

BR41N.10

THE BRAIN-COMPUTER INTERFACE
DESIGNERS HACKATHON

BR41N.I0



HzBenders

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INTRODUCTION

Unresponsive Wakefulness Syndrome (UWS)

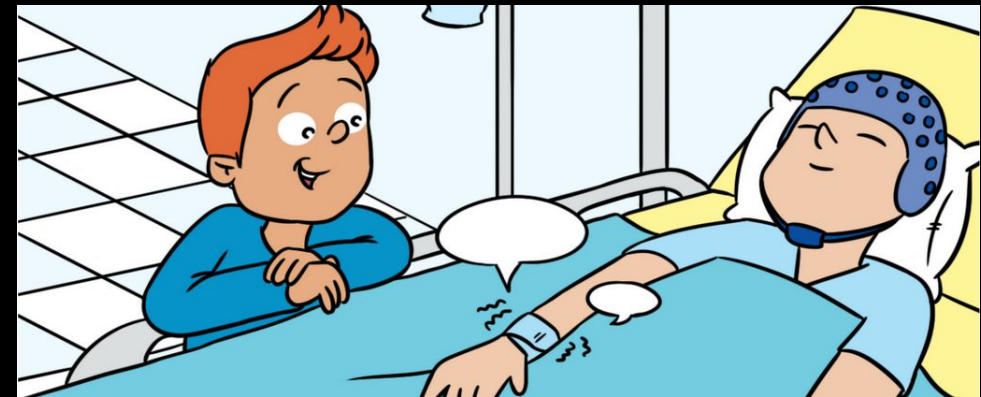
Clinical condition characterized by a state of wakefulness without any signs of awareness or conscious experience

P300 event-related potentials

elaborative processing of information; an index of conscious processing

Goal

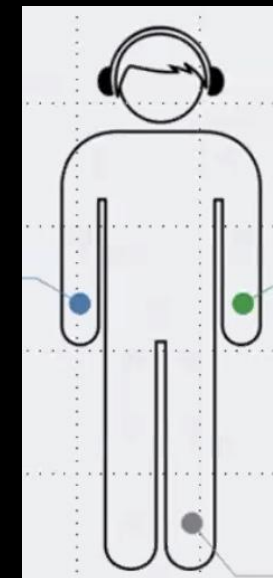
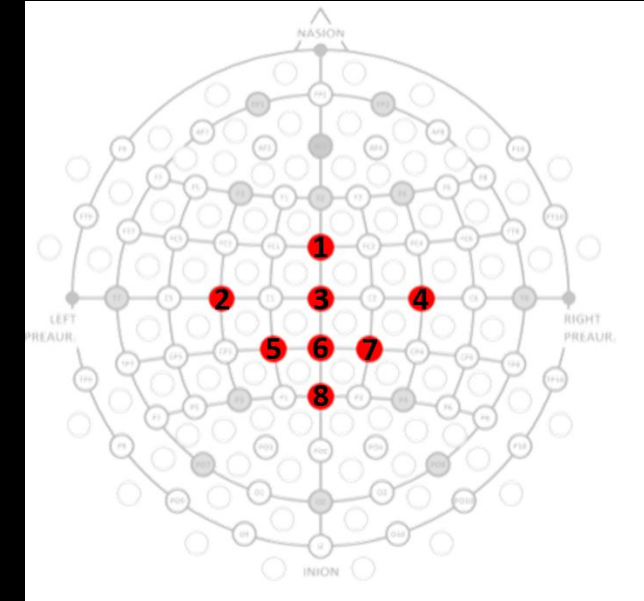
Accurately detect P300 responses elicited by vibro-tactile stimuli, via preprocessing, feature extraction and classification algorithms



INTRODUCTION

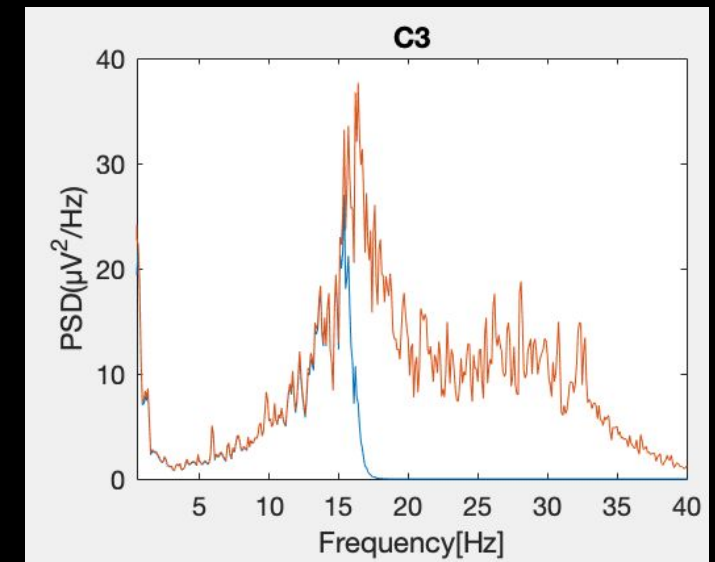
8 data from 2 participants

- Sampling rate: 256 Hz
- Number of Channels:
8 (FZ, C3, C4, CZ, CP1, CP2, CPZ, PZ)
- Vibro-tactile stimuli: 3 tactors placed on the user's body (wrists, left ankle) to provide tactile stimulation.
- Types of stimuli (trigger) as in Spatero et al., 2018:
 - Distractor (-1)
 - Nontarget (1)
 - Target (2)



