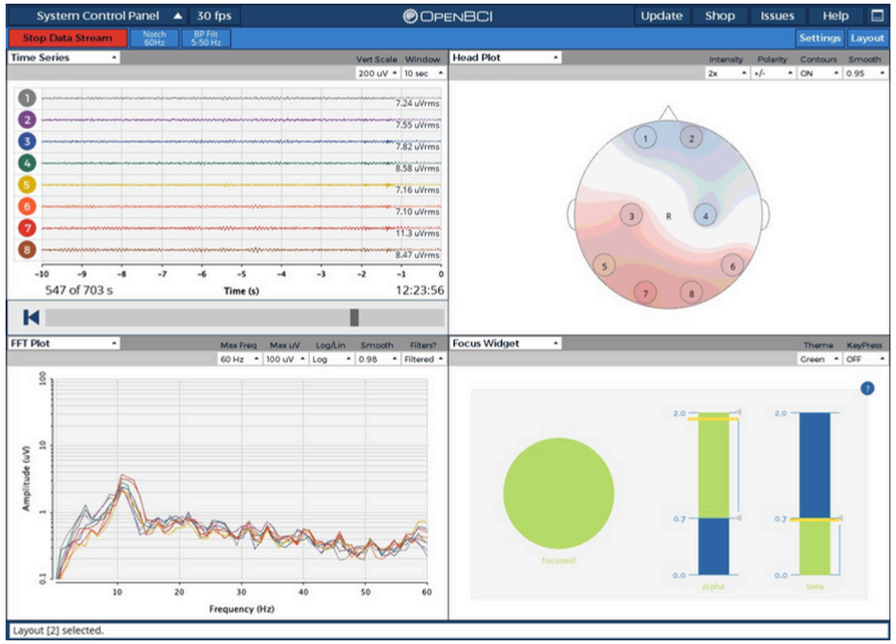


Cyton + Daisy
Biosensing Boards

- Cyton is the main microcontroller
- Daisy is an expansible module
- 16 channels
- EEG, EMG, and ECG
- Wireless communication (dongle)
- Sampling Frequency of 125 Hz
- 24-bit channel data resolution
- Pre-loaded with OpenBCI firmware

OpenBCI

OpenBCI GUI and drivers



BrainFlow Python Libraries

BrainFlow
How Biosensors Work

```python
from brainflow.board_shim import BoardShim, BrainFlowInputParams, BoardIds
from brainflow.data_filter import DataFilter

board_id = BoardIds.CYTON_DAISY_BOARD.value
```

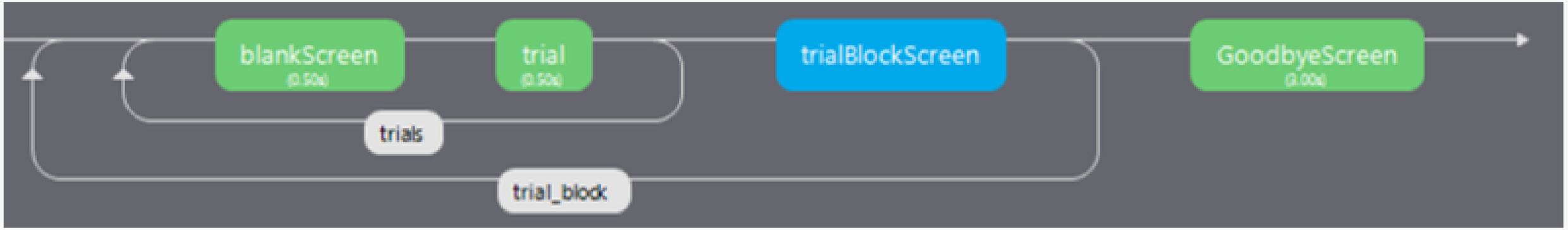
PsychoPy

PsychoPy is a free cross-platform package allowing you to run a wide range of experiments in the behavioral sciences (neuroscience, psychology, psychophysics, linguistics...) with a friendly user interface.

Enables conversion of graphical programming into python code

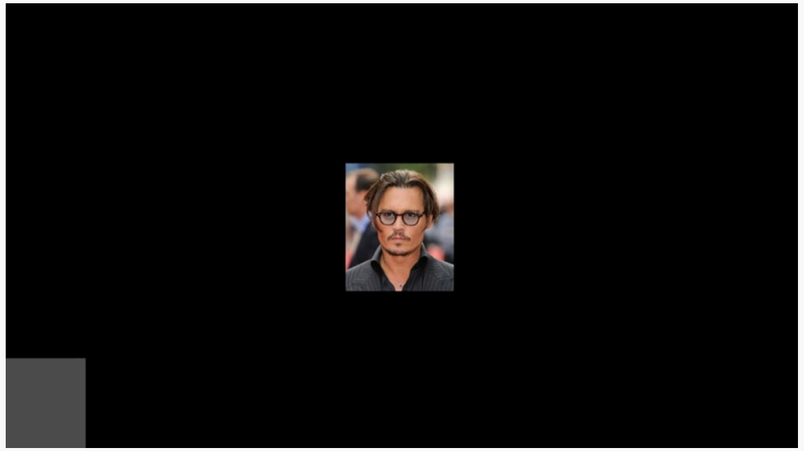
III Methods

Protocol



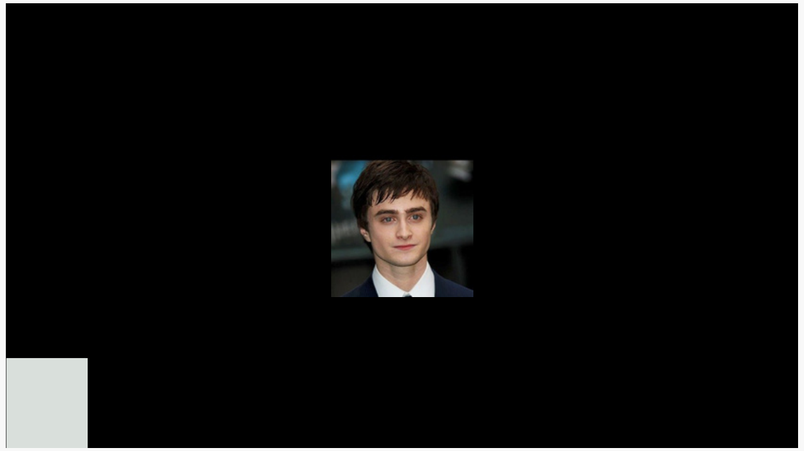
Protocol

Non-target



Blank

Target

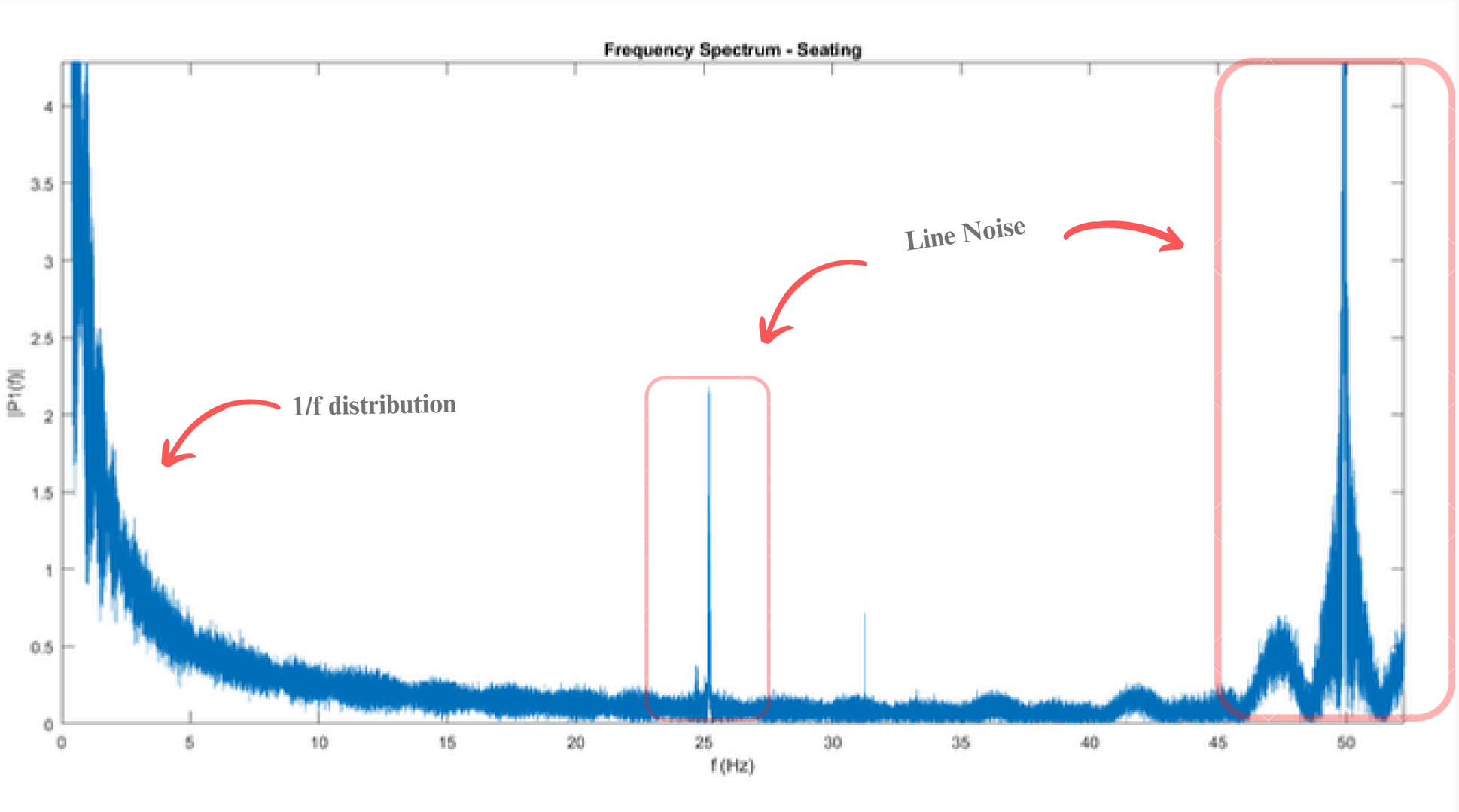


- 10 celebrities with 12 images each
- Complete aquisition: 12 blocks of 120 images each
- Target celebrity appears 10%

