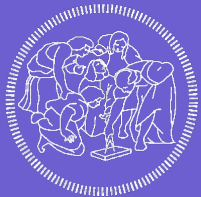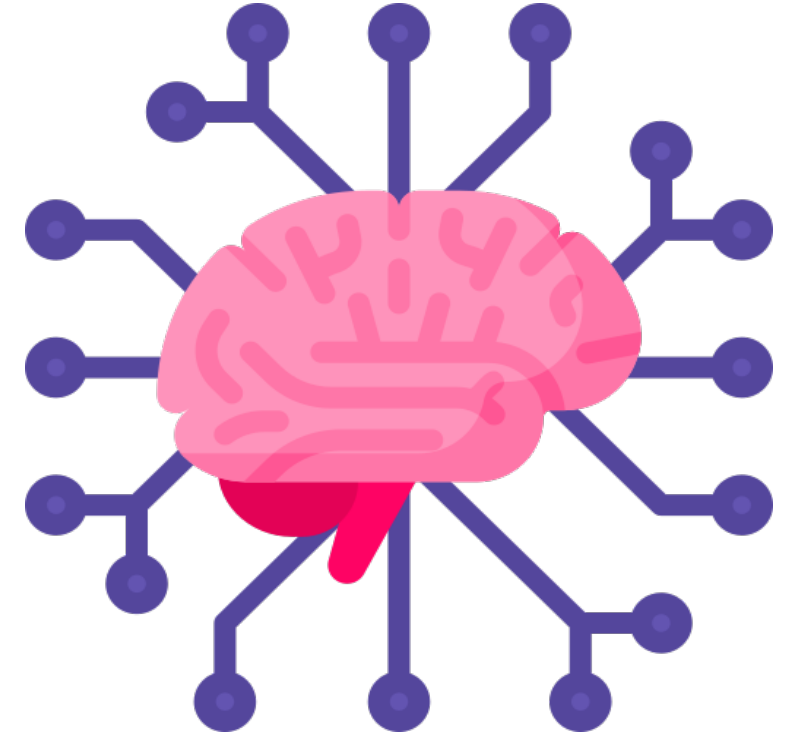**BIOMEDICAL SIGNAL PROCESSING AND MEDICAL IMAGES**

GROUP ASSIGNMENT

TOPIC 3: EEG DURING MENTAL ARITHMETIC

- **INTRODUCTION**
- **MATERIALS AND METHODS**
- **RESULTS**
- **DISCUSSION**

GROUP 13
Balzarotti Camilla   Rebuzzi Sara
Battaglia Emma   Penati Ester

REFERENCE PROFESSORS

Signorini Maria Gabriella, Steyde Giulio, Subitoni Luca

Politecnico di Milano, 13/11/2024

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INTRODUCTION

📰 **Detrended Fluctuation, Coherence, and Spectral Power Analysis of Activation Rearrangement in EEG Dynamics During Cognitive Workload**