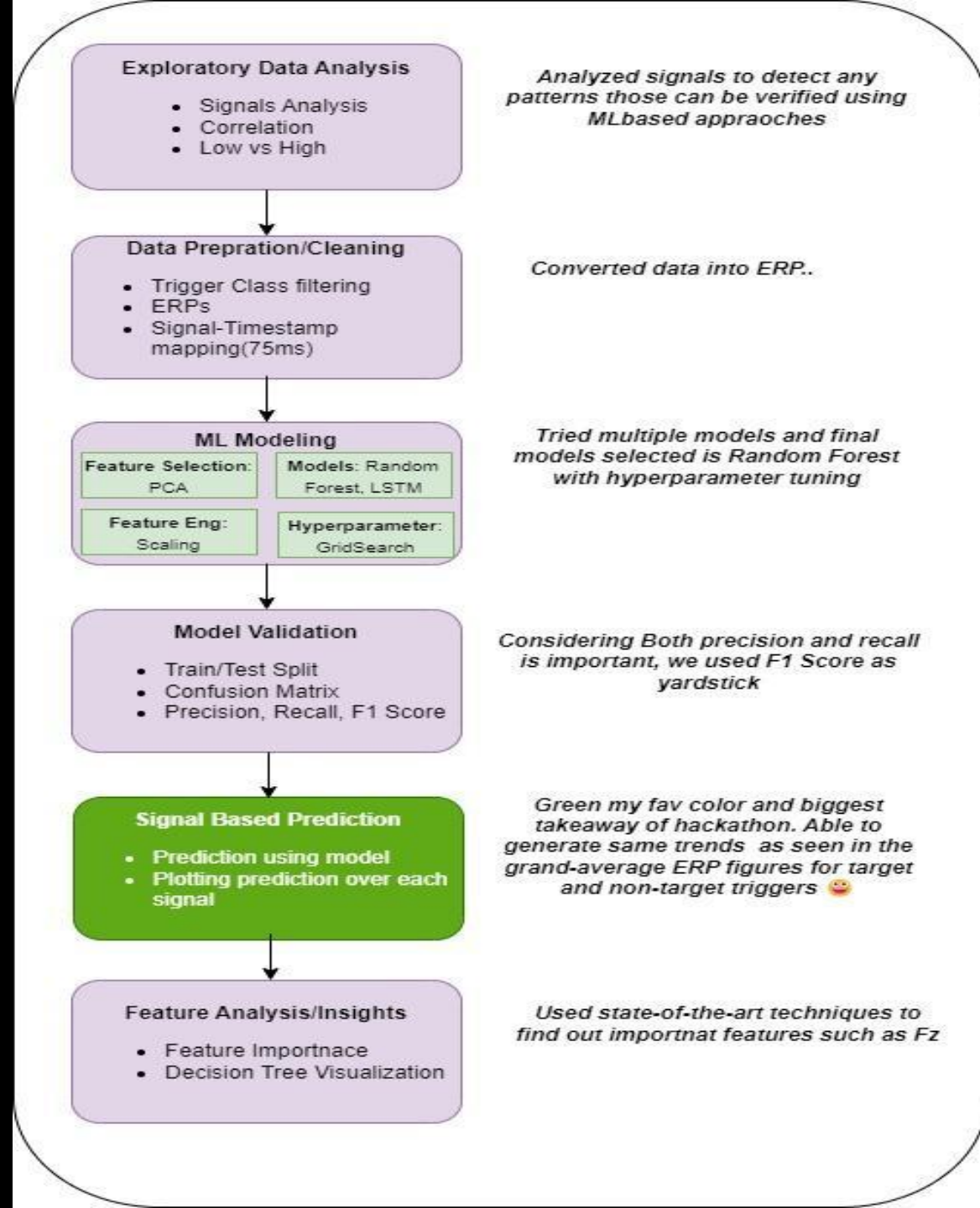
EEG and Event-Related Potentials

- Power Spectral Density plotted to check if notch filter (50Hz was applied)
- Filtering: Bandpass filtering (0.1-15 Hz)
- Epoching: epochs with a pre-event period of 100 ms and post-event period of 600 ms (Spatero et al., 2018)
- Epochs extracted: 60 targets and 60 non-targets
- Artifact rejection: 100 microvolt threshold
- One data: 9% artifacts, two had ~6%
- Event-Related Potentials and grand averages



ML Architecture

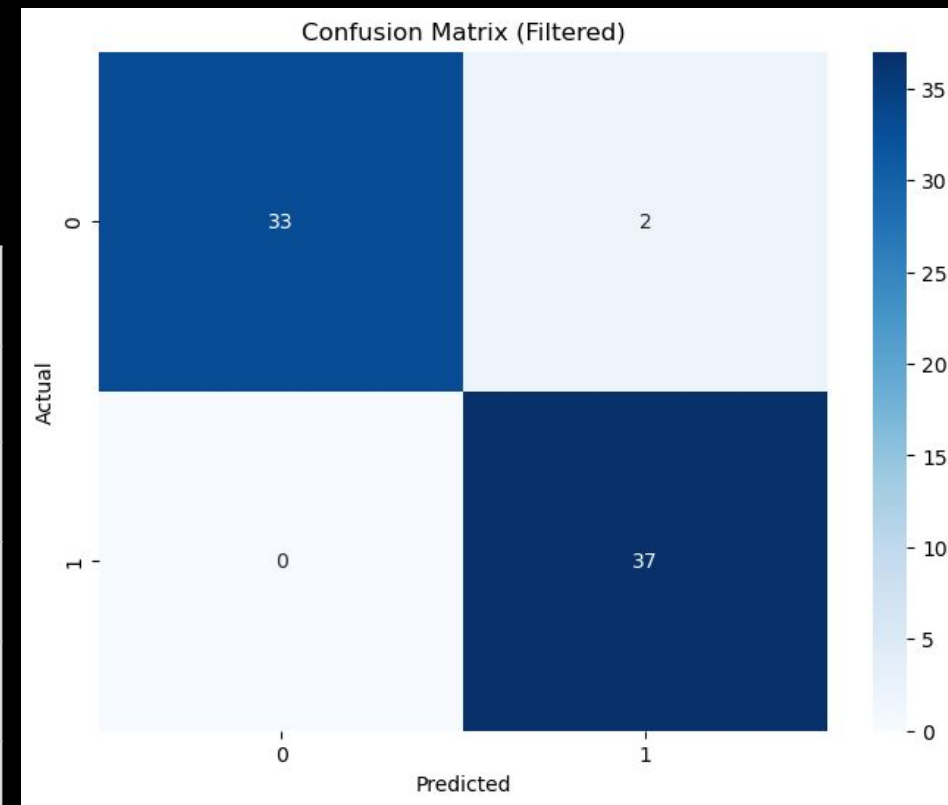
- A thorough Exploratory Data Analysis (EDA) at each signal level is performed to understand significance of each signal and its impact of patient
- A bunch of ML and DL algorithms are being tested such as Random Forest, Gradient Boosting, LSTM to get the best performing model.
- Industry standards practices such as hyperparameter tuning, cross validation, feature engineering etc been performed to get best generic model.