Protocol

Pipeline

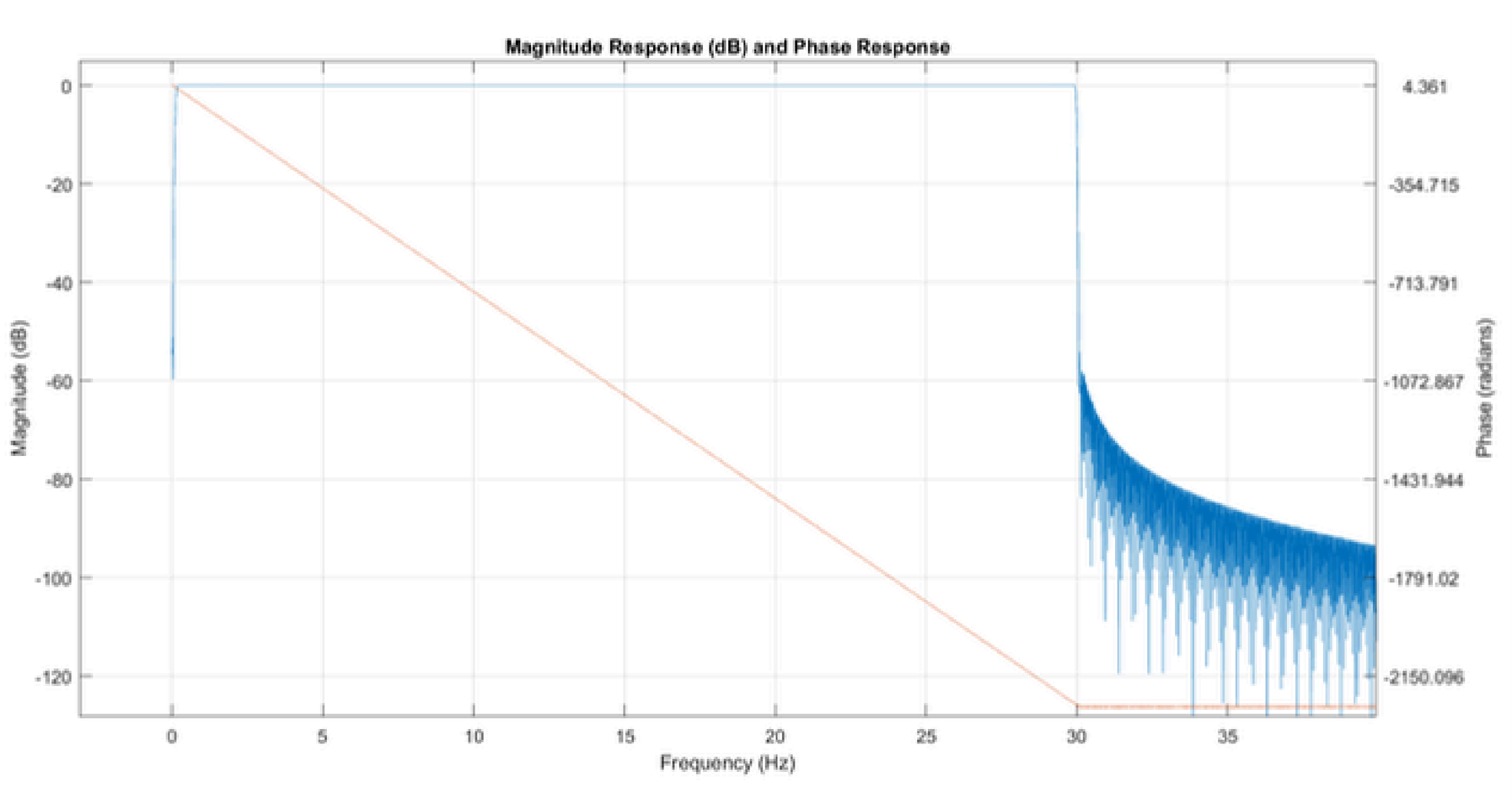
EEG analysis



Pipeline

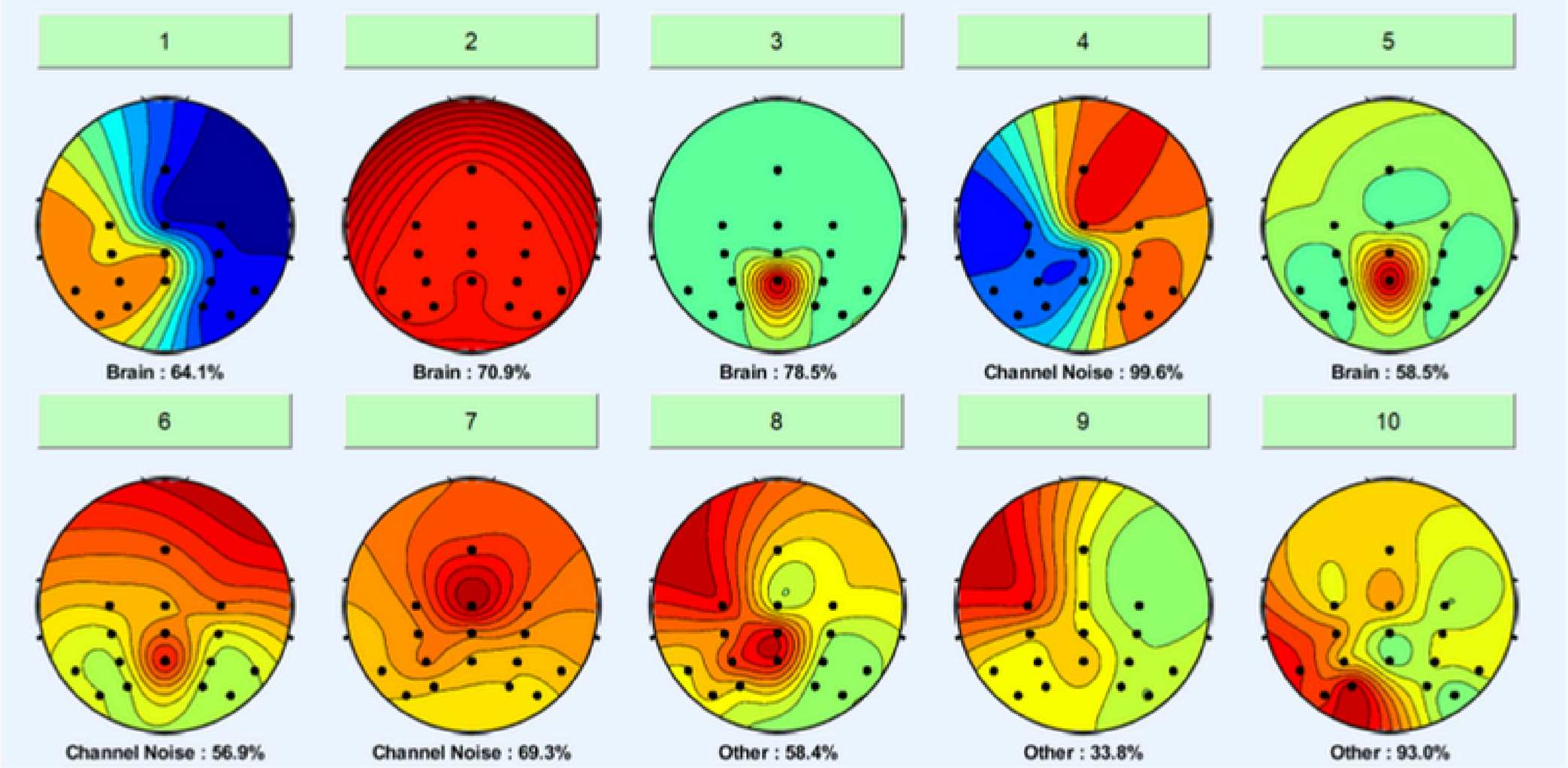
Filtering

FIR | 0.1 - 30 Hz | Hamming | 3000 Order



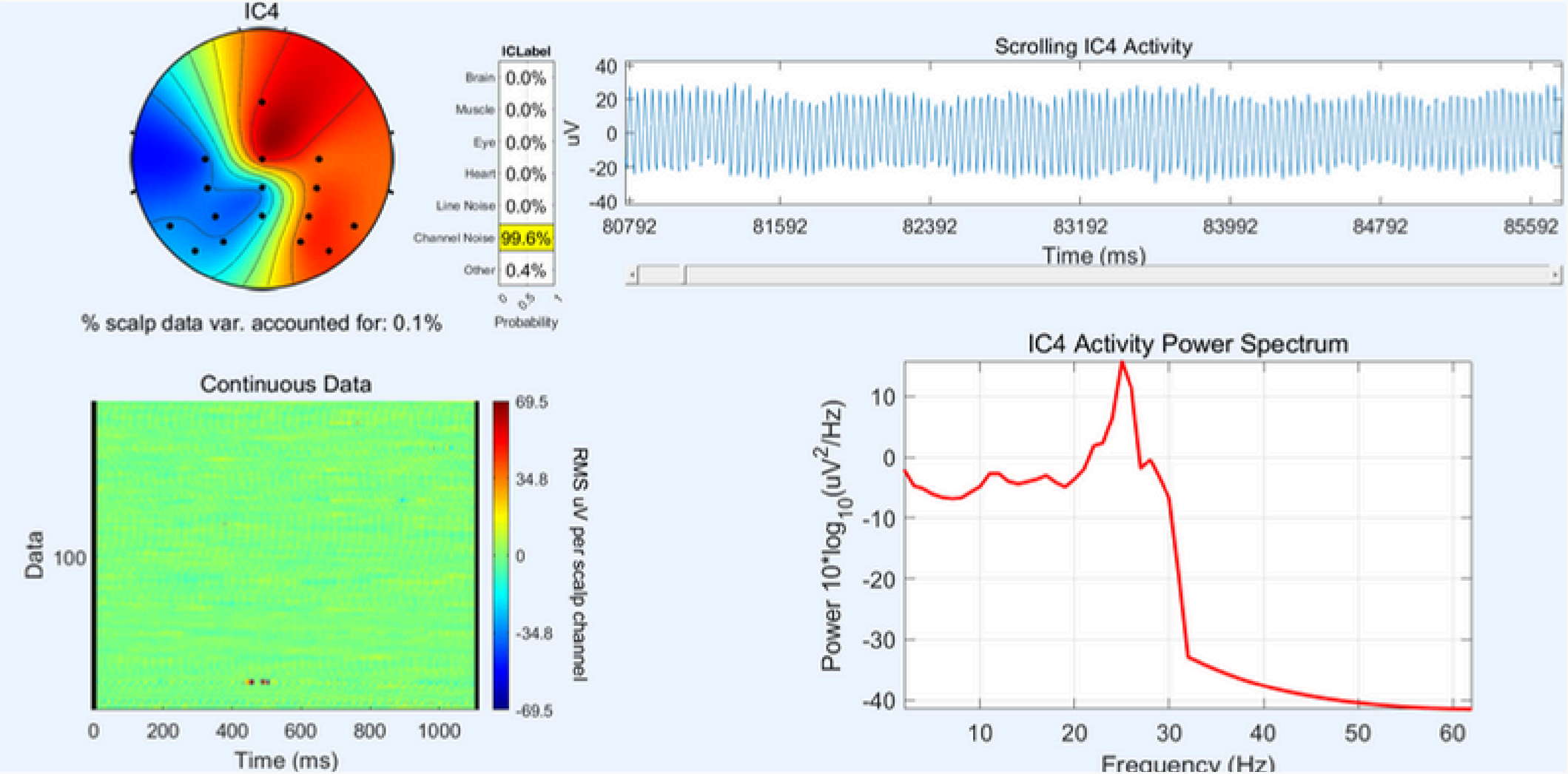
Pipeline

ICA Analysis



Pipeline

