OpenBCI Motor Imagery

Team: Tyler Twohig, Hila Mor, Phyllis Fei, Ankur Garg

Overview

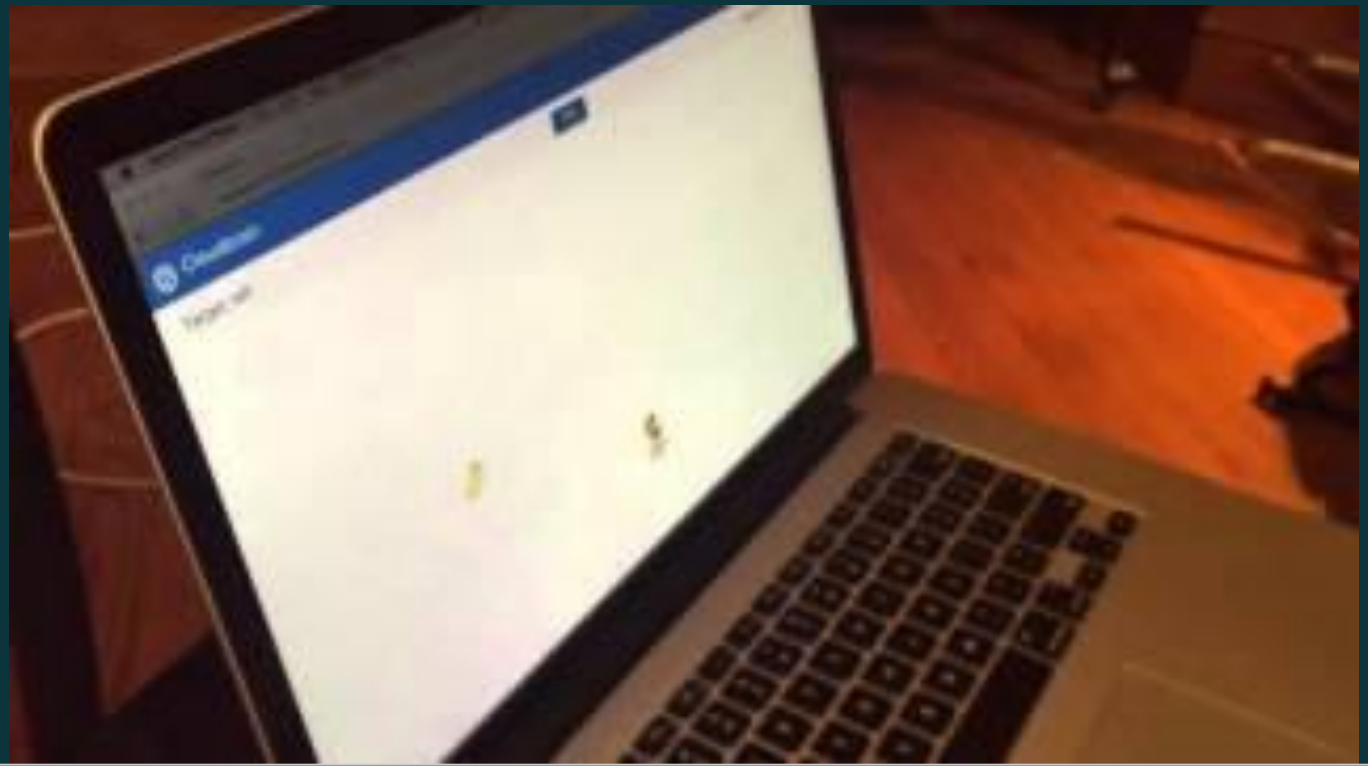
Overview

Objectives

Control of an avatar or a robot using brain signals

1. Left vs. Right classification
2. Actual Movement | Imagined Movement

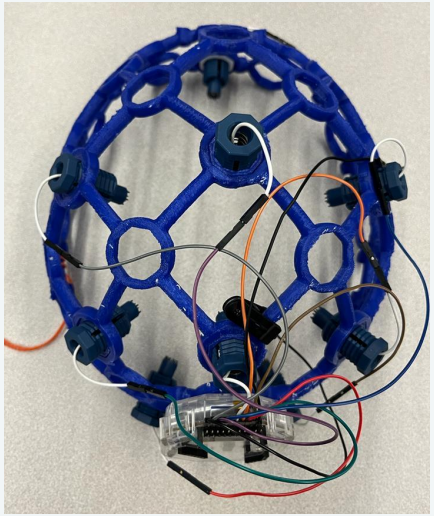
Ideally…



Overview

Tools & Materials

- 3D printed headset
- OpenBCI
- EEG data captured from team members



Overview

Electrodes locations: 10-20 system

Fpz - Ground

C3 - channel 1
Cz - channel 2
C4 - channel 3

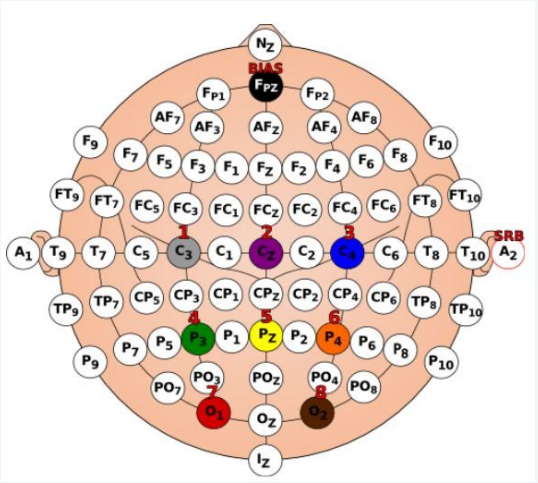
Central (T+F)

P3 - channel 4
Pz - channel 5
P4 - channel 6

Parietal - sensory

O1 - channel 7
O2 - channel 8

Occipital - visual



Right | Left

Overview

Electrodes locations: 10-20 system

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C3 - channel 1
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C4 - channel 3 — **Central (T+F)**

P3 - channel 4
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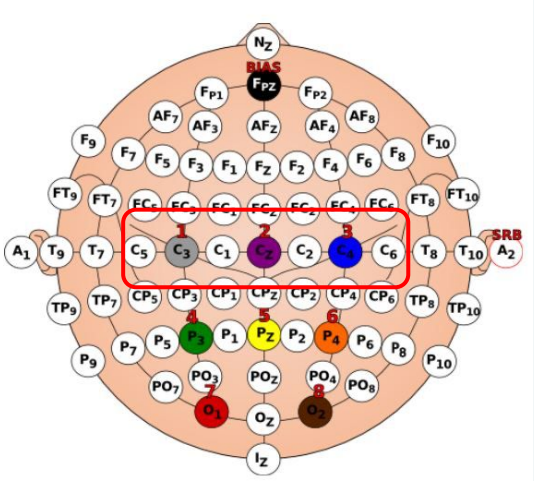
P4 - channel 6 — Parietal - sensory

O1 - channel 7
O2 - channel 8 — Occipital - visual



Right | Left

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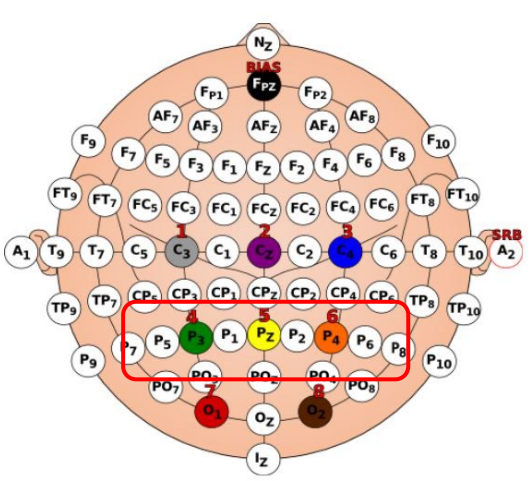

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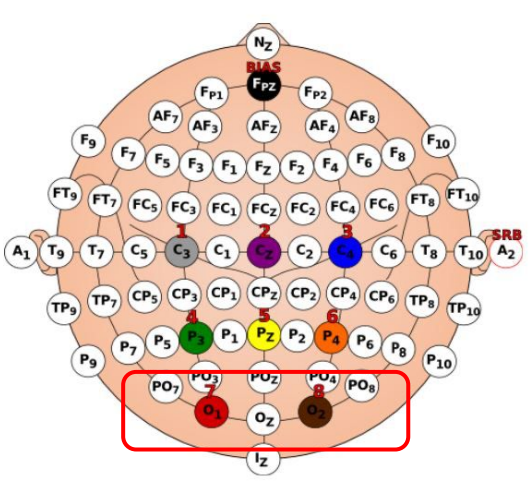
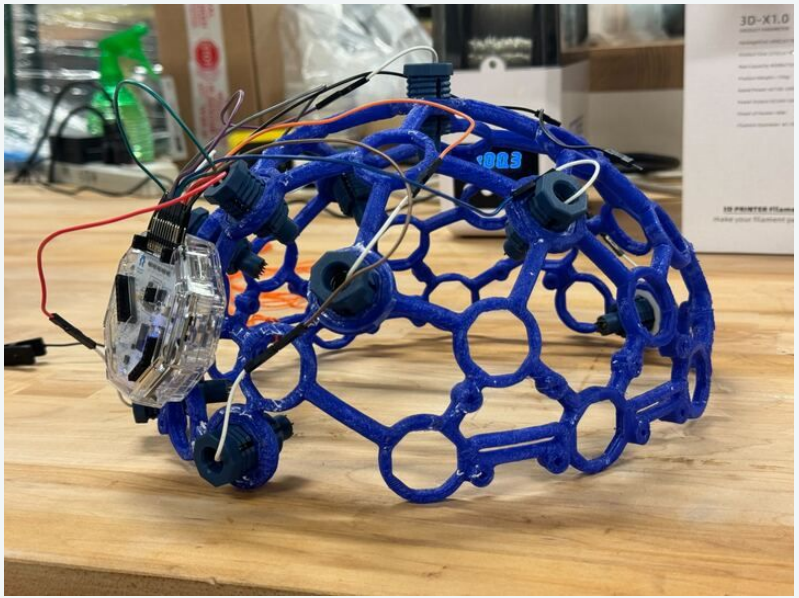