RESULTS

(Random Forest–best performance)

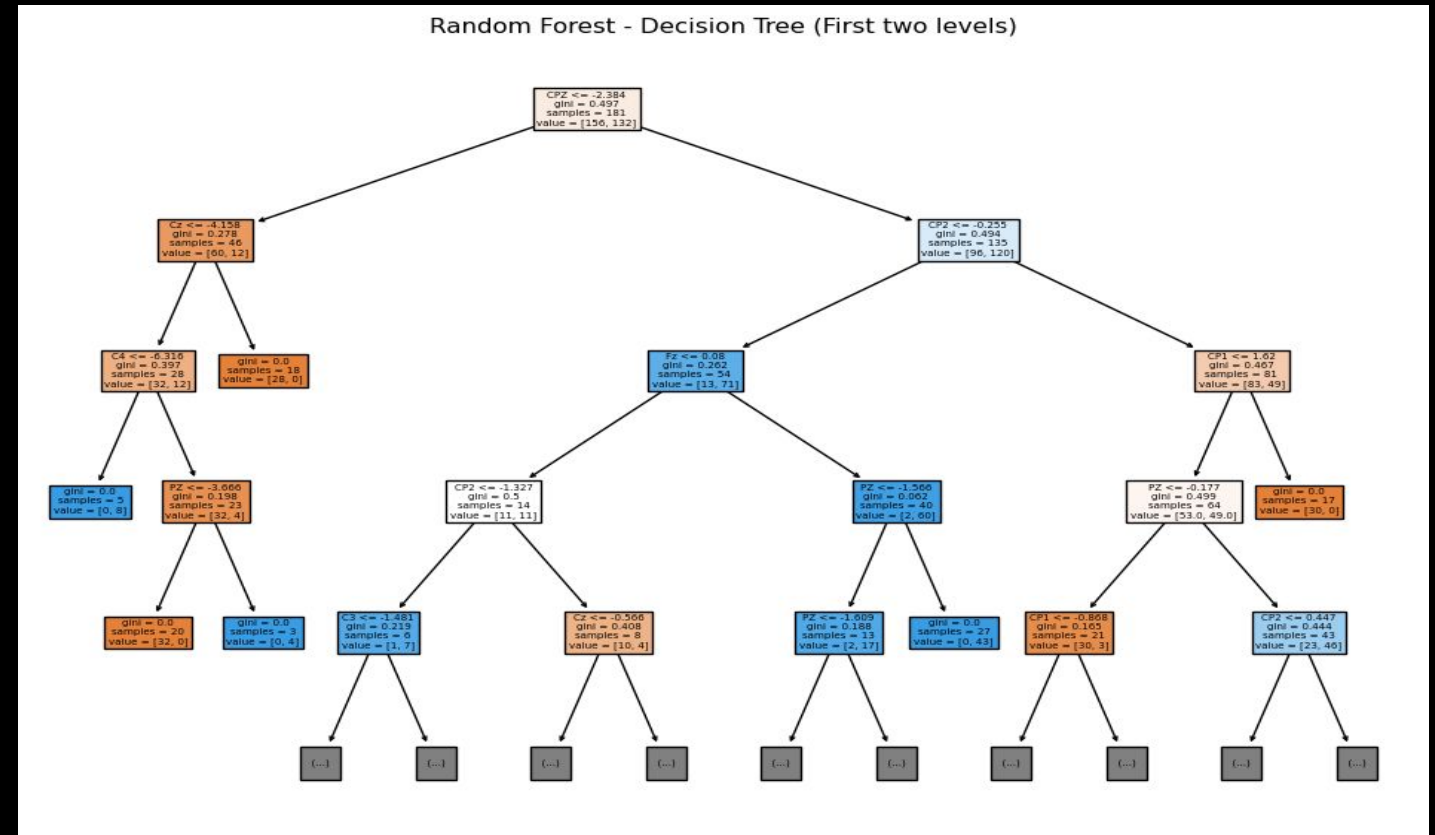
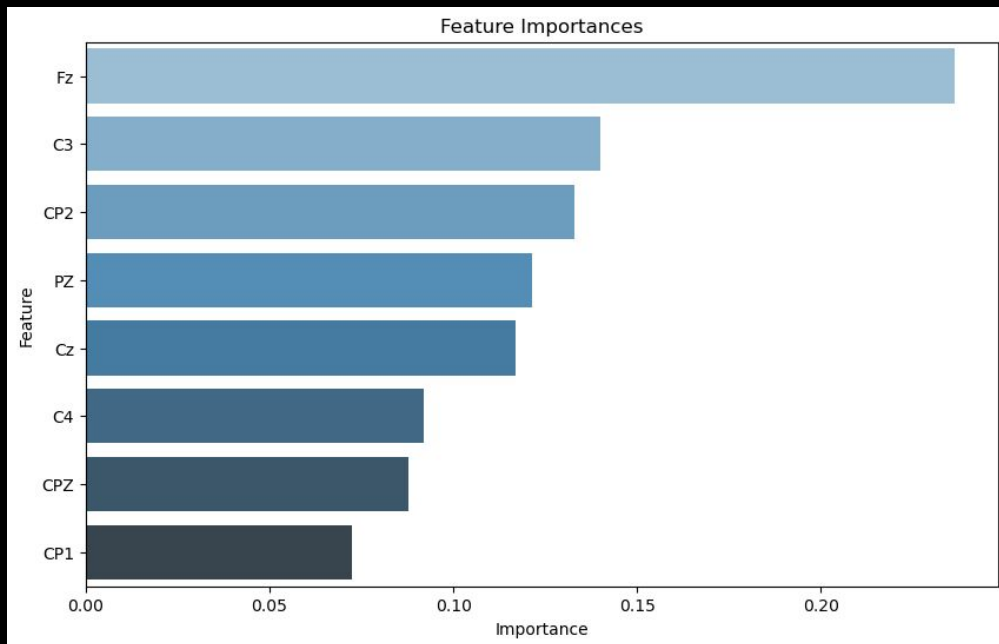
Patient_data	Accuracy	Precision	Recall	F1 Score
P1_L1	0.9583	0.9706	0.9429	0.9565
P1_H2	0.9722	1	0.9429	0.9706
P1_L2	0.9722	1	0.973	0.9861
P2_H1	0.9167	0.9091	0.9143	0.9117
P2_H2	0.9289	0.949	0.973	0.9594
P2_L1	0.9167	0.9143	0.8919	0.9031
P2_L2	0.975	0.9621	0.9719	0.9767