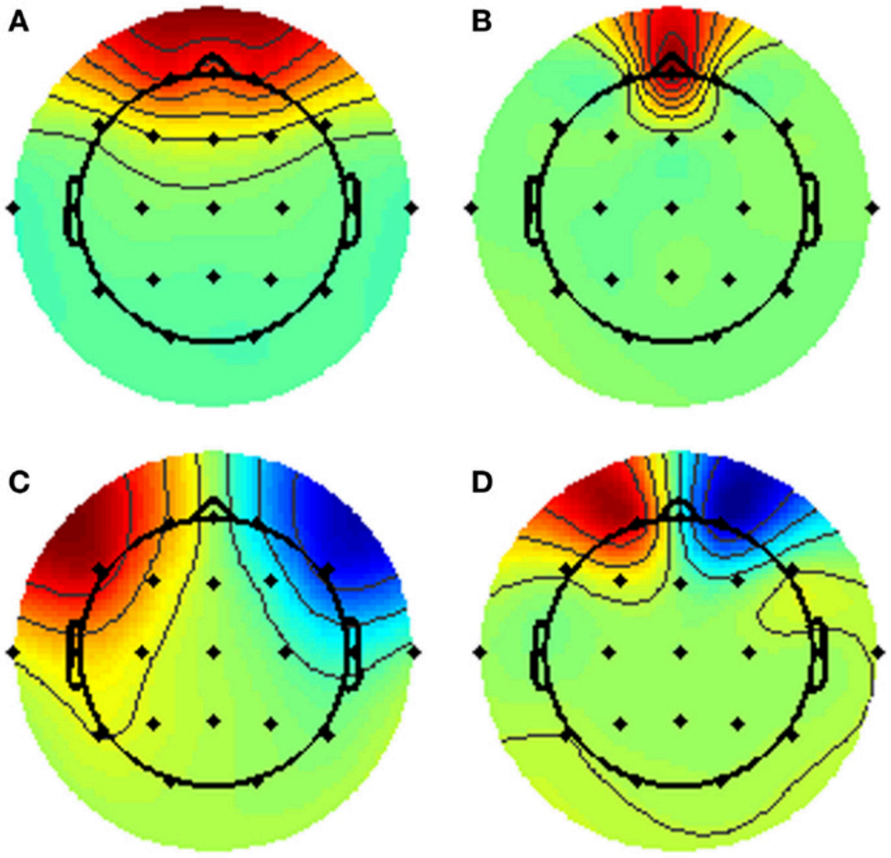
ICA Analysis



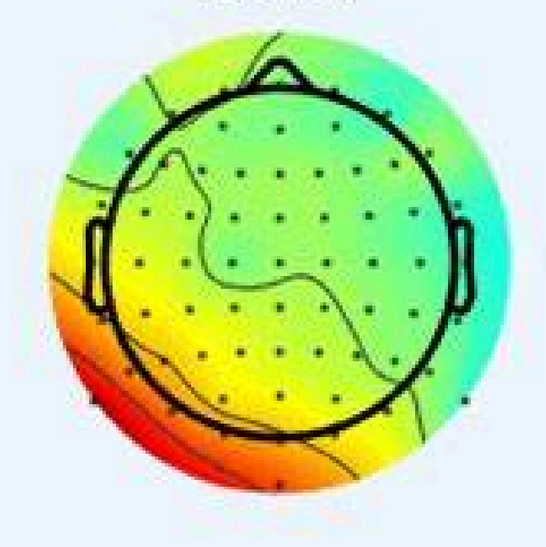
Pipeline

ICA Analysis

EOG

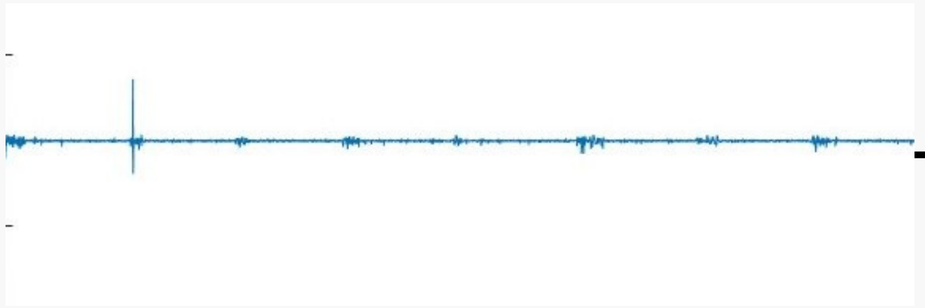


Neck EMG

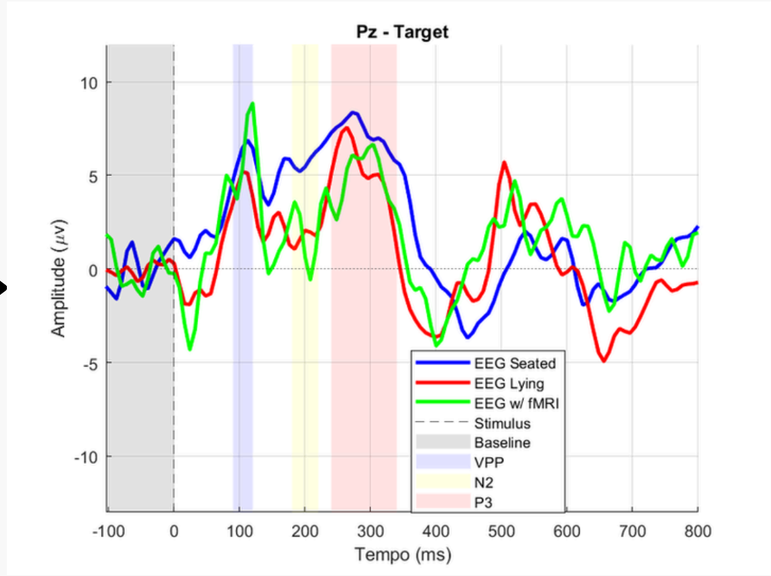


Pipeline

Segmentation



?