Right | Left

Process

Process

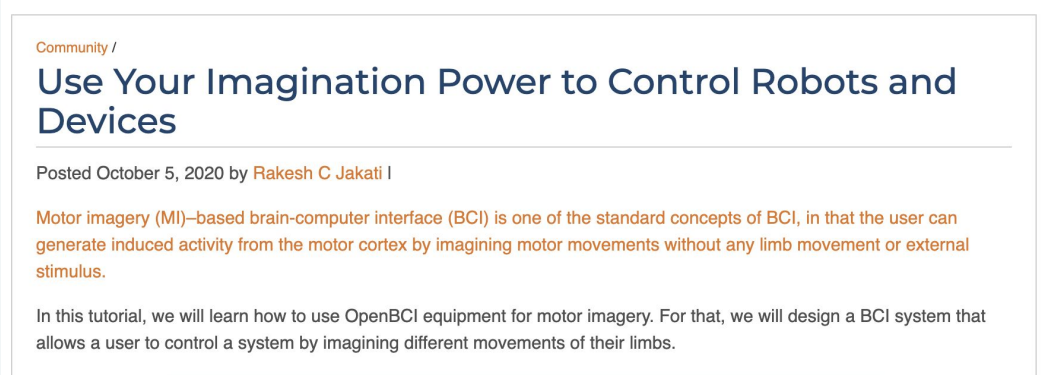
3D printed headset



* Link to the ultracortex headset

Process

Reference: OpenBCI Motor Imagery Tutorial



Community /

Use Your Imagination Power to Control Robots and Devices

Posted October 5, 2020 by Rakesh C Jakati I

Motor imagery (MI)–based brain-computer interface (BCI) is one of the standard concepts of BCI, in that the user can generate induced activity from the motor cortex by imagining motor movements without any limb movement or external stimulus.

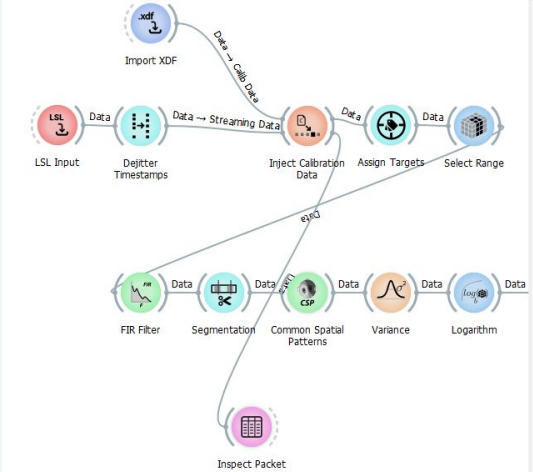
In this tutorial, we will learn how to use OpenBCI equipment for motor imagery. For that, we will design a BCI system that allows a user to control a system by imagining different movements of their limbs.

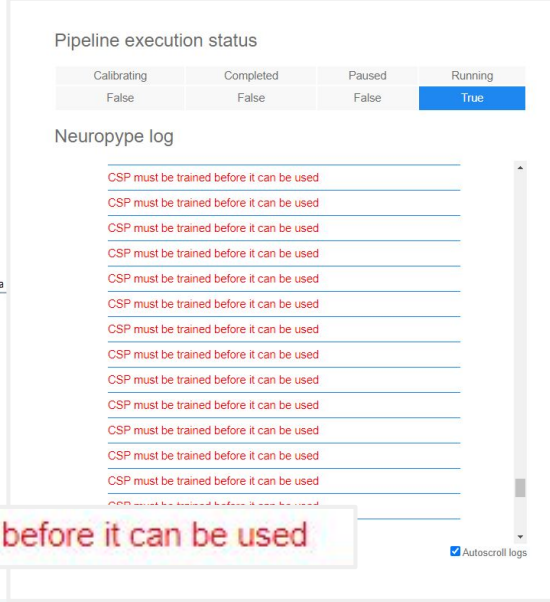
* Link to tutorial documentation

Process

Prep & Setup

Common Spatial Pattern (CSP) error when running the pipeline in Neuropype for data preprocessing / spatial filtering:



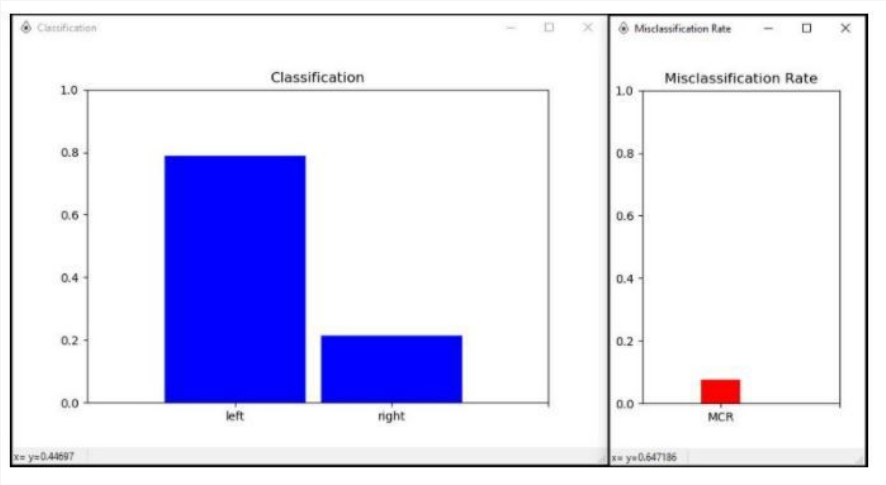


CSP must be trained before it can be used

Process

Prep & Setup

Our goal was to get to classify the Right vs. Left like the graph below:



* Link to tutorial documentation

Process

Prep & Setup

Our goal was to get to classify the Right vs. Left like the graph below:

Didn’t work - change of plans

* Link to tutorial documentation

Iterated Project Objectives

Process

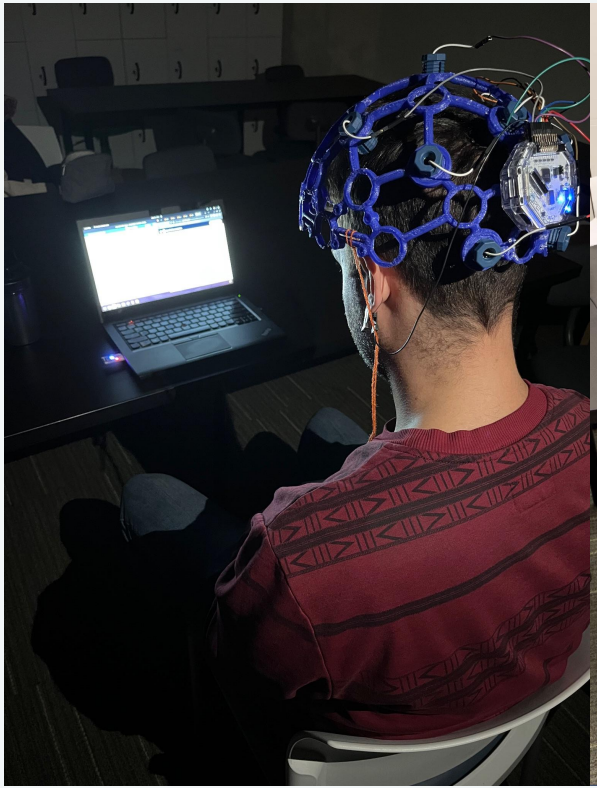
Repurposed Plan

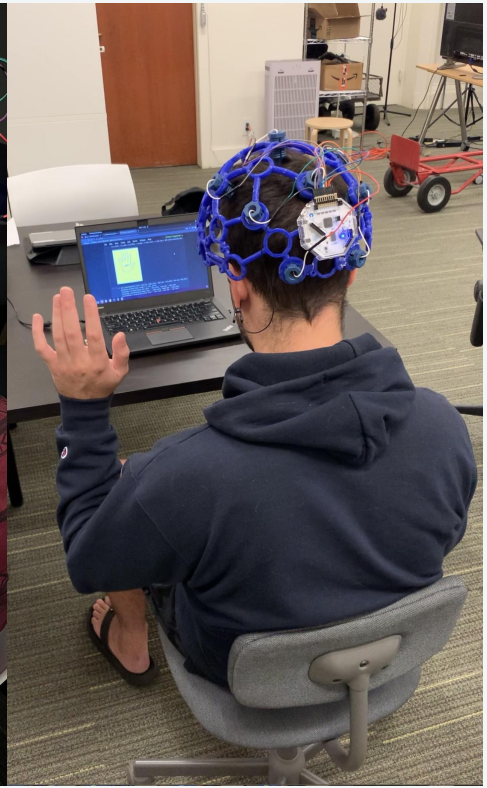
1. **Build our own randomized left/right protocol for data collection**
2. **Data collection from participants**
    a. Real gestures | b. Imagined gestures
        i. Lifting left hand
        ii. Lifting right hand
        iii. Resting (1 sec)
3. **Matching data with timestamp**
4. **Translating data: power ➔ frequency**
5. **Data analysis**
    a. Imagined v.s Actual gestures data patterns
    b. Left v.s Right data patterns
6. **Classification/Training for prediction**