- Overall average accuracy is around 96%
- Model shows generalized results
- Performance is consistent across various combination of signals

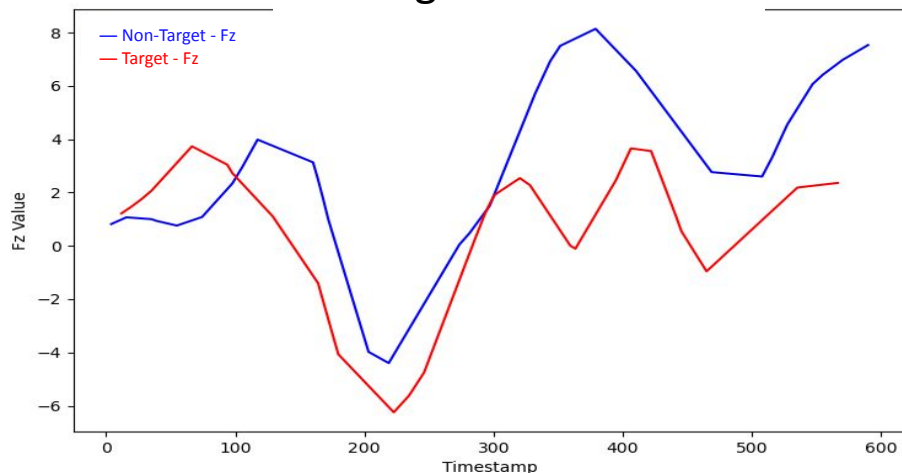
Feature Importance/Model Explainability

- Its always important to explain any ML model, so we used feature importance and Decision Tree to explain our model
- Fz, C3, CP2 appears to be most contributing to our model.
- Fz is one of such feature that models found most easy to classify.