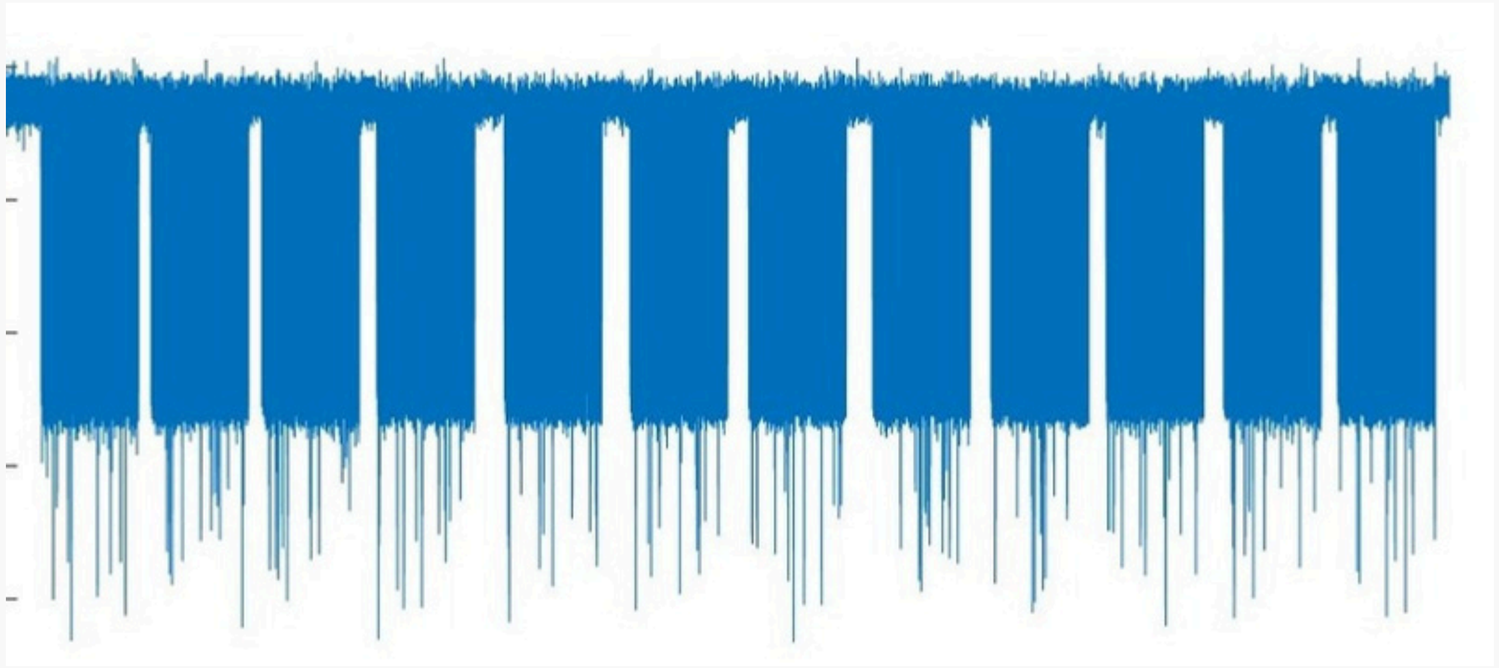
Whole EEG signal

Segmeted EEG signal

Pipeline

Segmentation

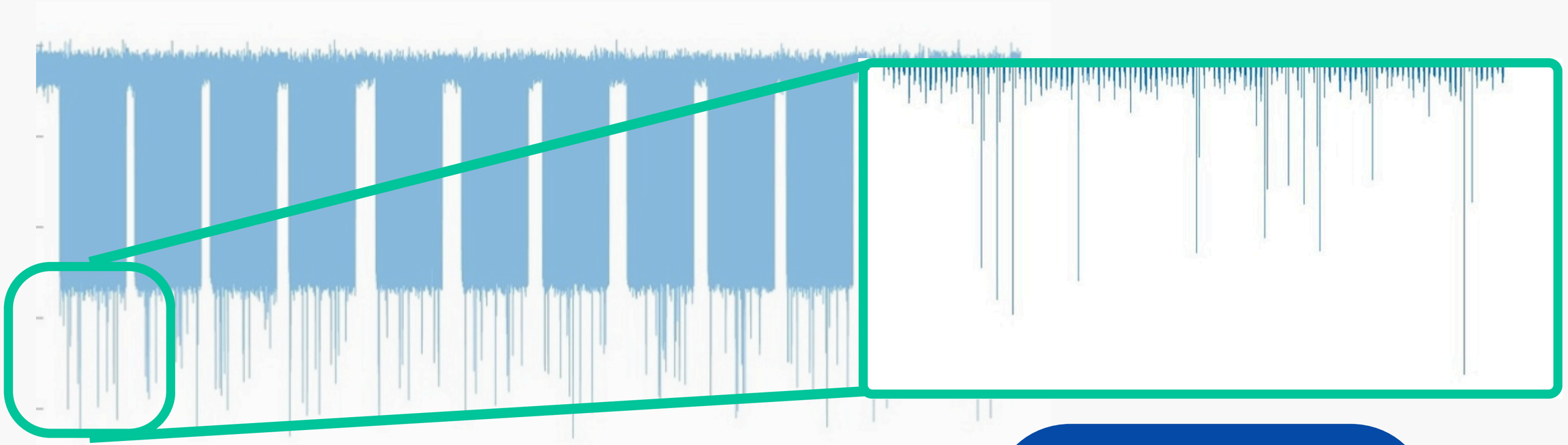
Signal Segmentation



12 Blocks = 12 Trials

Pipeline

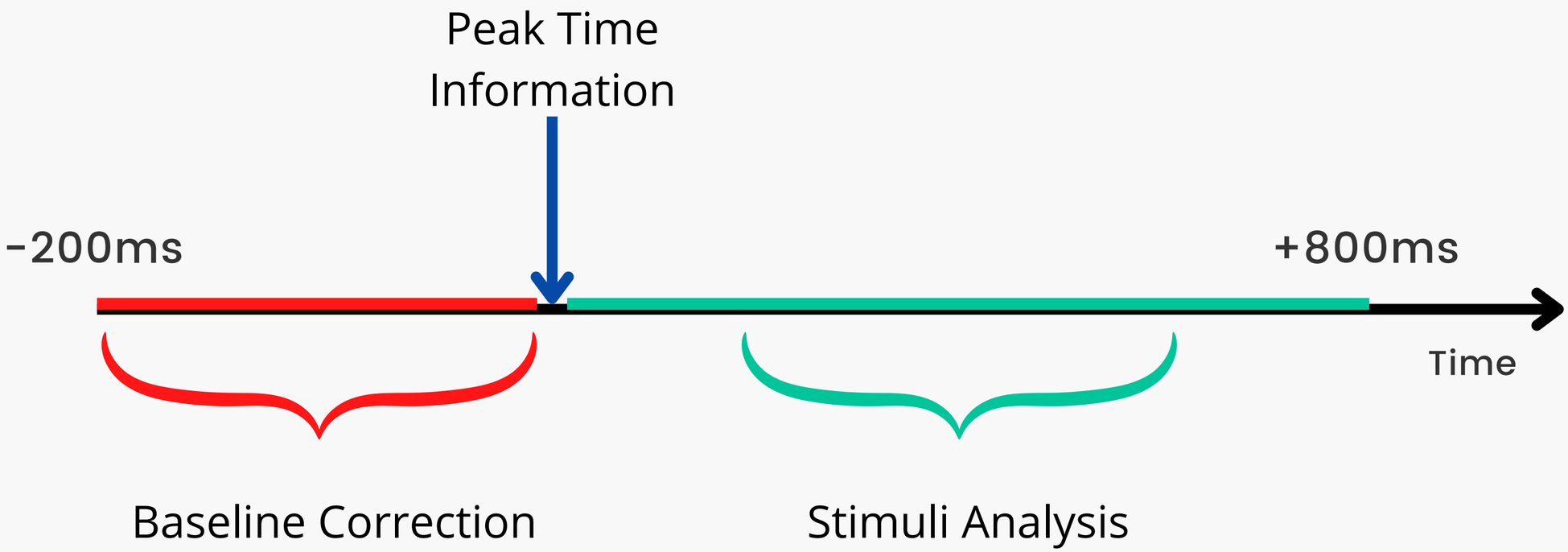
Segmentation



12 Peaks = 12 Targets