Analyze data patterns of imagined & actual gestures

Data Collection

Build Our Own Protocol





Data Collection

Protocol

1. Avoid eye blinks during each task to minimize noise
2. Avoid distractions
   a. Electronic devices
   b. Environment noise
3. Follow the screen, raise left or right hands accordingly
4. Collect data for 100 sets
5. Stop data collection

Data Analysis

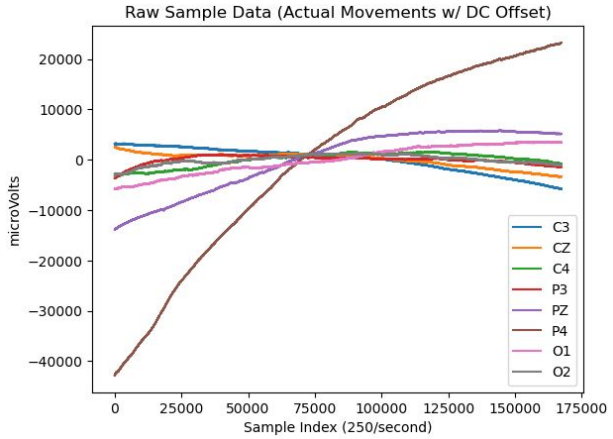
Key tasks

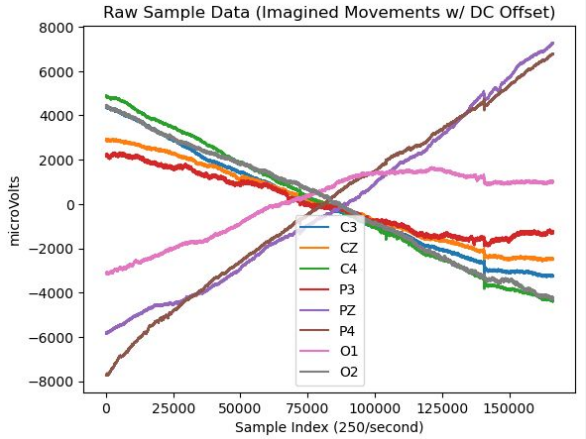
1. Time format conversion: unix→standard
2. Match timestamps with each task
3. Re-organize dataset into lists
4. Remap data from power to frequency domain

Data Analysis

Possible issues with the data

- " DC drift" - slight down/up trend of data
- Converting to frequency to power density
- Multiple types of noise
- Some peaks may be flipped (negative/positive voltage)