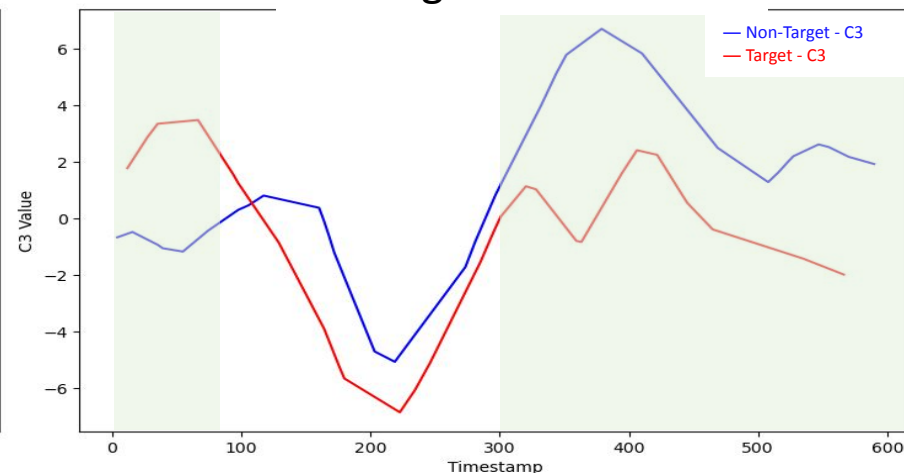


ML Model Prediction Over Time

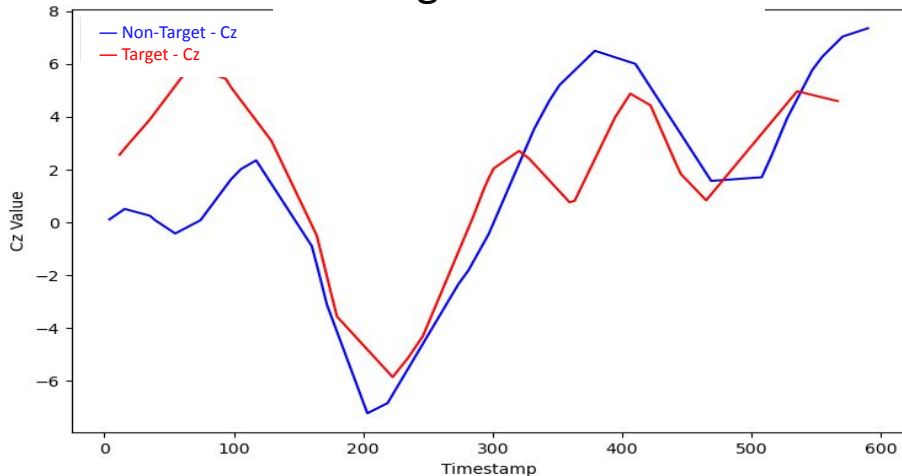
Fz Signal Over Time



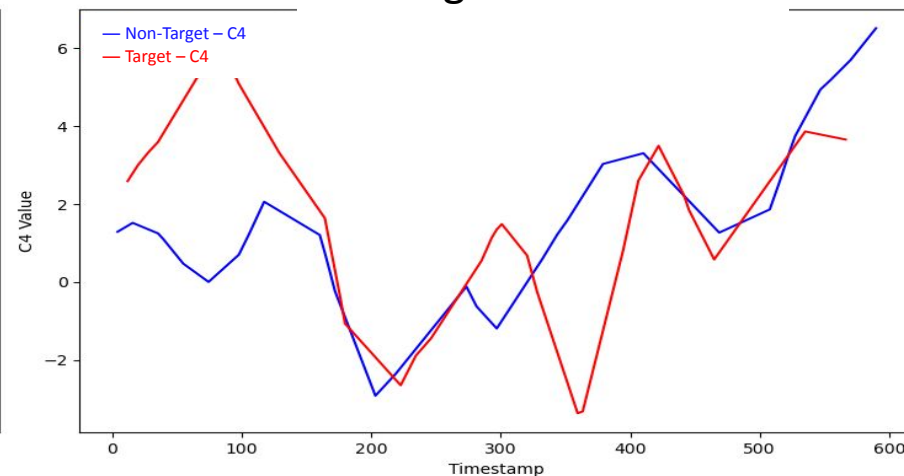
C3 Signal Over Time



Cz Signal Over Time

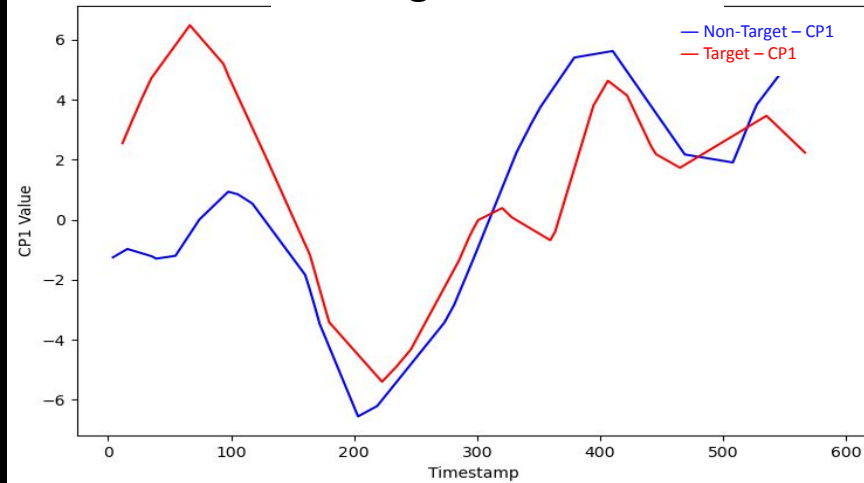


C4 Signal Over Time

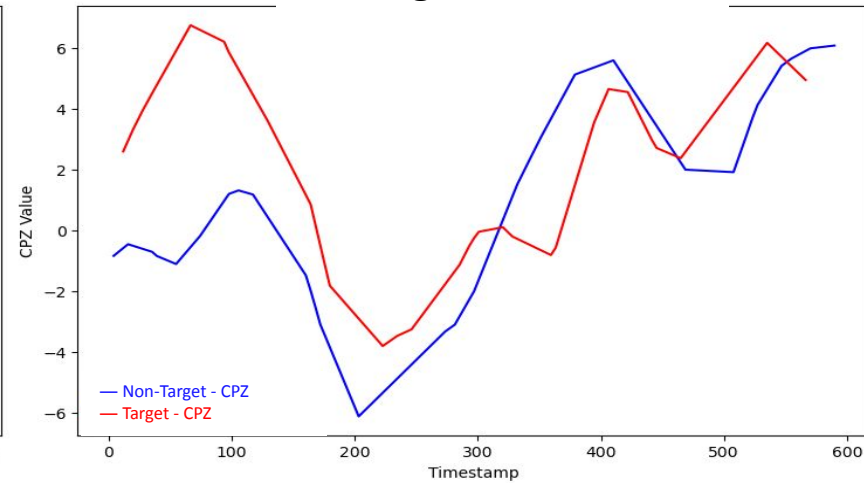


ML Model Prediction Over Time

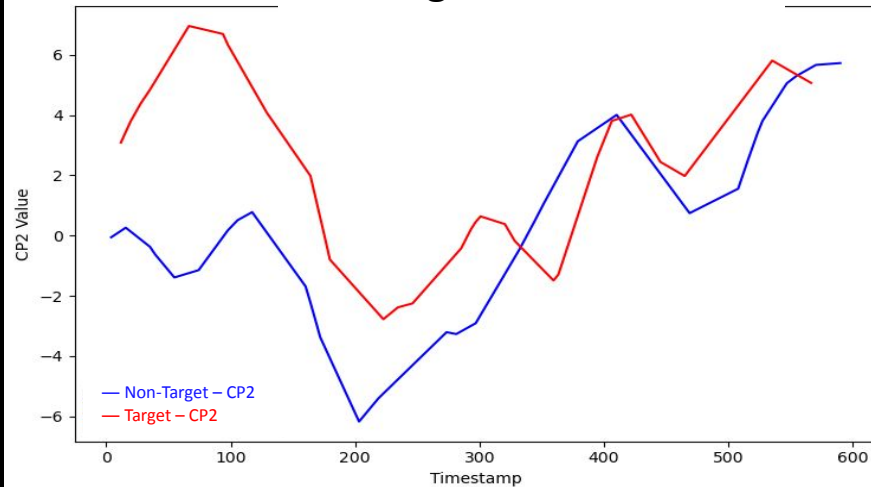
CP1 Signal Over Time



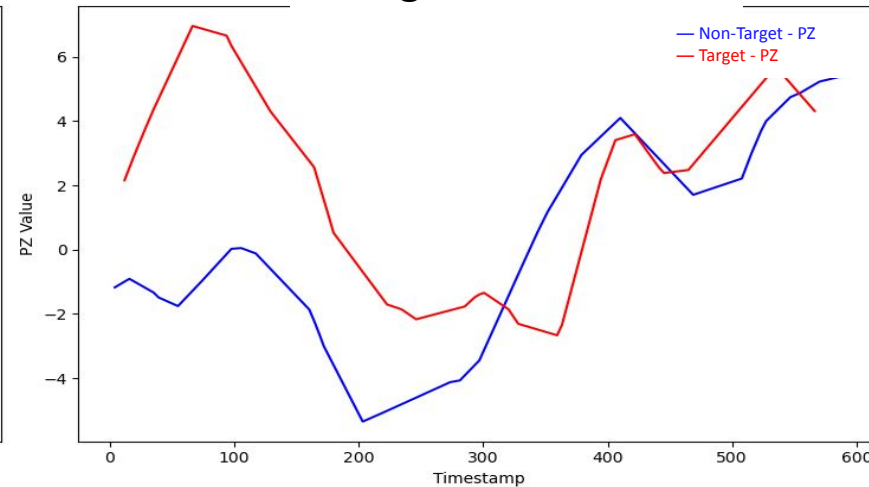
CPZ Signal Over Time



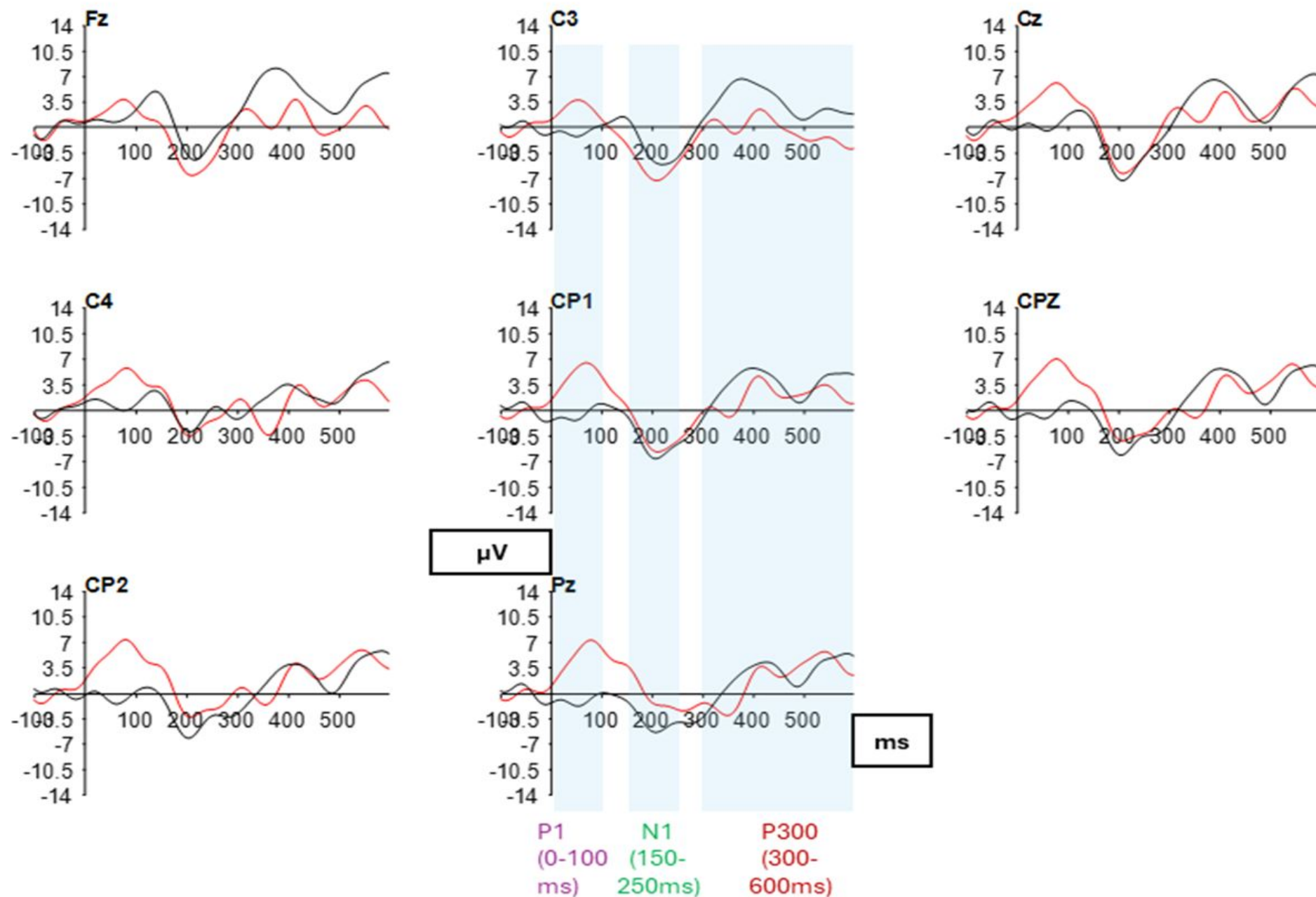
CP2 Signal Over Time



PZ Signal Over Time



Patient1 with highscore in session1 (P1_High1): ERPs of non-target vs. **target**