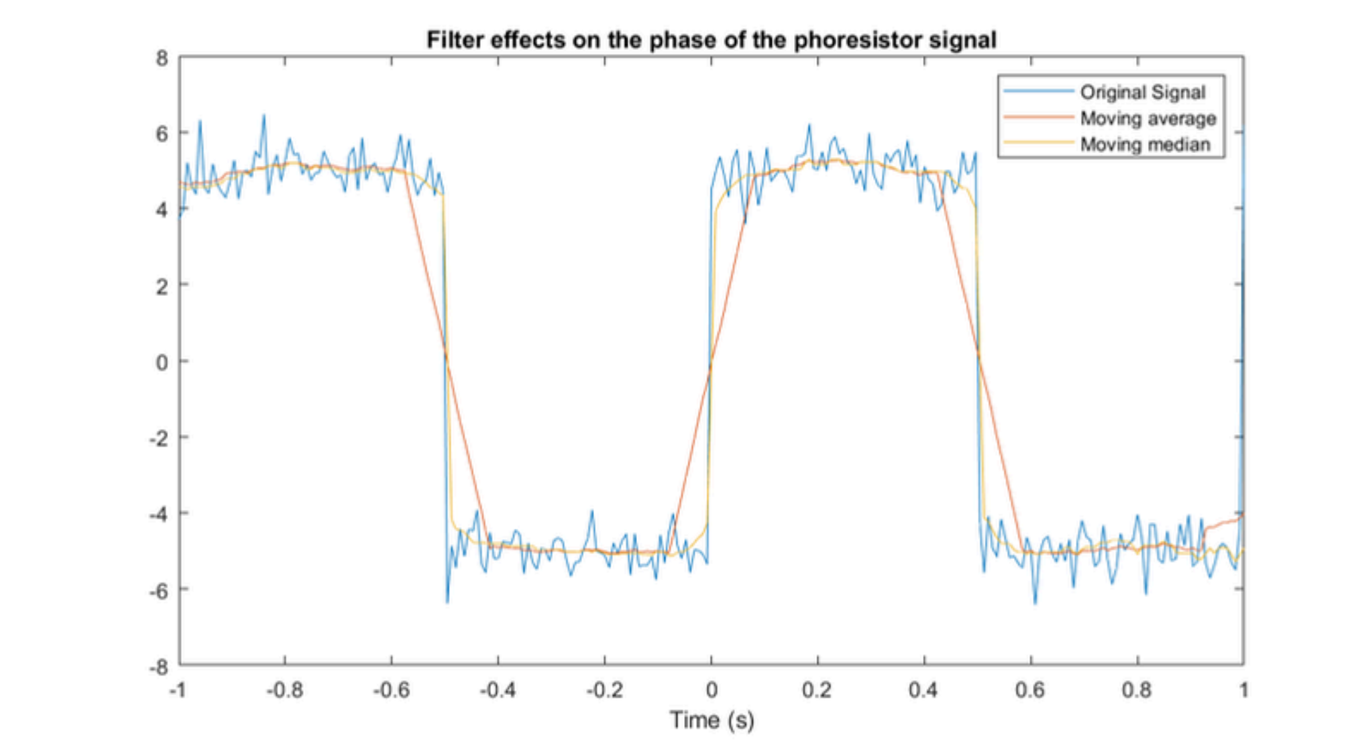
Pipeline

Segmentation



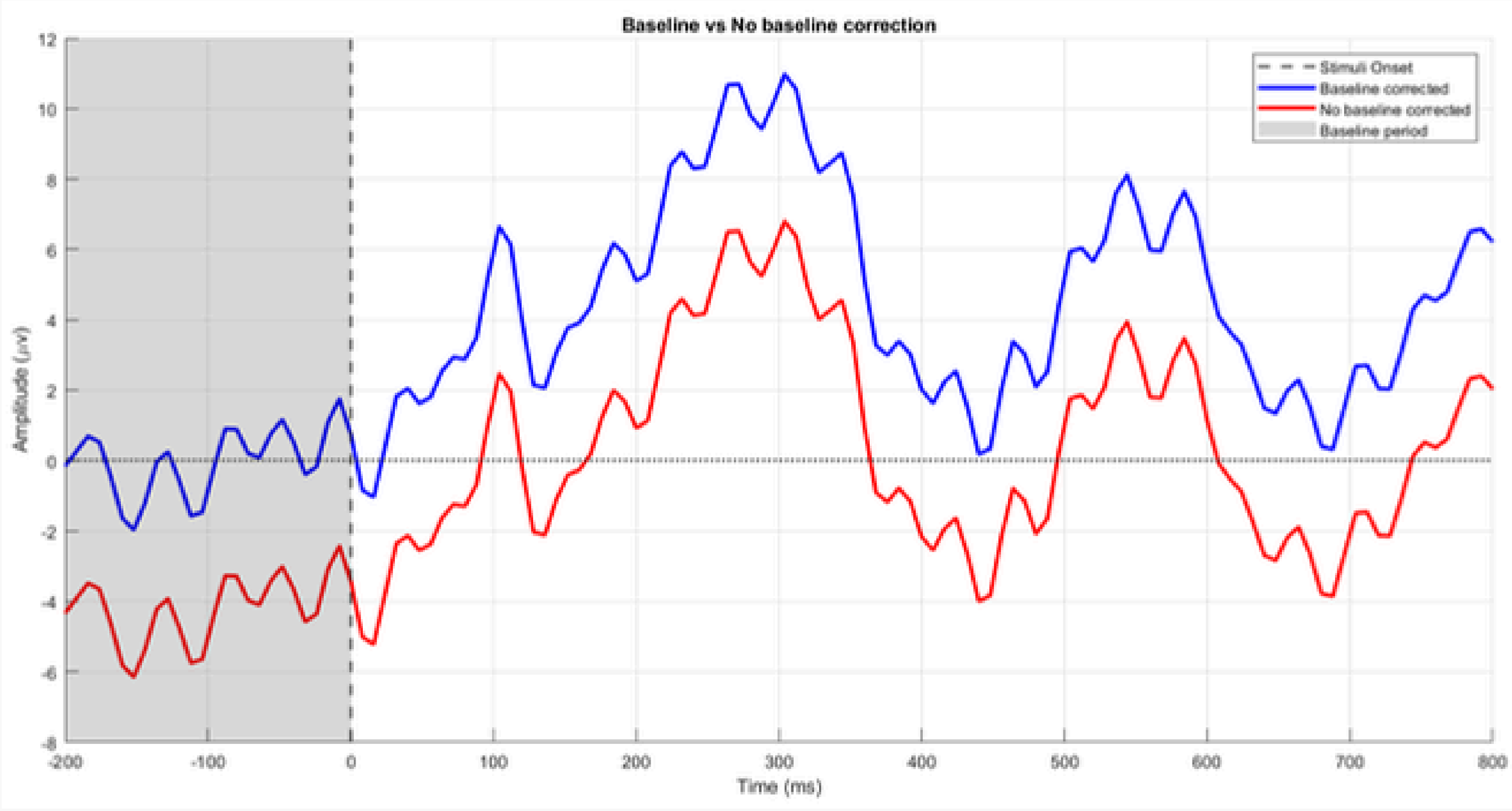
Pipeline

Segmentation



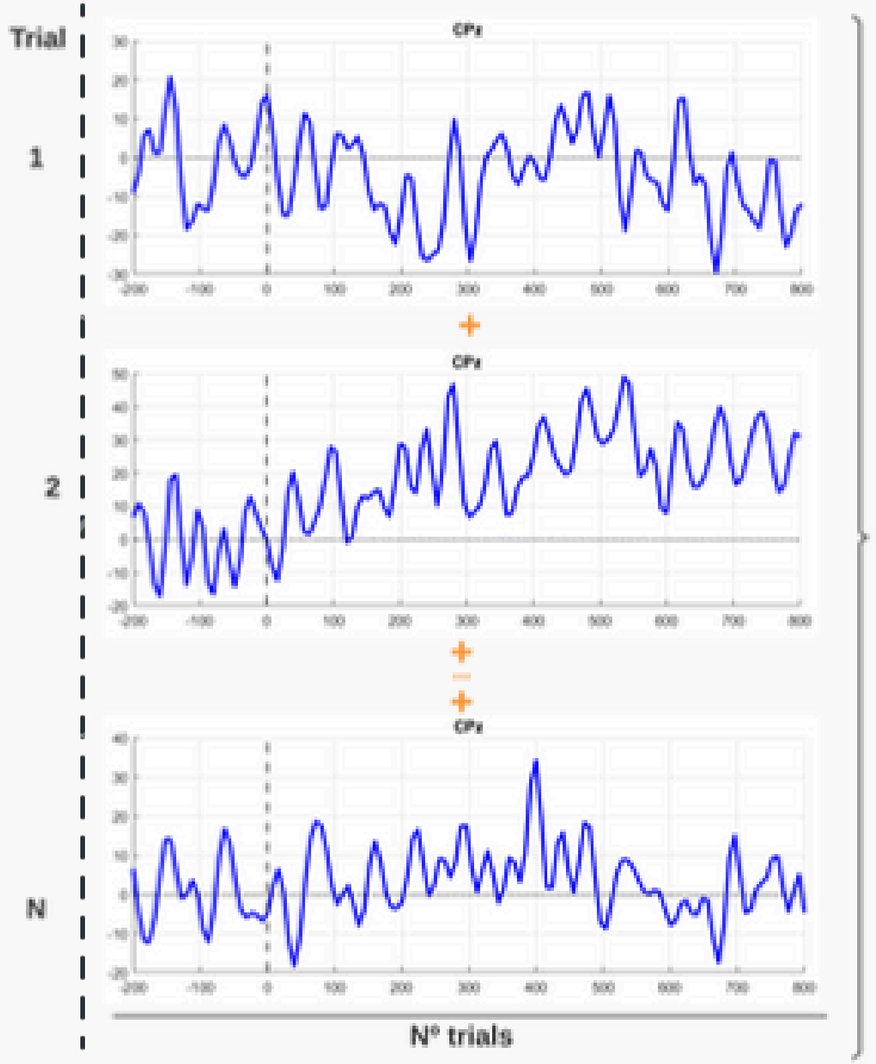
Pipeline

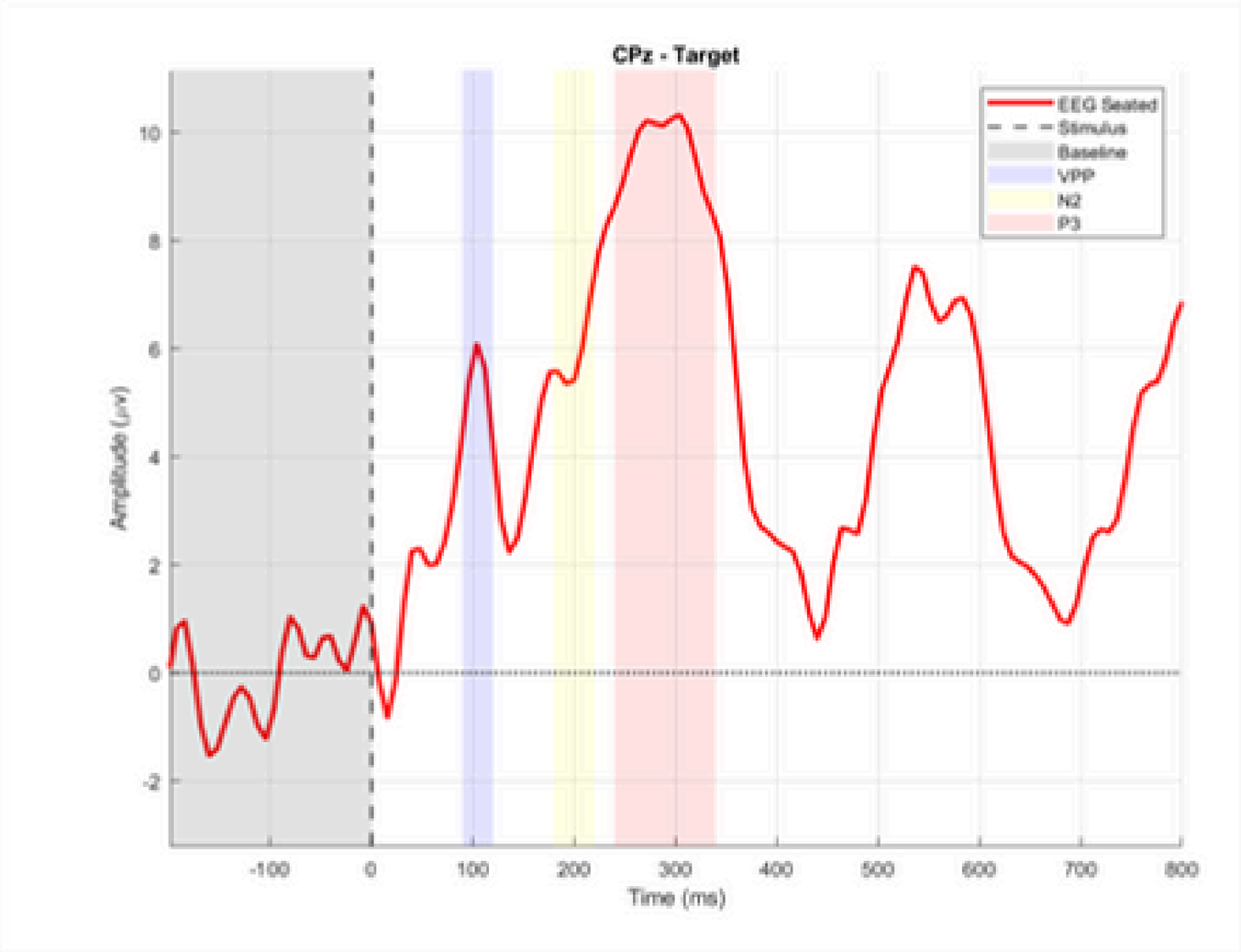
Baseline correction



Pipeline