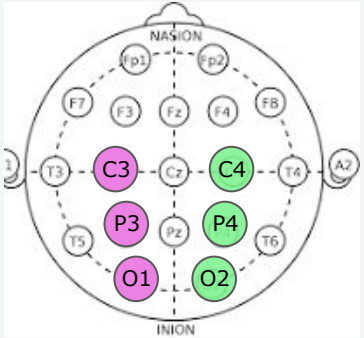




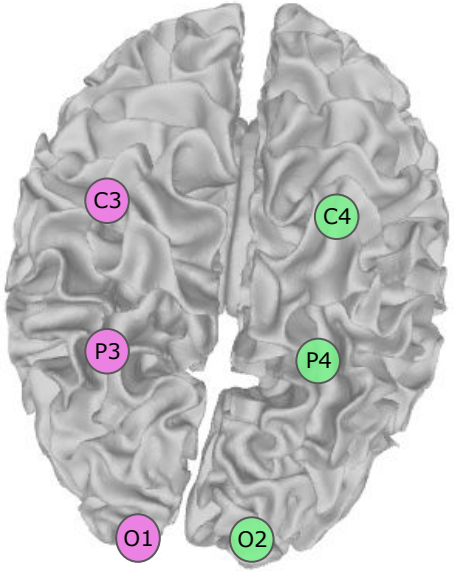
Data Analysis

Brain MRI Model

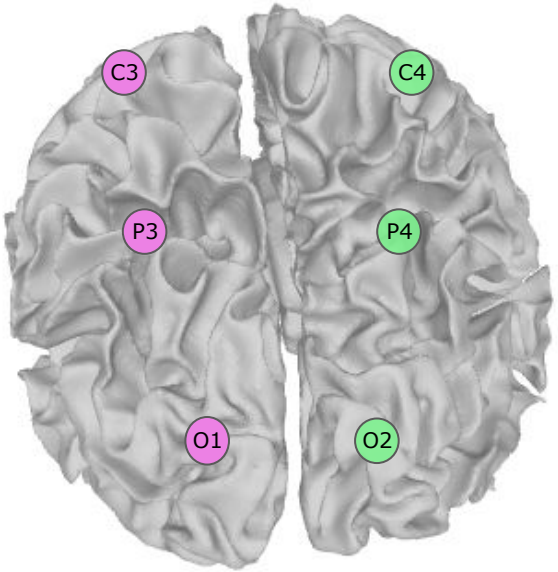
Top View
10-20 map



Top View



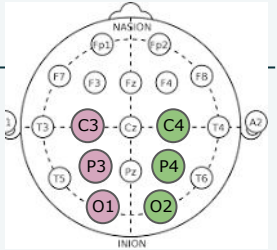
Back view



*issues on some data of c4 + c3

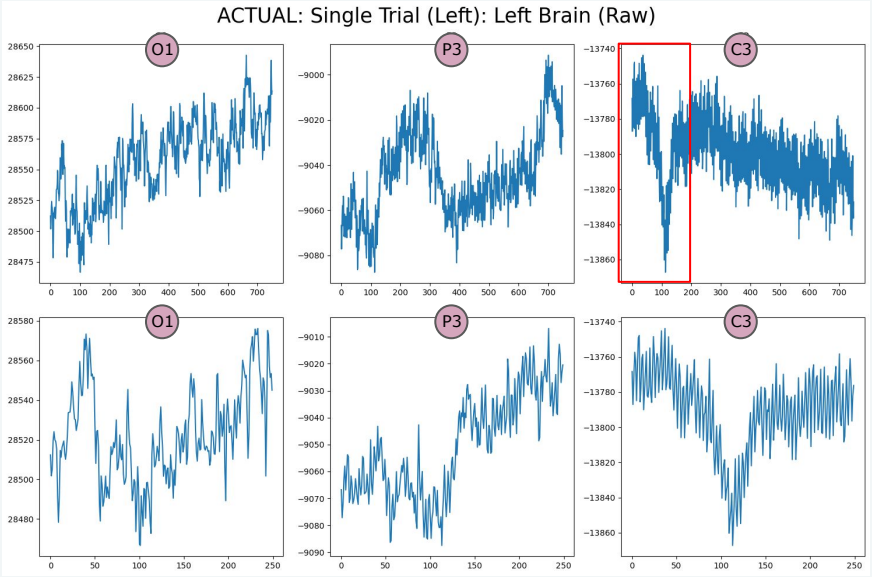
Actual Gestures

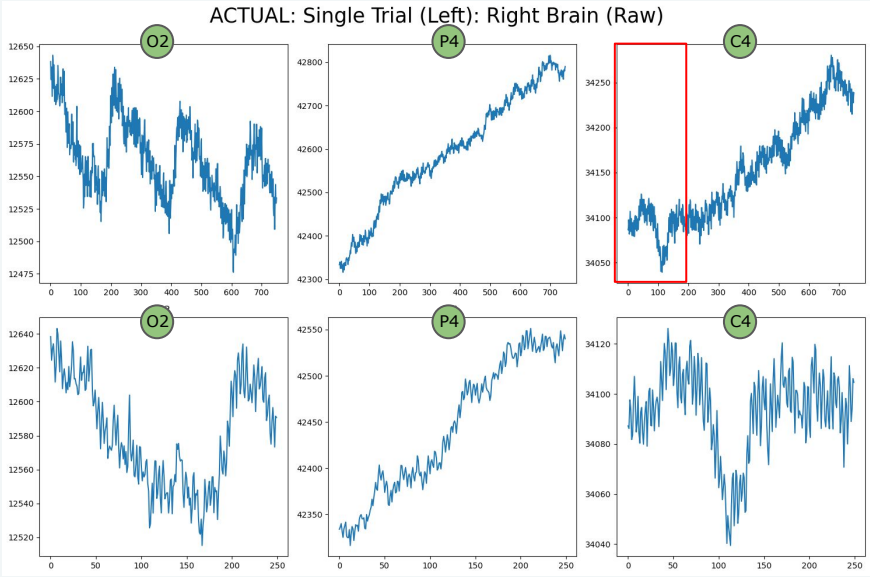
Actual Left | Single Trial | Raw Data



Actual

Rest

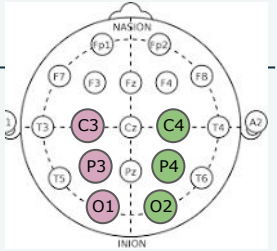




Left brain

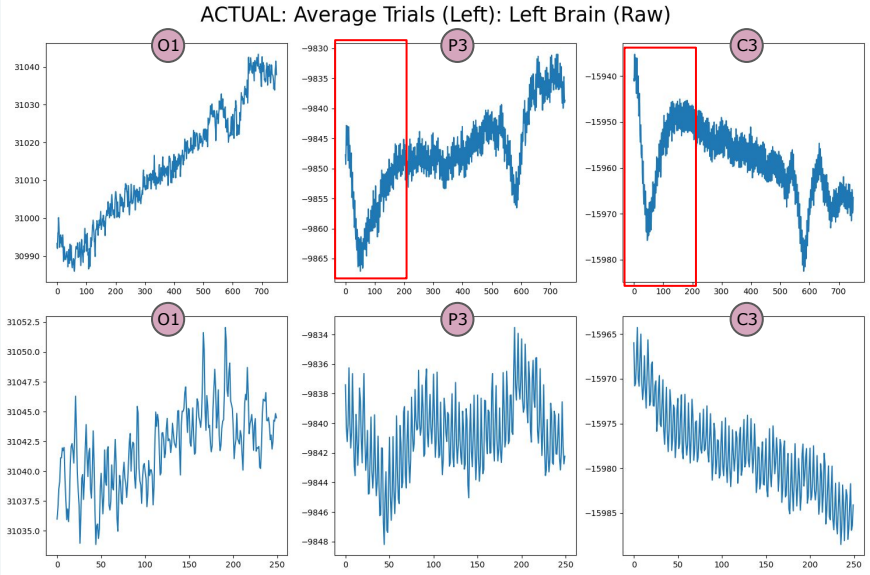
Right brain

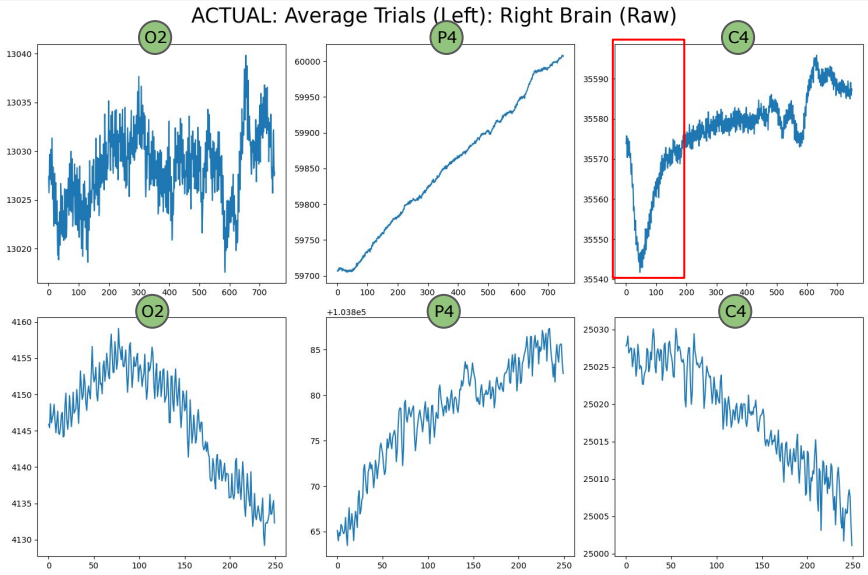
Actual Left | Average | Raw Data



Actual

Rest

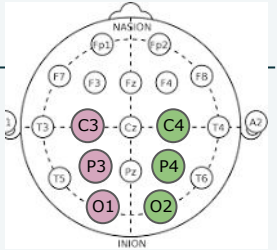




Left brain

Right brain

Actual Right | Single Trial | Raw Data



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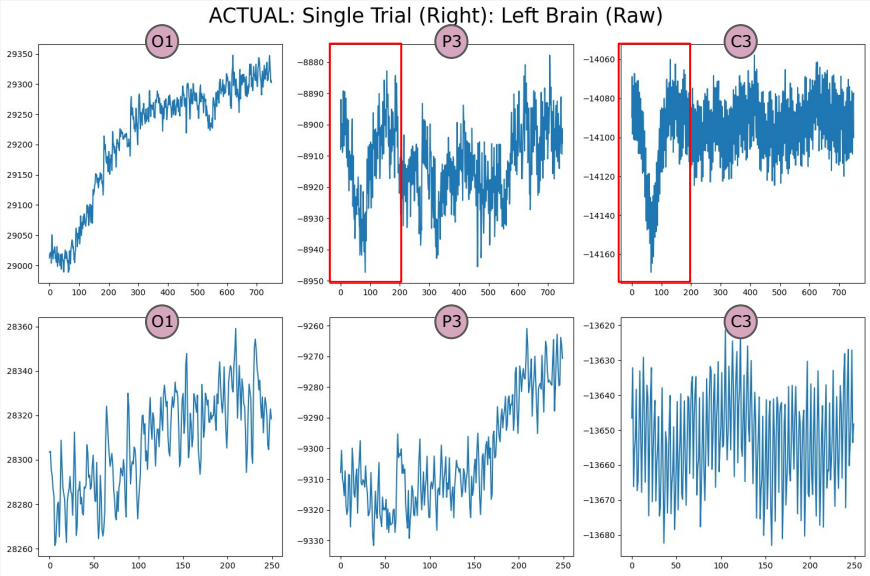

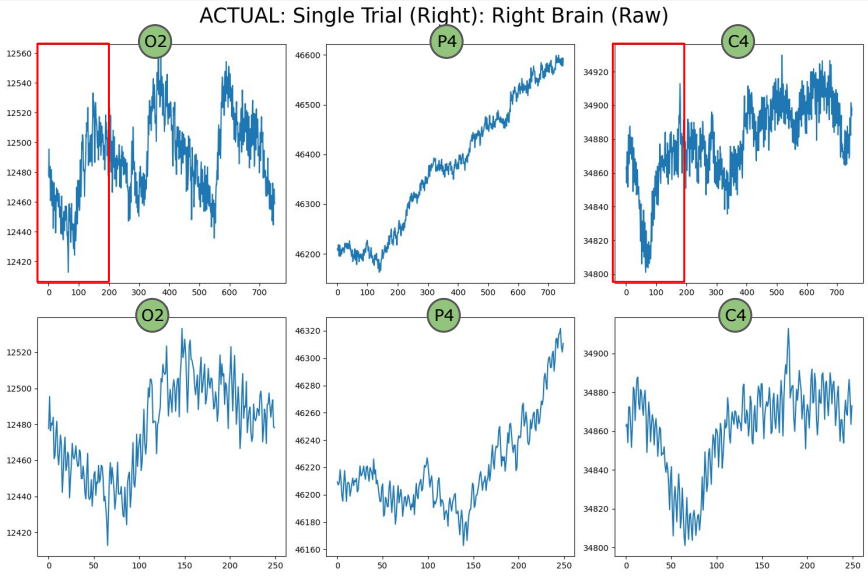

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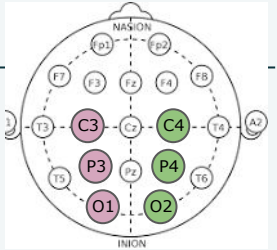

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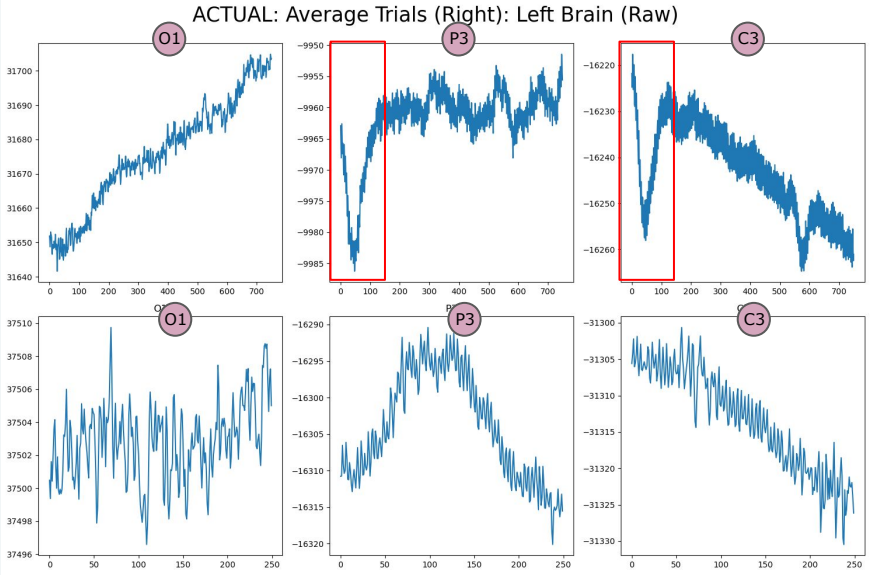
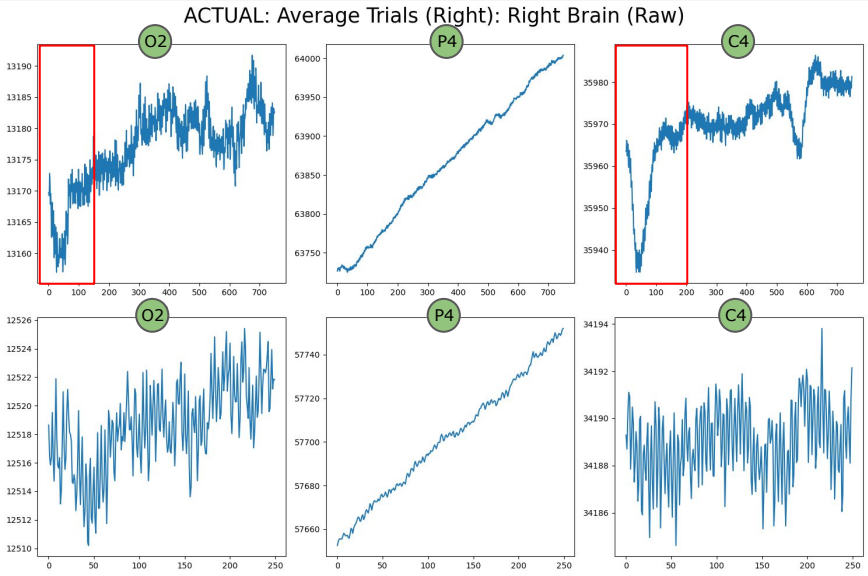