DISCUSSION

Our P300 results replicate the UCS study (Spatero et al., 2018) and consciousness-disorder study (Zhang et al., 2017): more positive deflection for non-target than target stimulus in the P300 time-window

P300 (P3)

- P300 indexes **conscious processing, late attentional processes and also novelty**
- It is elicited by infrequent, task-relevant stimuli and reflects context updating and memory processes. P300 amplitude is reduced in various neurological and psychiatric disorders, such as schizophrenia and Alzheimer's disease.

P1

- P1 is a positive-deflection with peak in positive direction around 50ms from stimulus onset
- Indexes **EARLY ATTENTION**

N1

- N1 is a negative deflection that follows P1
- It is associated with **SELECTIVE ATTENTION** and stimulus discrimination.

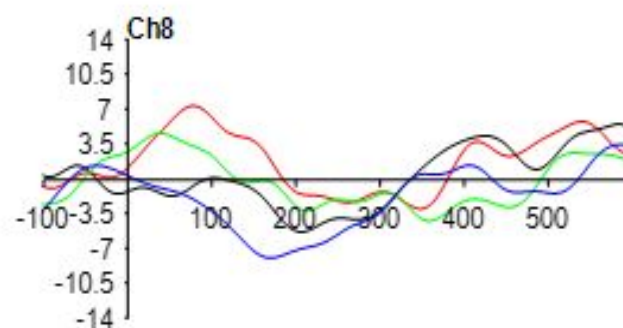
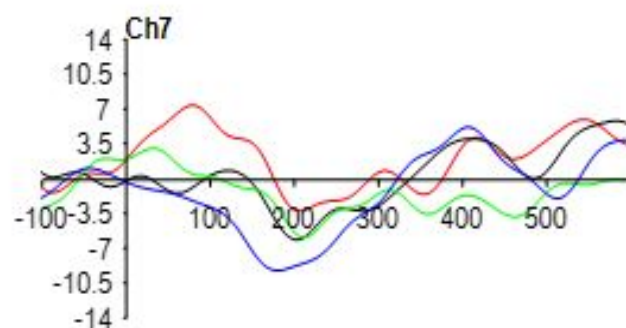
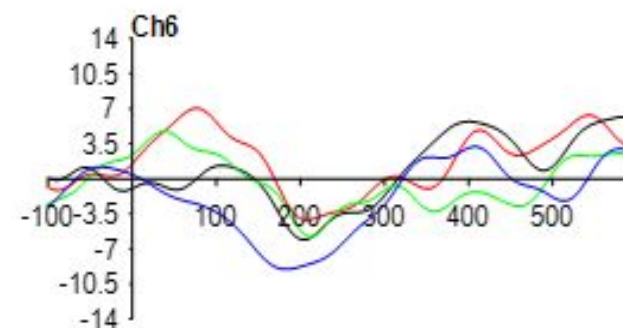
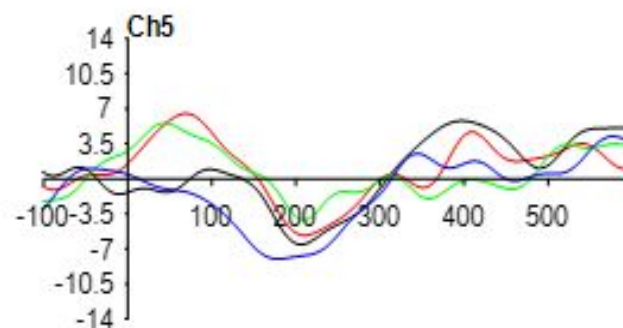
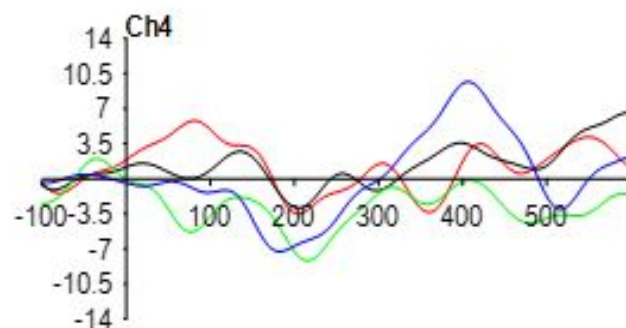
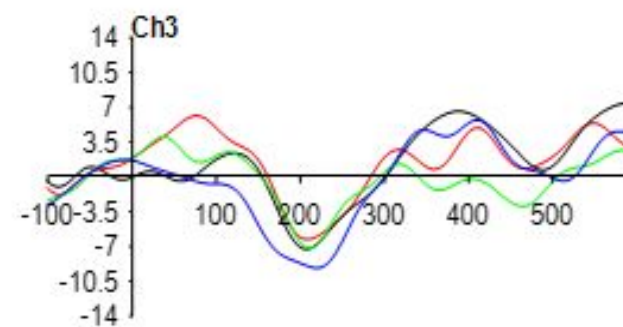
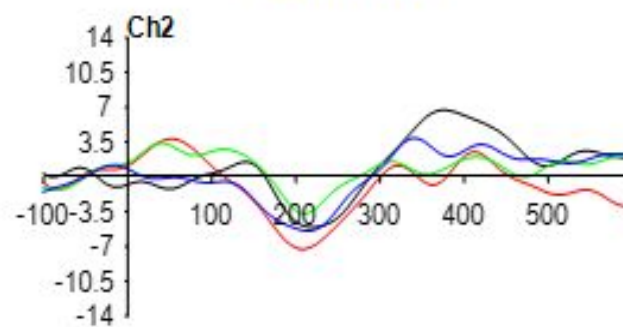
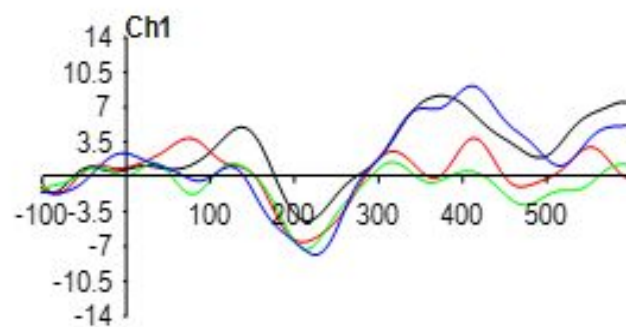
Future scope: Patient1 with highscore vs. lowscore (P1_High1 vs. P1_Low1):