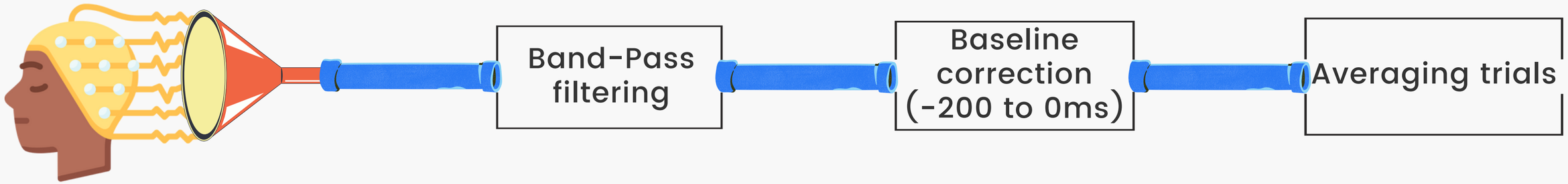
Computing the ERPs

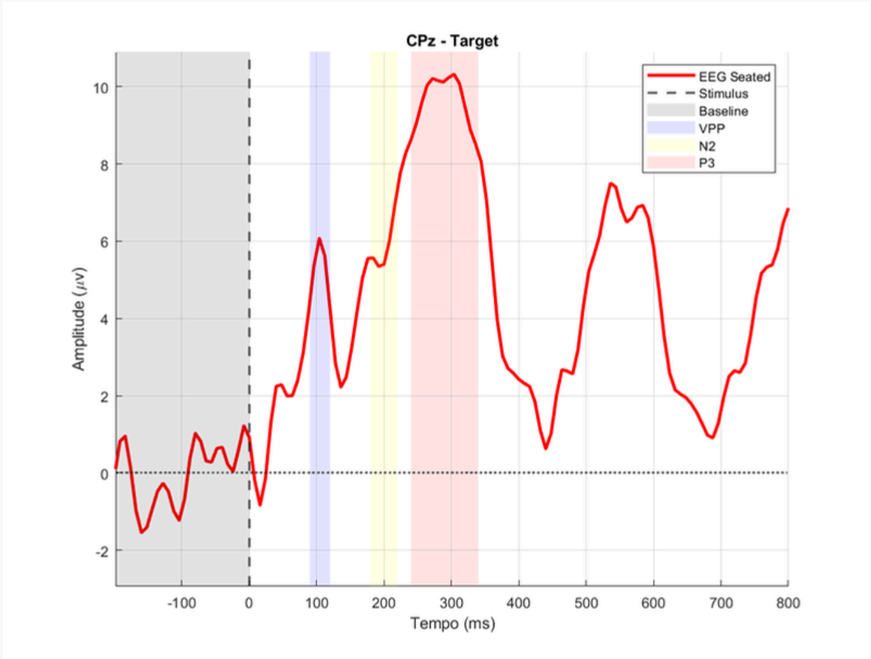




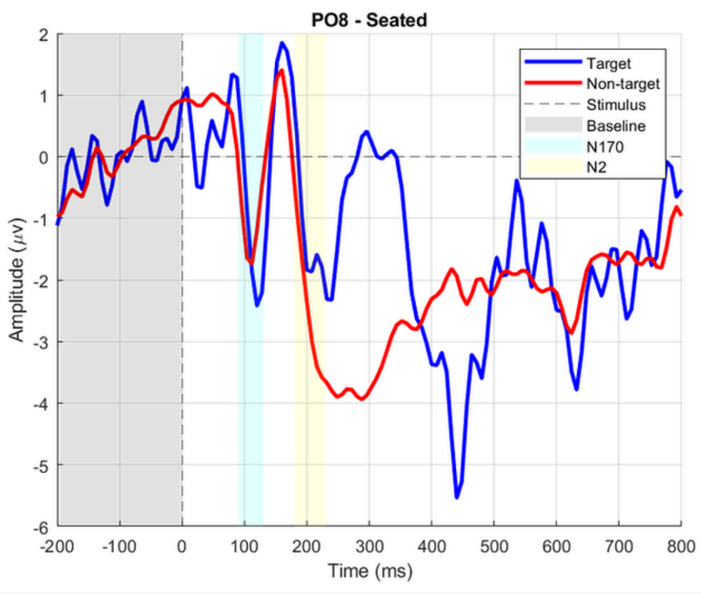
Question

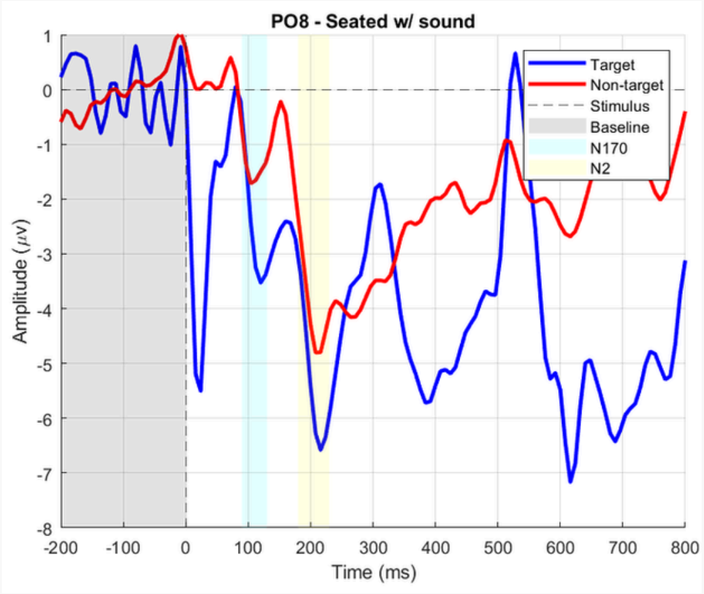
What is expected in the final result if the order of the pipeline is changed