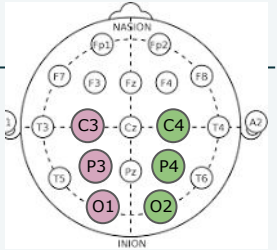


Left brain

Right brain

Imagined Gestures

Imagined Left | Single Trial | Raw Data



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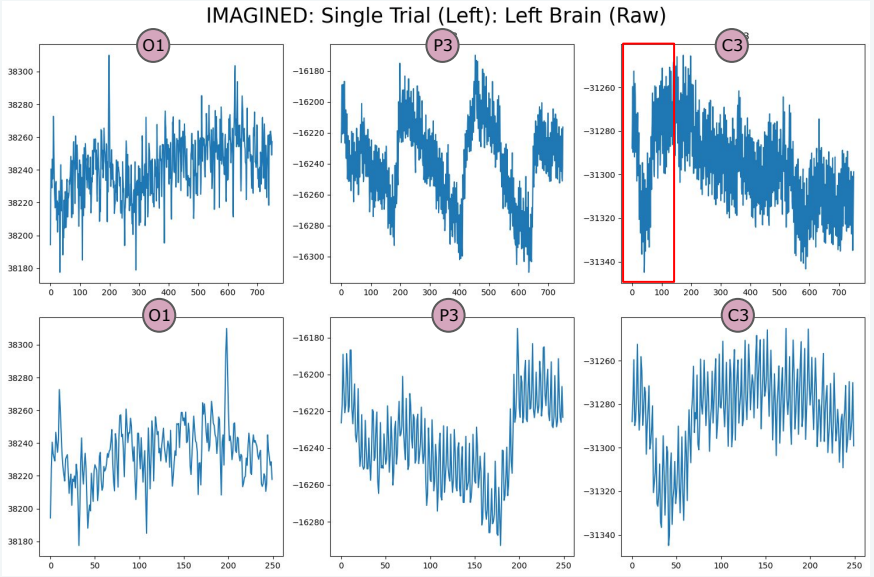

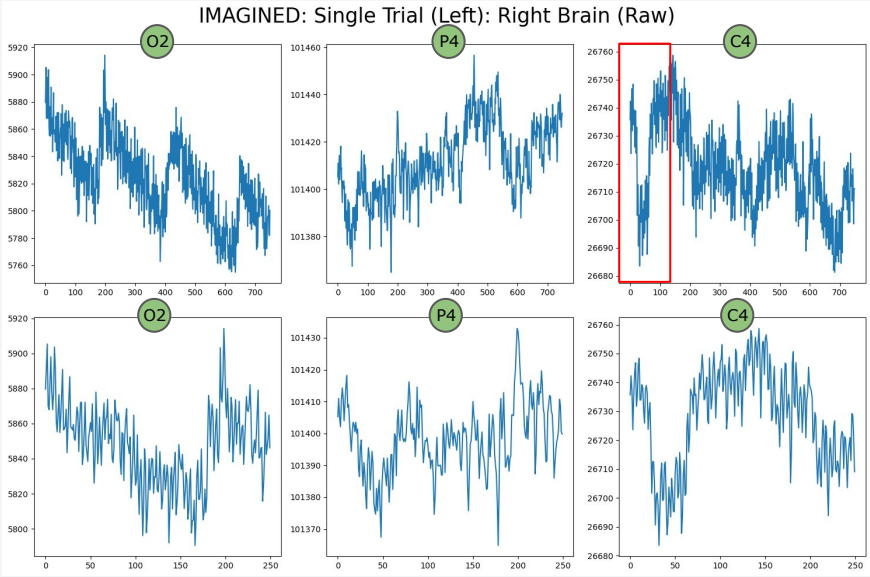

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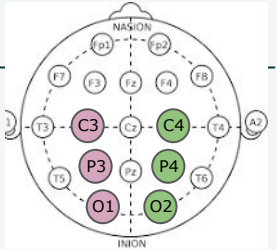

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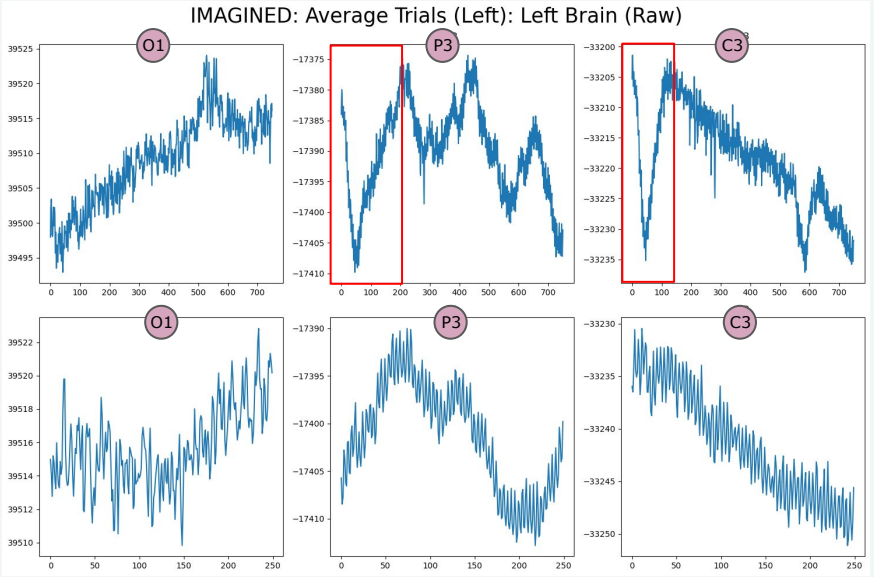
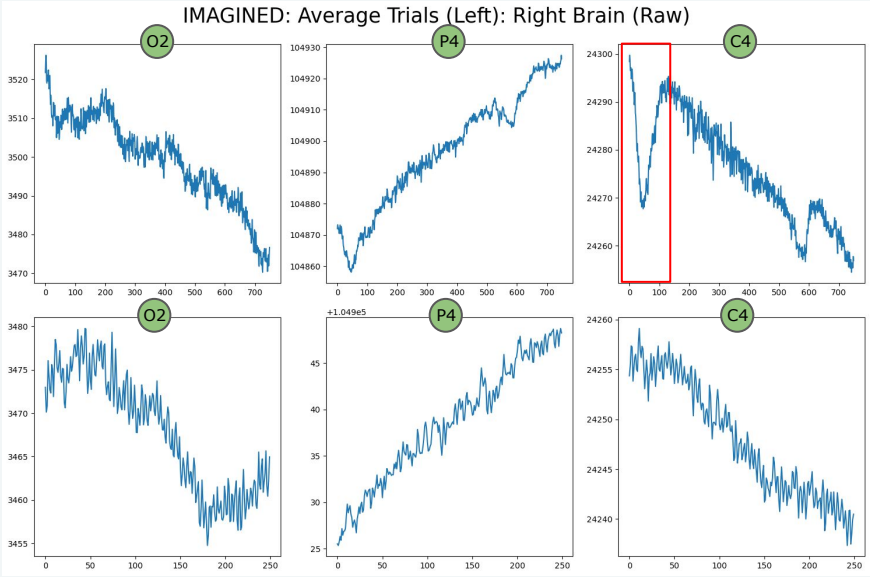
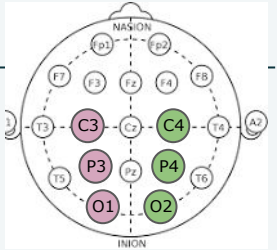




Left brain

Right brain

Imagined Right | Single Trial | Raw Data



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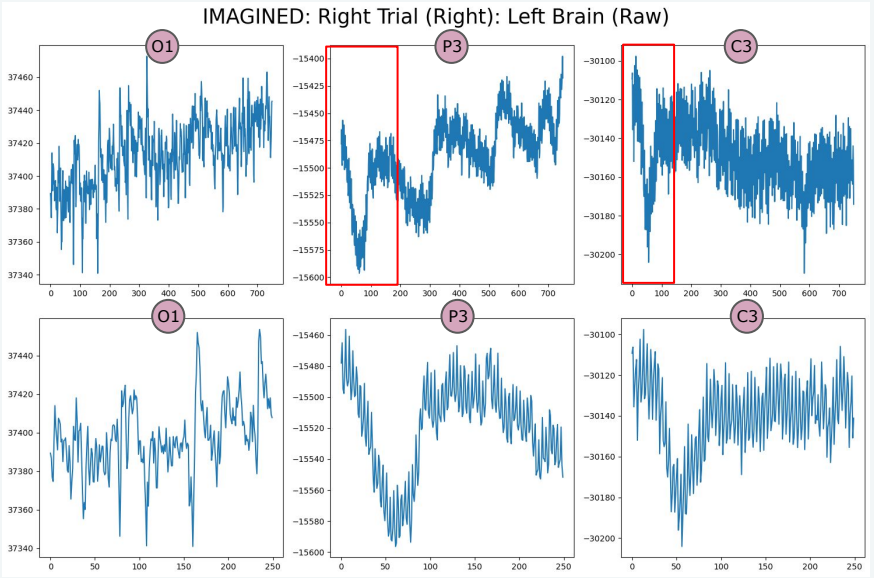