High non-target

High target

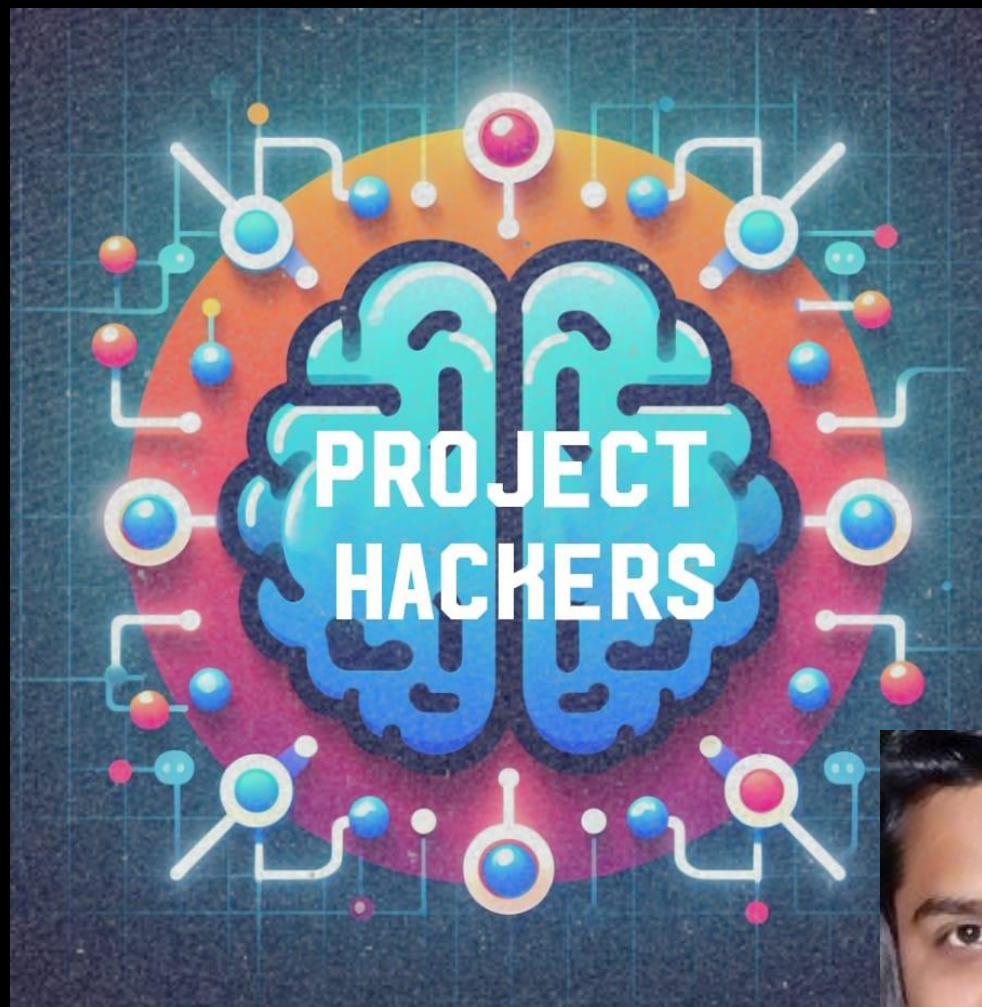
Low-non-target

Low-target



REFLECTIONS

1. **Communication and interaction:** It can provide a means of communication and interaction for individuals with UWS, improving their quality of life.
1. **Diagnosis and prognosis:** Accurate detection of P300 responses can aid in the diagnosis and assessment of cognitive function in disorder of Consciousness (DOC) patients, informing treatment decisions and prognosis, end-of-life care.
1. **Neuroscientific research:** Analyzing vibro-tactile P300 data can contribute to a better understanding of the neural mechanisms underlying consciousness and cognitive processing in DOC patients.



... Leck Kye-Cin, Alessio Guarachi

A BIGCC Thanks To The Organizers