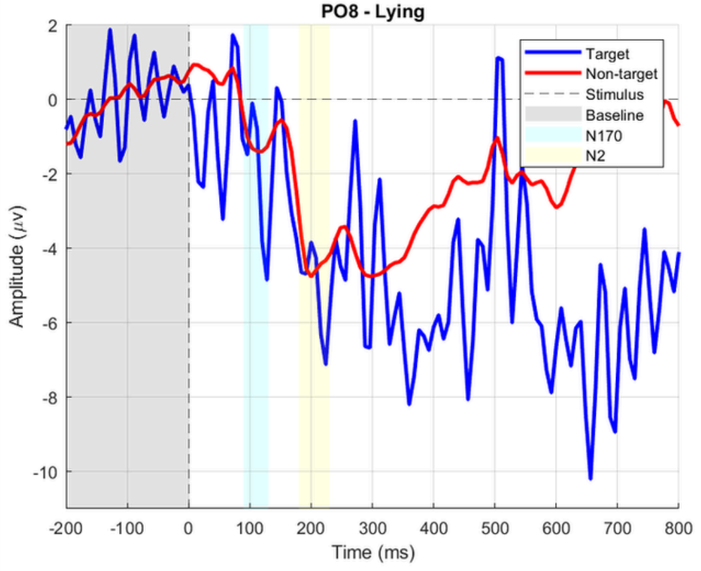


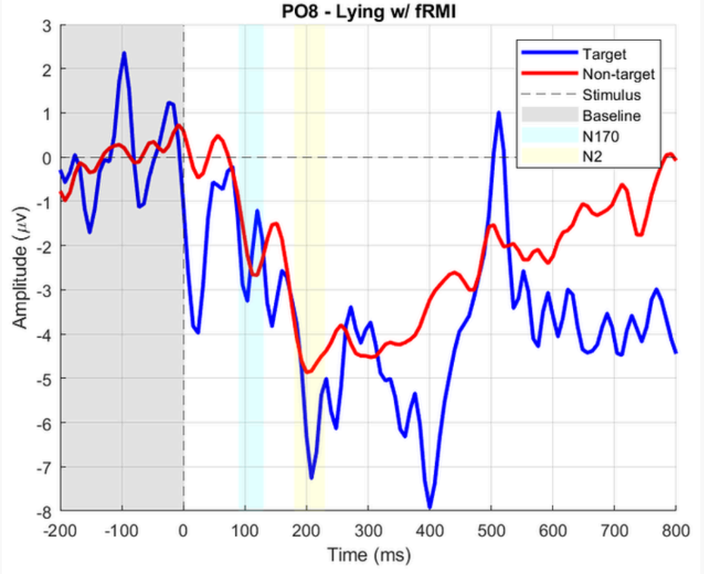


Target vs non-Target N170 - N2

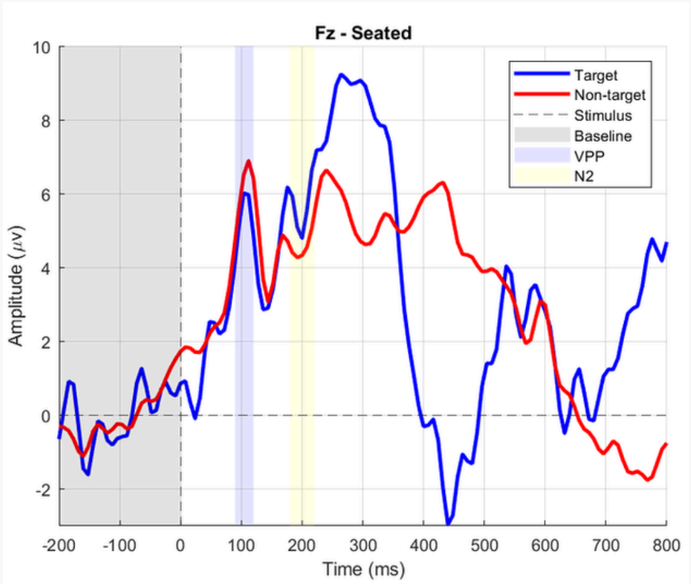


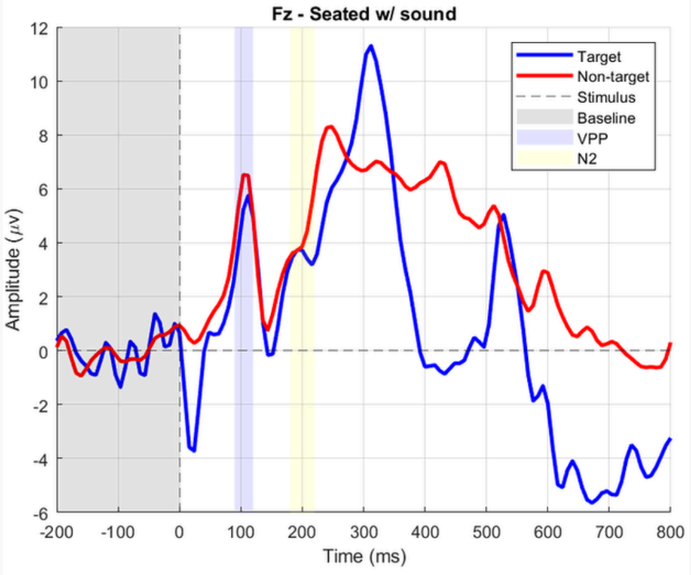


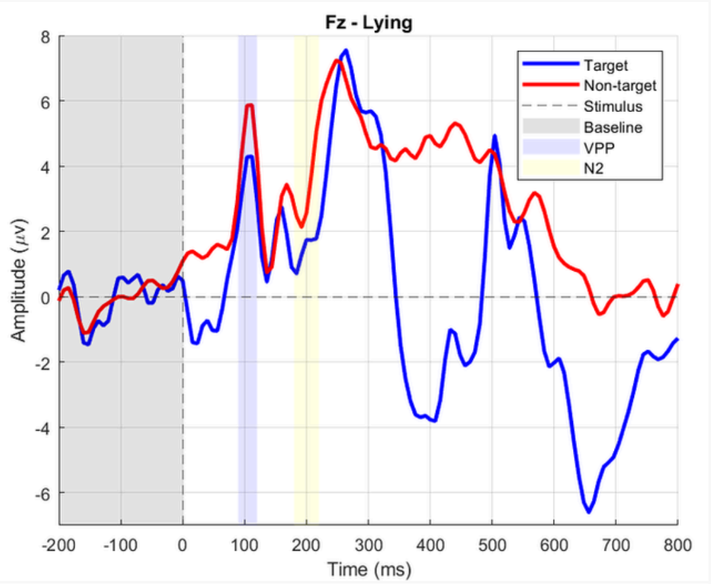


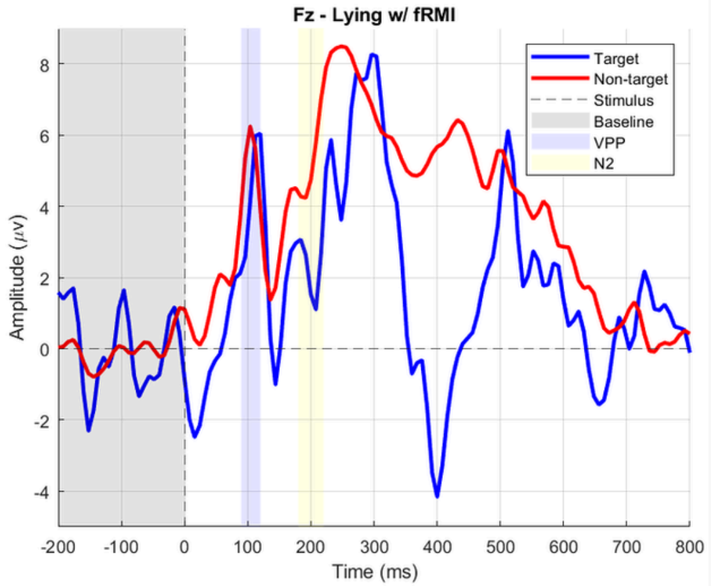


Target vs non-Target VPP - N2

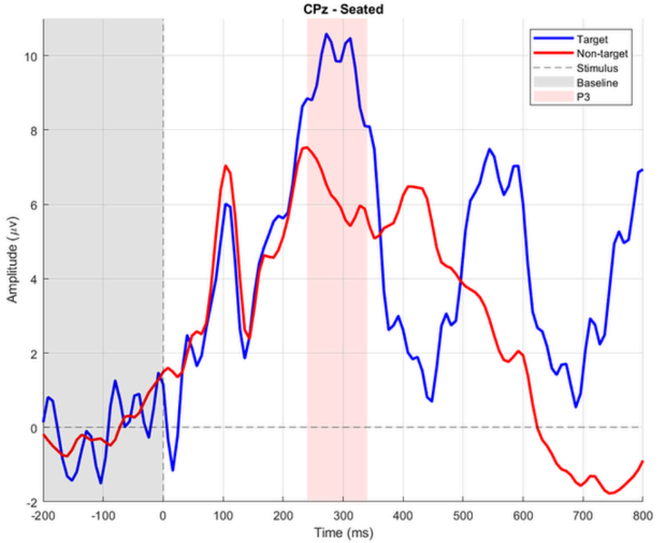


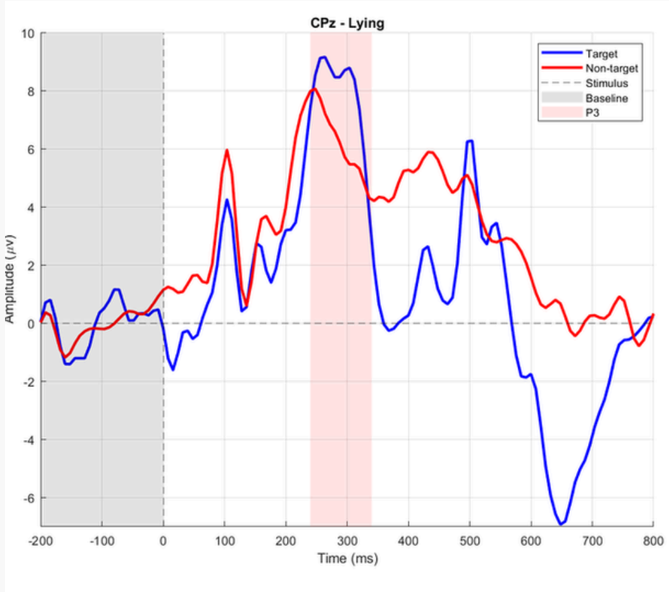