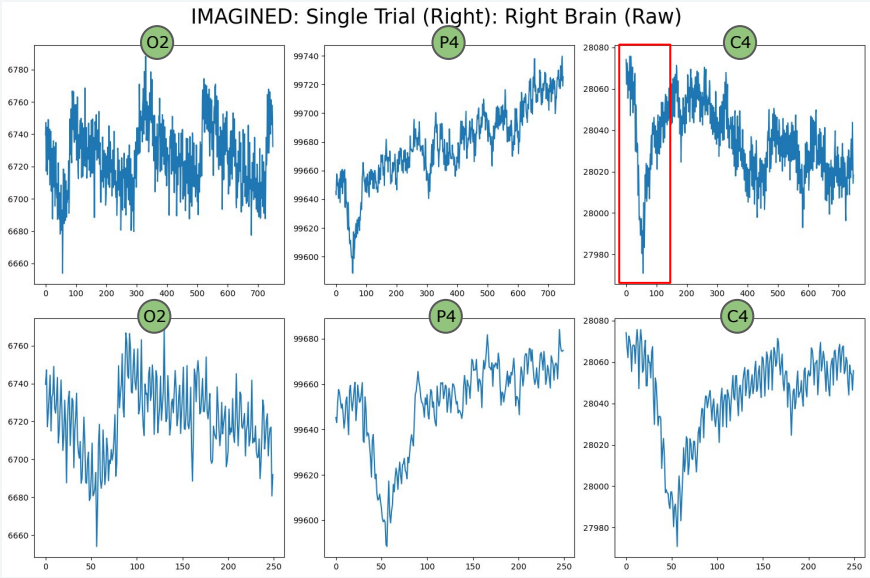

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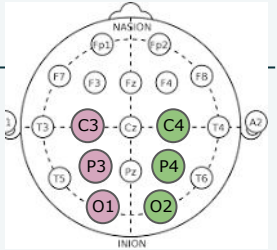
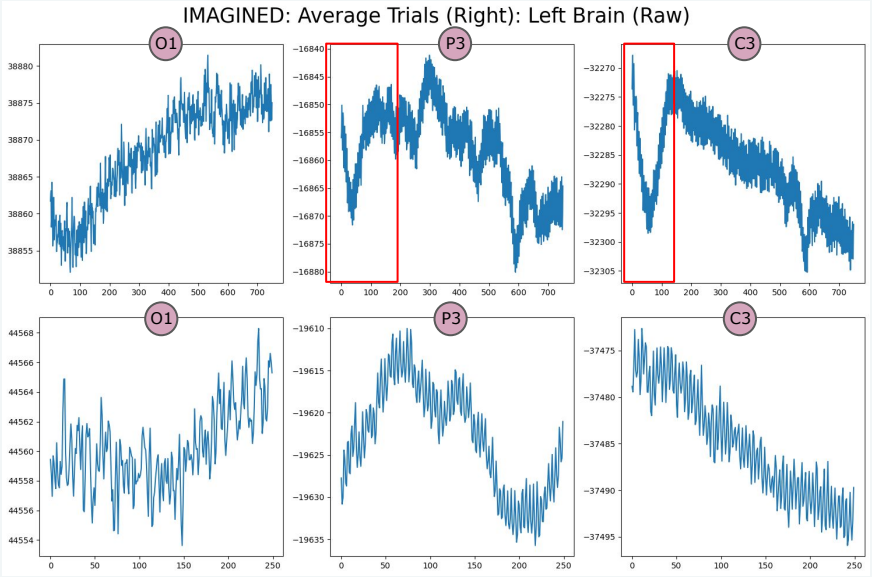
Right brain

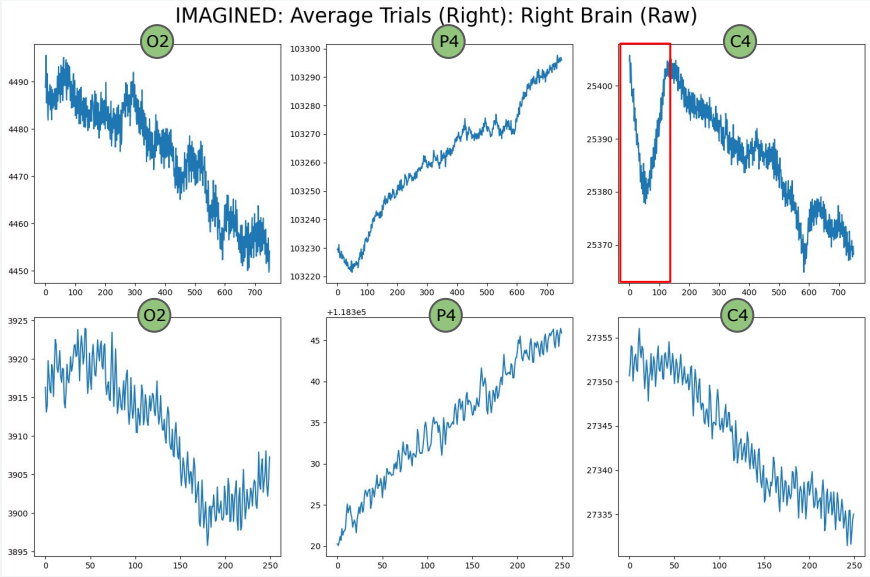
Imagined Right | Average | Raw Data



Imagined

Rest



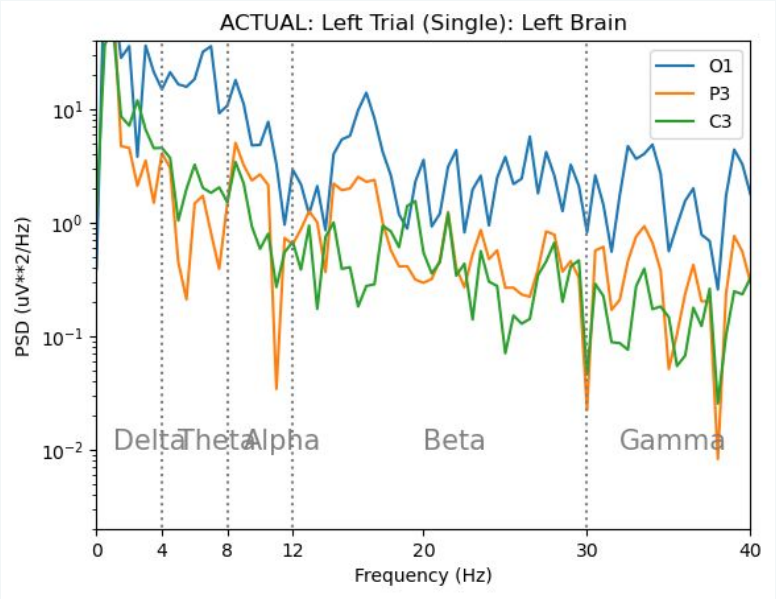


Left brain

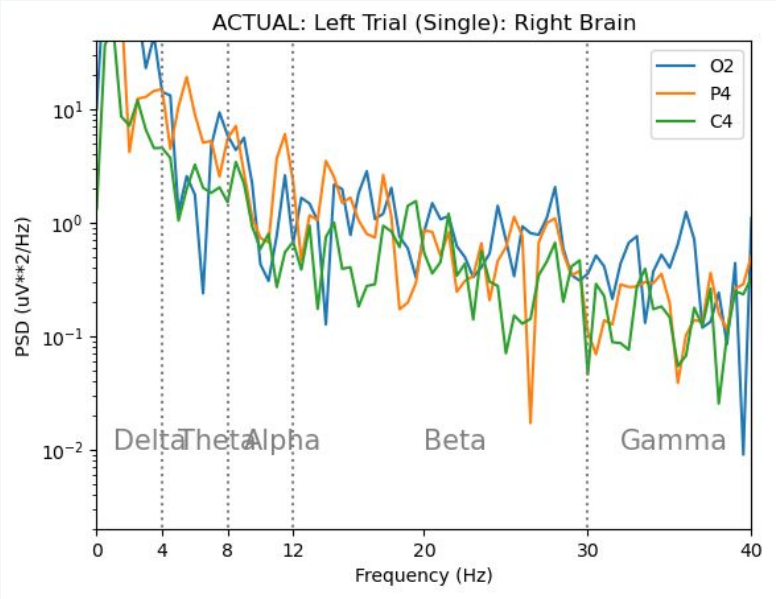
Right brain

Power Spectrum Density

Actual Left

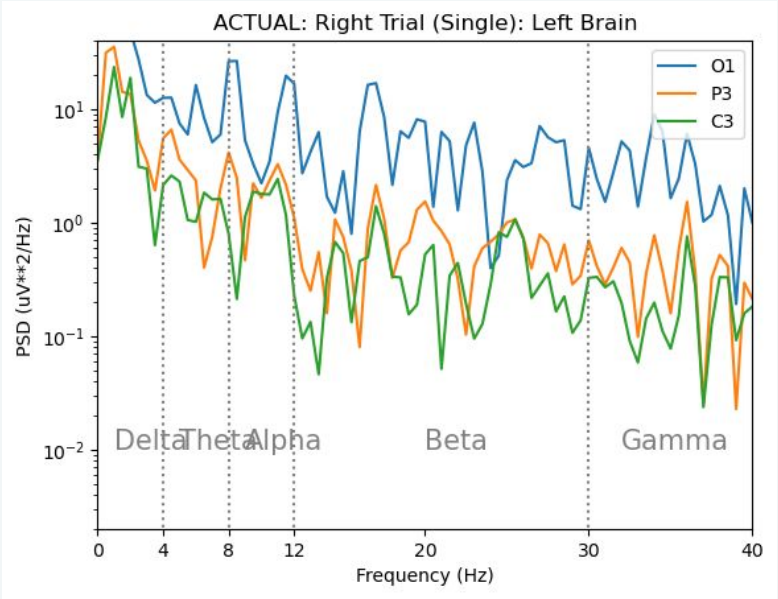


Left brain

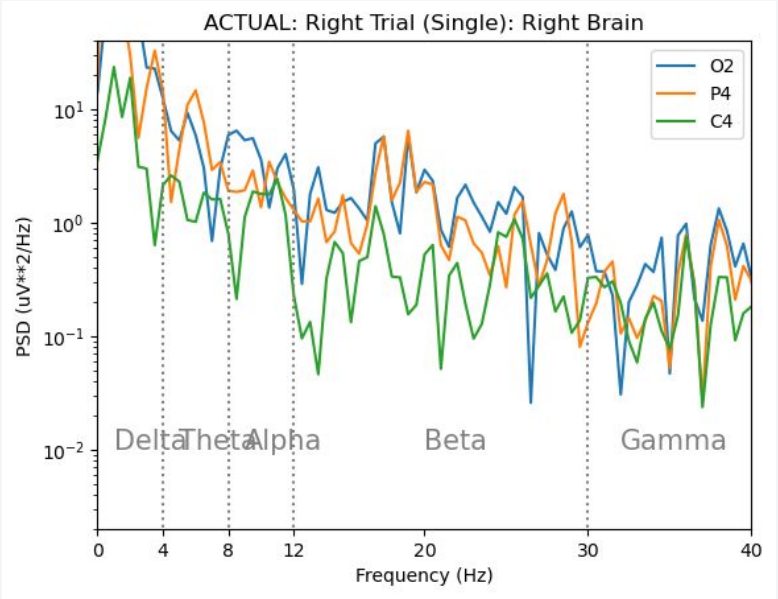


Right brain

Actual Right

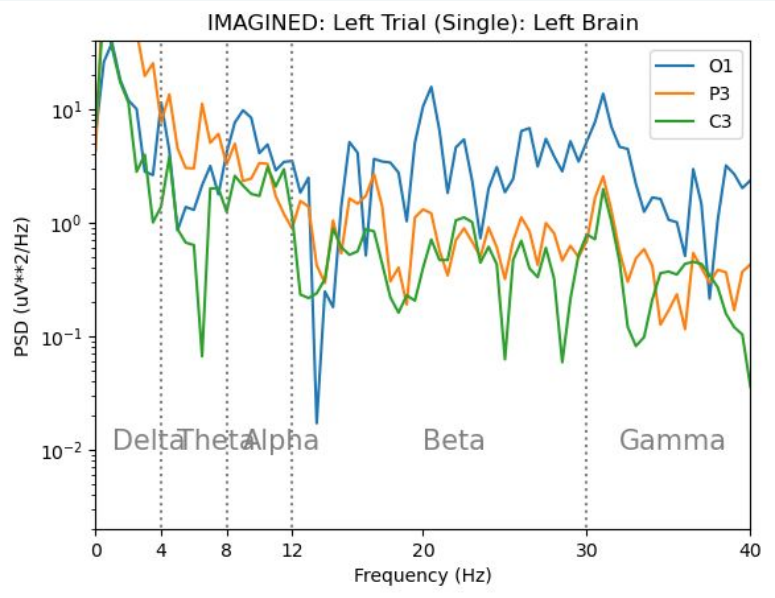


Left brain

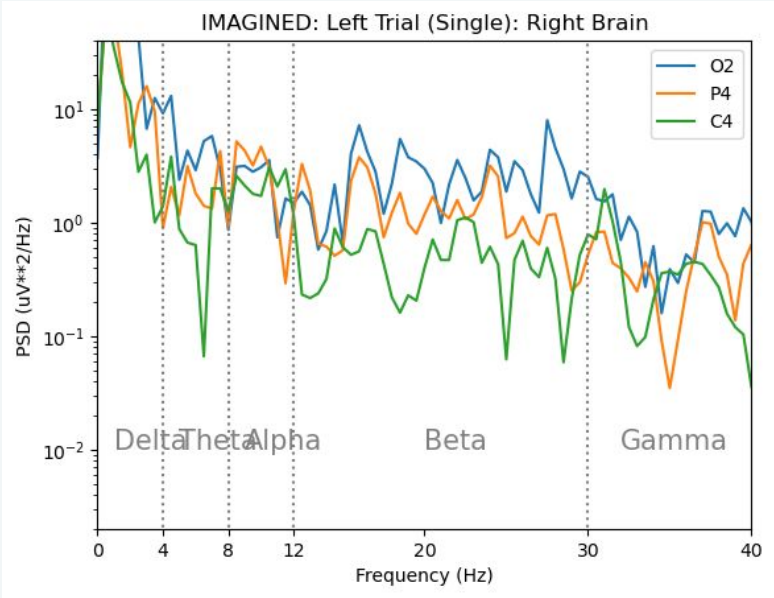


Right brain

Imagined Left

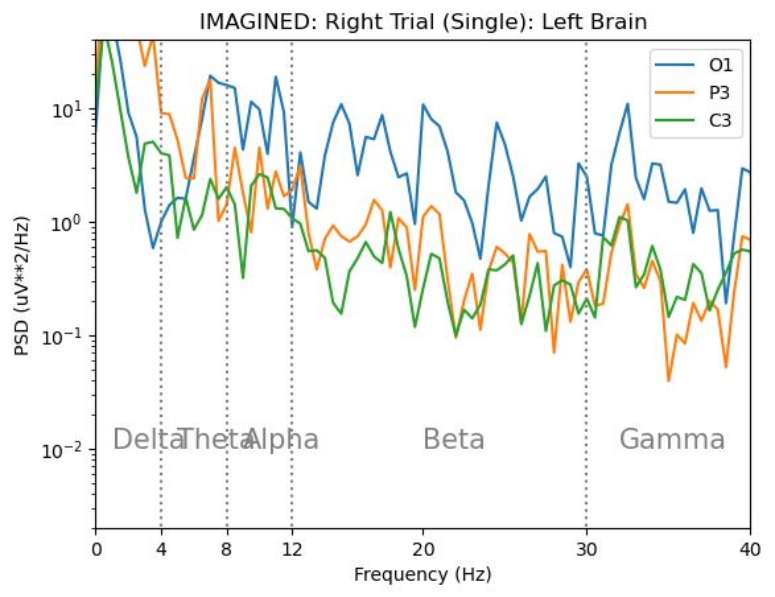


Left brain

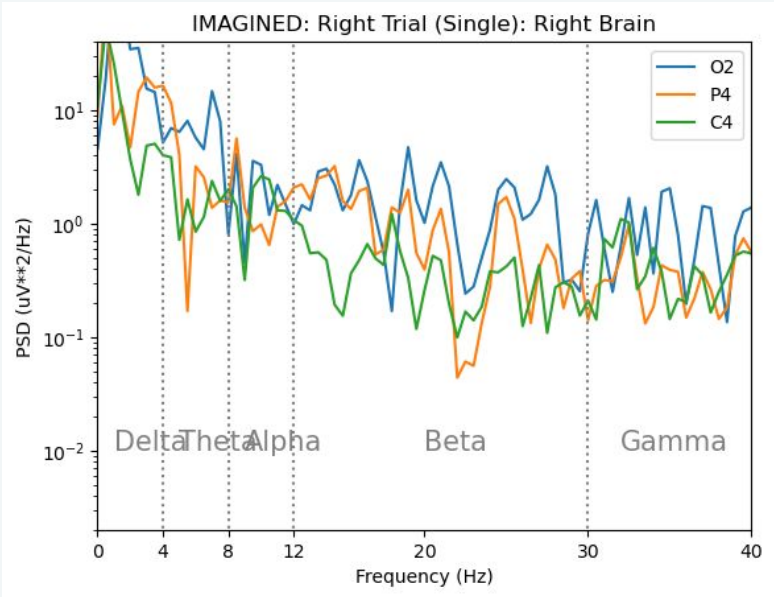


Right brain

Imagined Right



Left brain

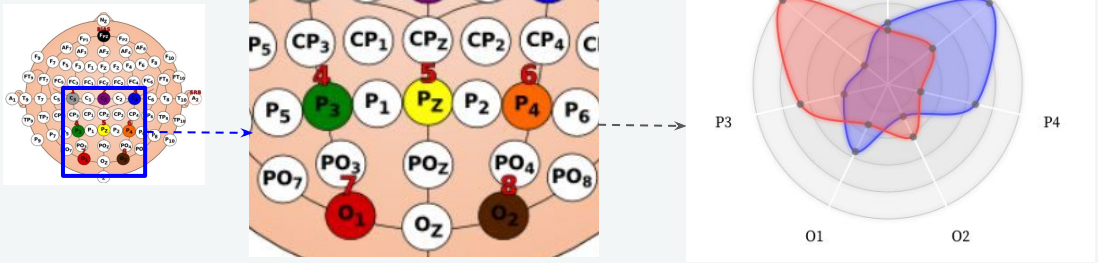


Right brain

Visualization

Visualization

Considering Spatial Visualization of PSD



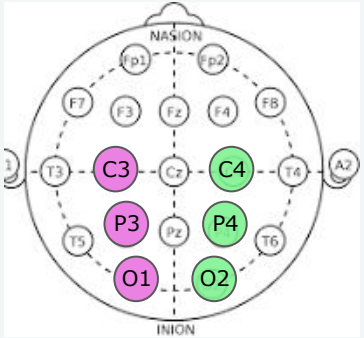
(Sketch)
PSD for right vs. left
hands across electrodes