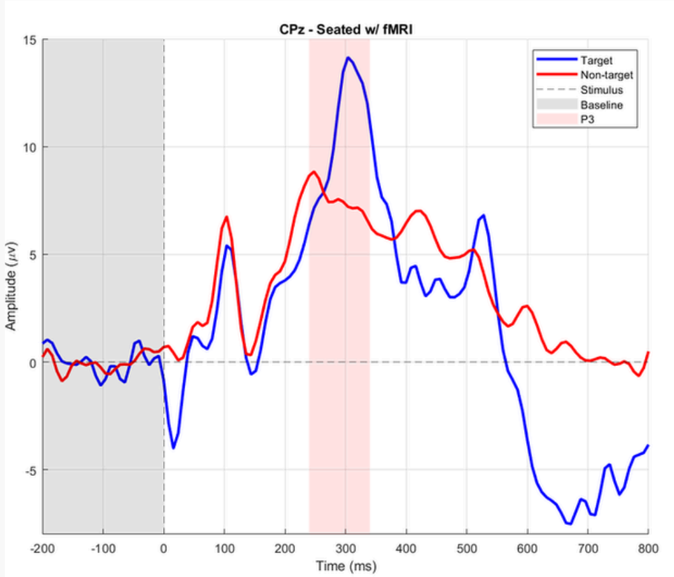


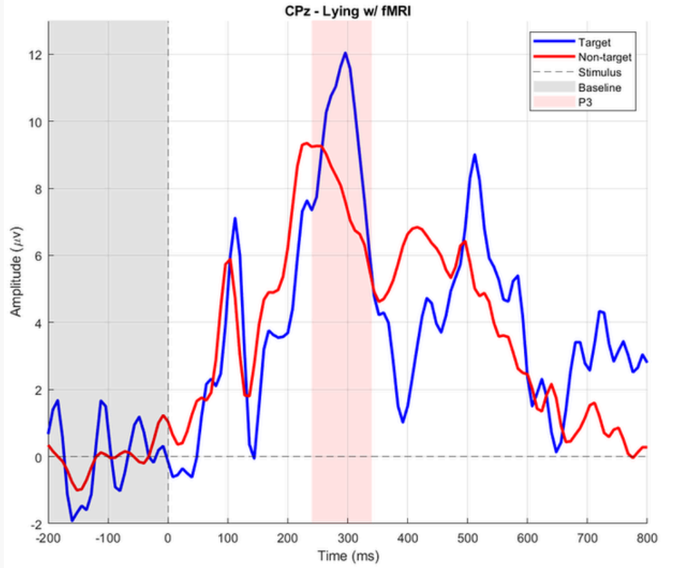


Target vs non-Target P300

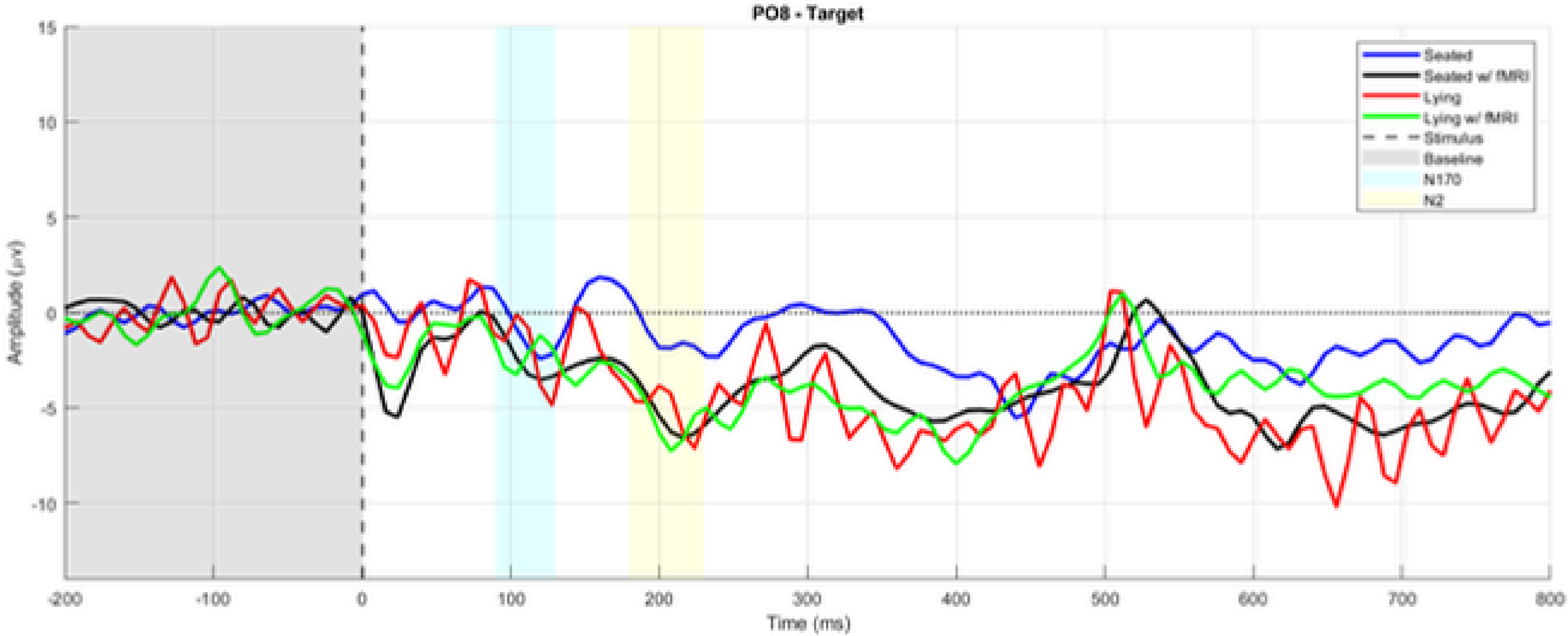




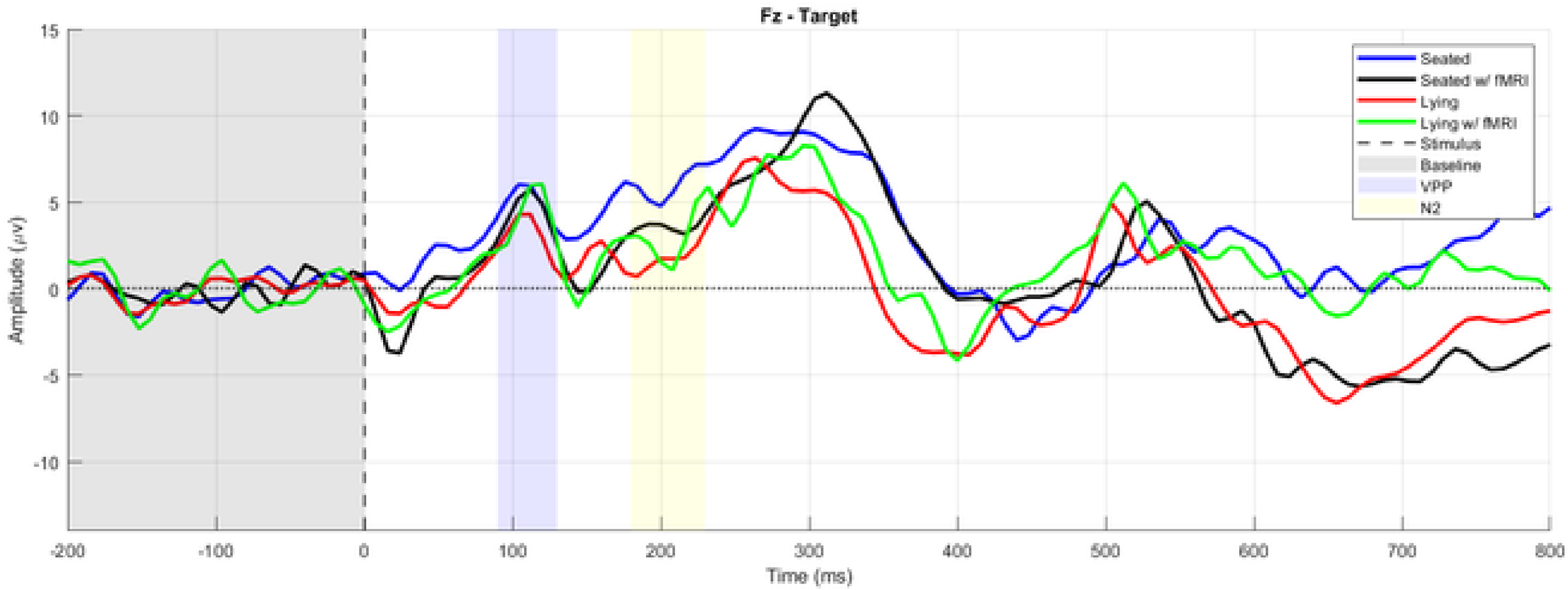




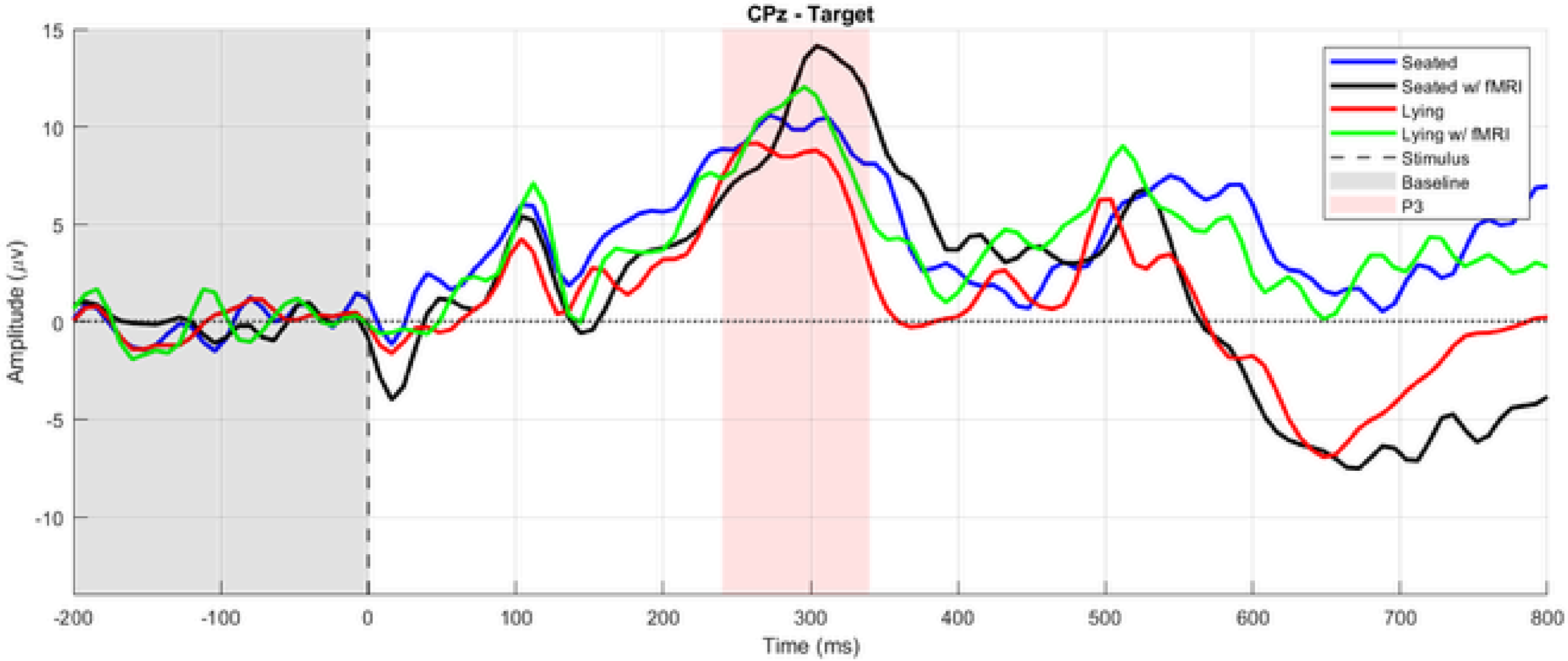
Condition comparison N170 - N2



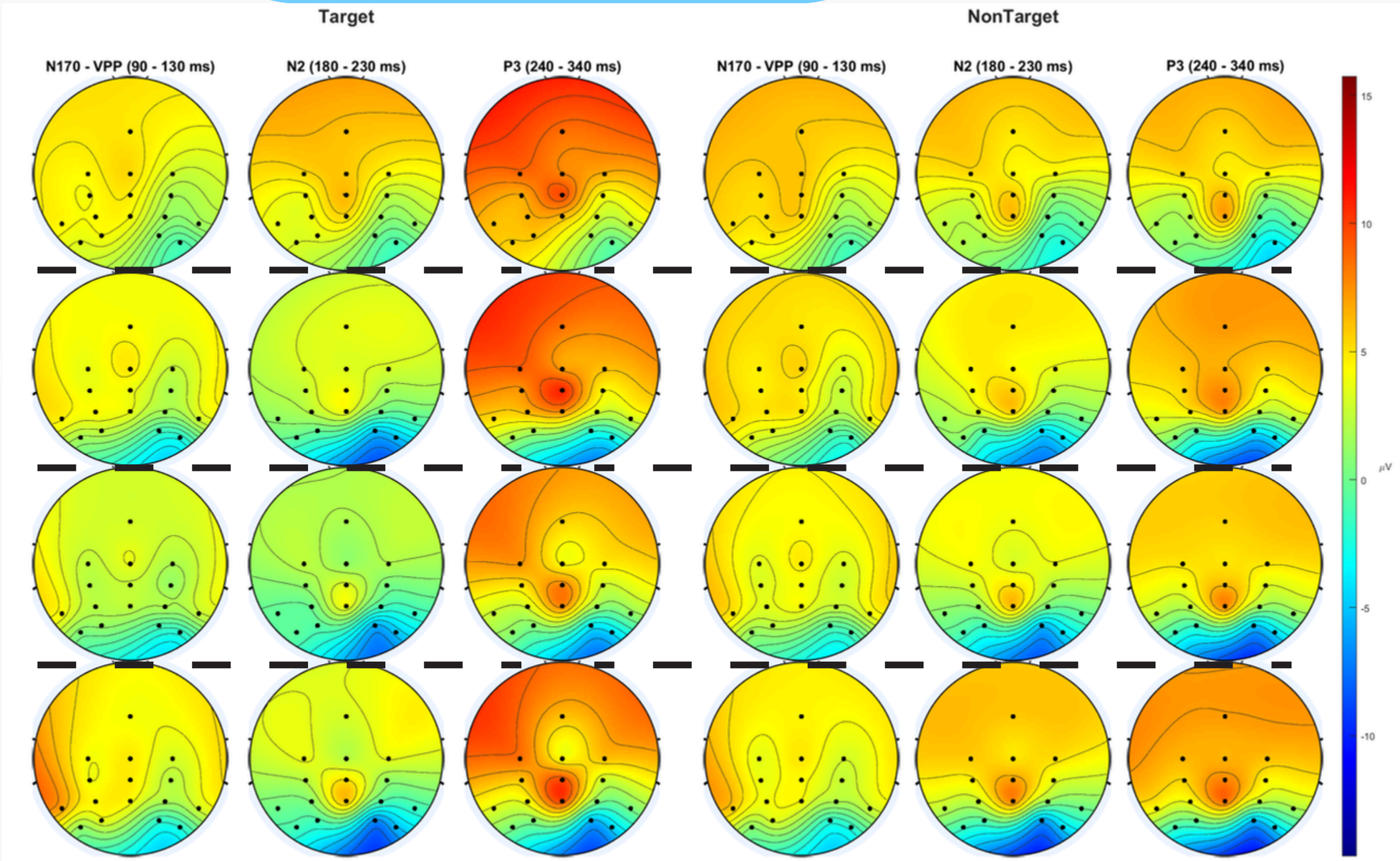
Condition comparison VPP - N2



Condition comparison P300



Topographic maps



Live Script

http://bit.ly/42Txuni