Channels used for visualization:

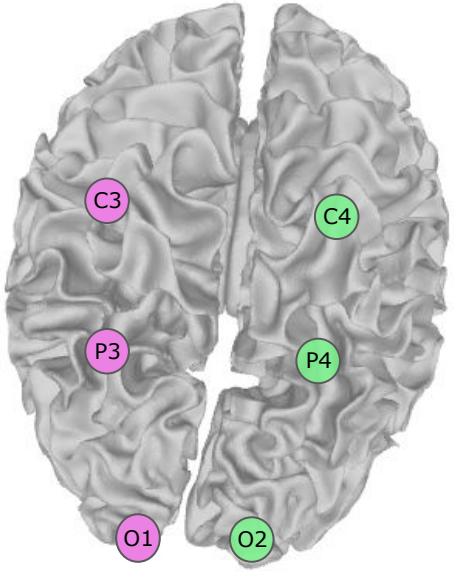
~~Fpz - Ground~~
C3 - channel 1
~~Cz - channel 2~~
C4 - channel 3
P3 - channel 4
~~Pz - channel 5~~
P4 - channel 6
O1 - channel 7
O2 - channel 8

Brain MRI Model

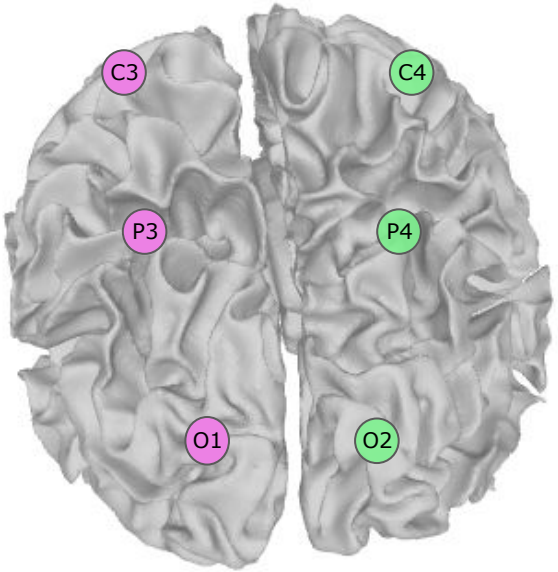
Top View
10-20 map



Top View



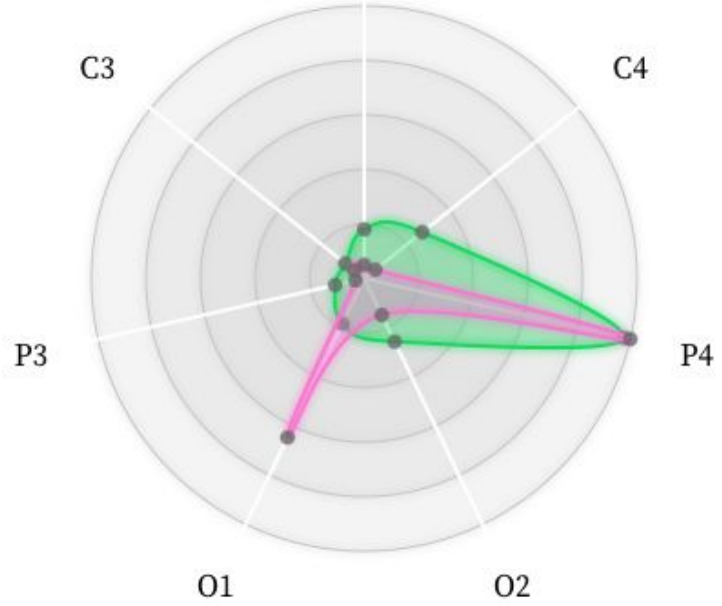
Back view

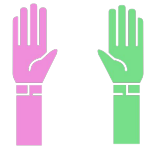


*issues on some data of c4 + c3

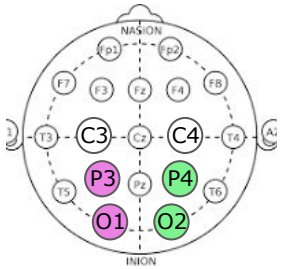
Single Trial PSD%

Actual



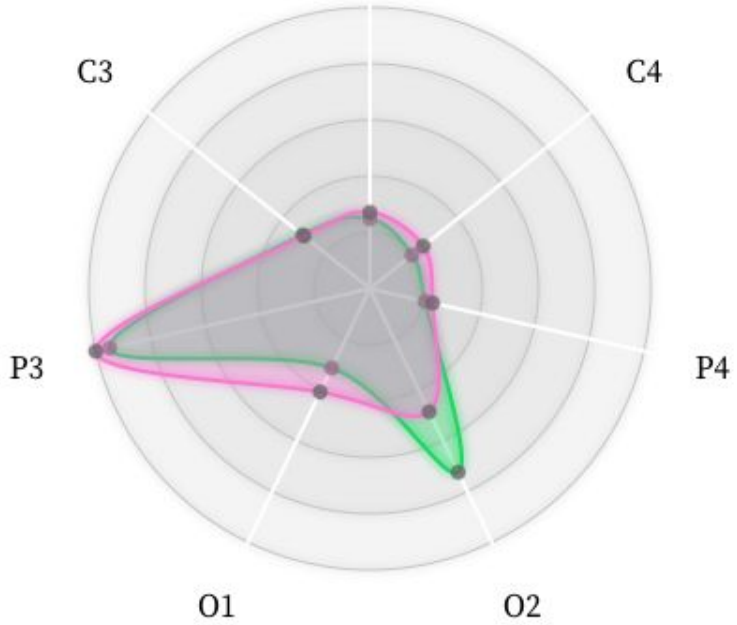


Left | Right



10-20 Electrode Map

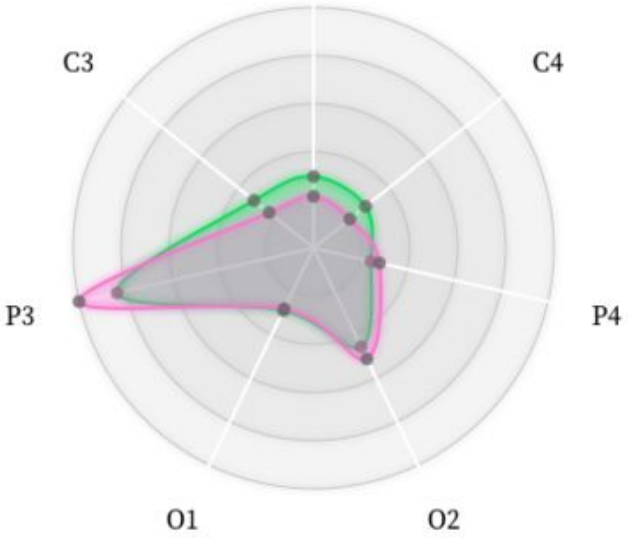
Imagined

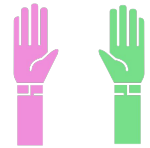


Power Spectral Density % of Actual and Imagined Right vs. Left Hand Movement of a single trial.

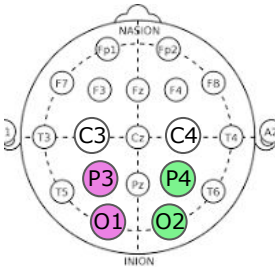
Average of All Trials PSD %

Actual



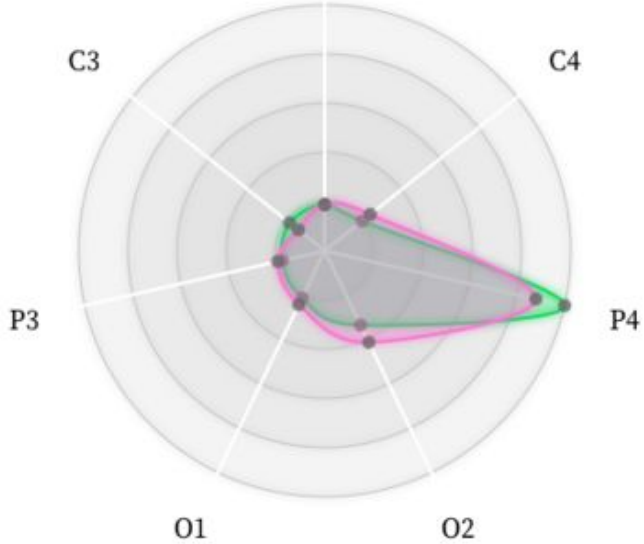


Left | Right



10-20 Electrode Map

Imagined



Power Spectral Density % of Actual and Imagined Right vs. Left Hand Movement of the average across all trials.

Reflection

Reflection

Challenges & Learnings

- Complicated dataset - multiple electrodes
- Data collection fatigue
- Replicability of data collection setups
- Data loading / cleaning / transforming
- Visualization complexity: How to compare multiple signals across multiple parameters

Next Steps

Future work

Next Steps

Technical:

Beyond Right and Left

- Expand data collection
- Build our own classifiers
- gesture prediction
- Use the pipeline to control robots and video game avatars
  - Start with left/right
  - Expand to more directions / body movements

Conceptual:

The future of Brain-controlled Interfaces

- Control robots / avatar
- Explore more body movements
- Explore how imagined input is affected by distractions
- Explore the patterns differences across different users

Thank you!