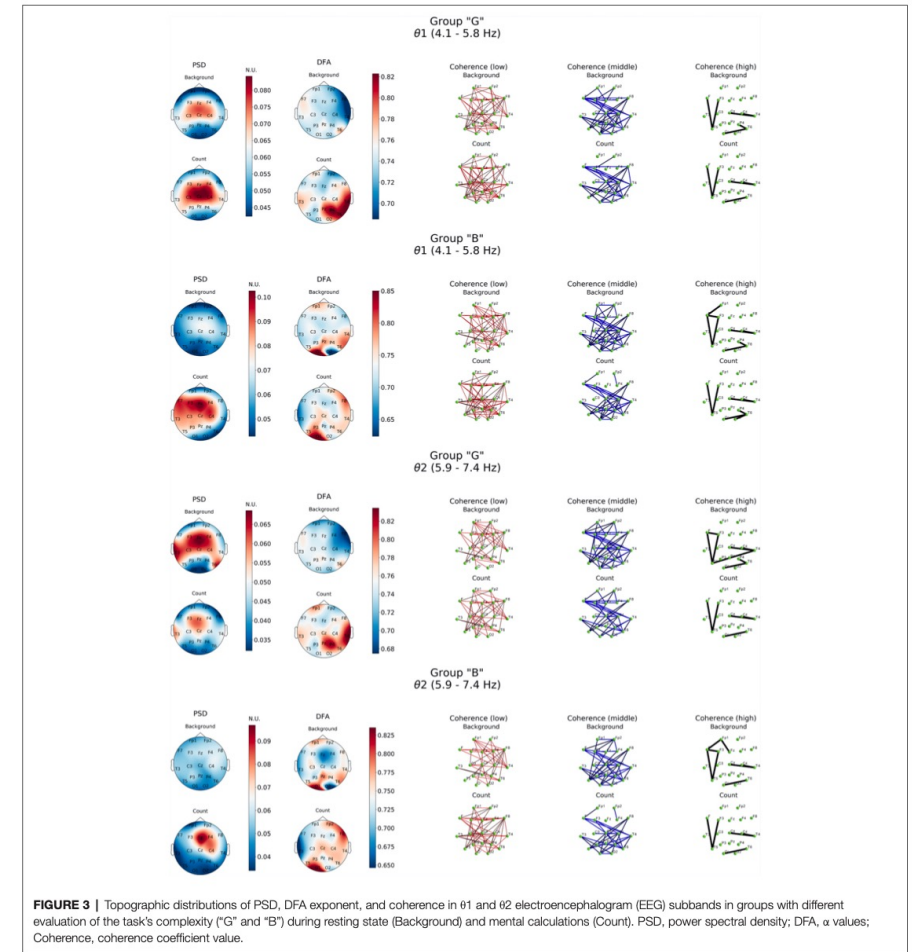*Ivan Seleznov, Igor Zyma, Ken Kiyono, Sergii Tukaev, Anton Popov, Mariia Chernykh and Oleksii Shpenkov*

GOAL

🎯 Understand how brain activity shifts between rest and task-based cognitive engagement

🎯 Identify patterns in brainwave power linked to cognitive states, highlighting both common and individual responses

FIGURE 3 | Topographic distributions of PSD, DFA exponent, and coherence in θ1 and θ2 electroencephalogram (EEG) subbands in groups with different evaluation of the task's complexity ("G" and "B") during resting state (Background) and mental calculations (Count). PSD, power spectral density; DFA, α values; Coherence, coherence coefficient value.

MATERIAL AND METHODS

- 6 subjects

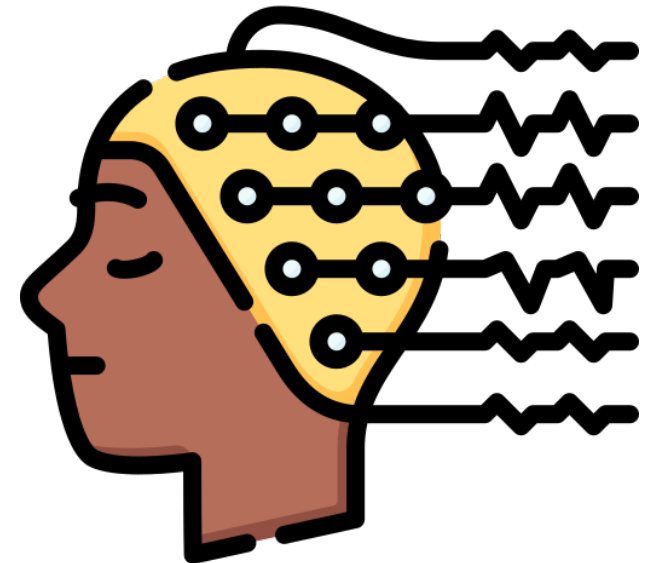- 2 EEG signals for each subject

  Resting state (3 min)

  Arithmetic tasks (1 min)

- 19 channels grouped in 6 key regions

- 3 frequency bands
  - Theta (4–7 Hz)
  - Alpha (8–12 Hz)
  - Beta (13–30 Hz)

- **POWER SPECTRAL DENSITY (PSD)**
- **MAGNITUDE-SQUARED COHERENCE (MSC)**

MATERIAL AND METHODS : PSD

POWER SPECTRAL DENSITY

- Welch's method
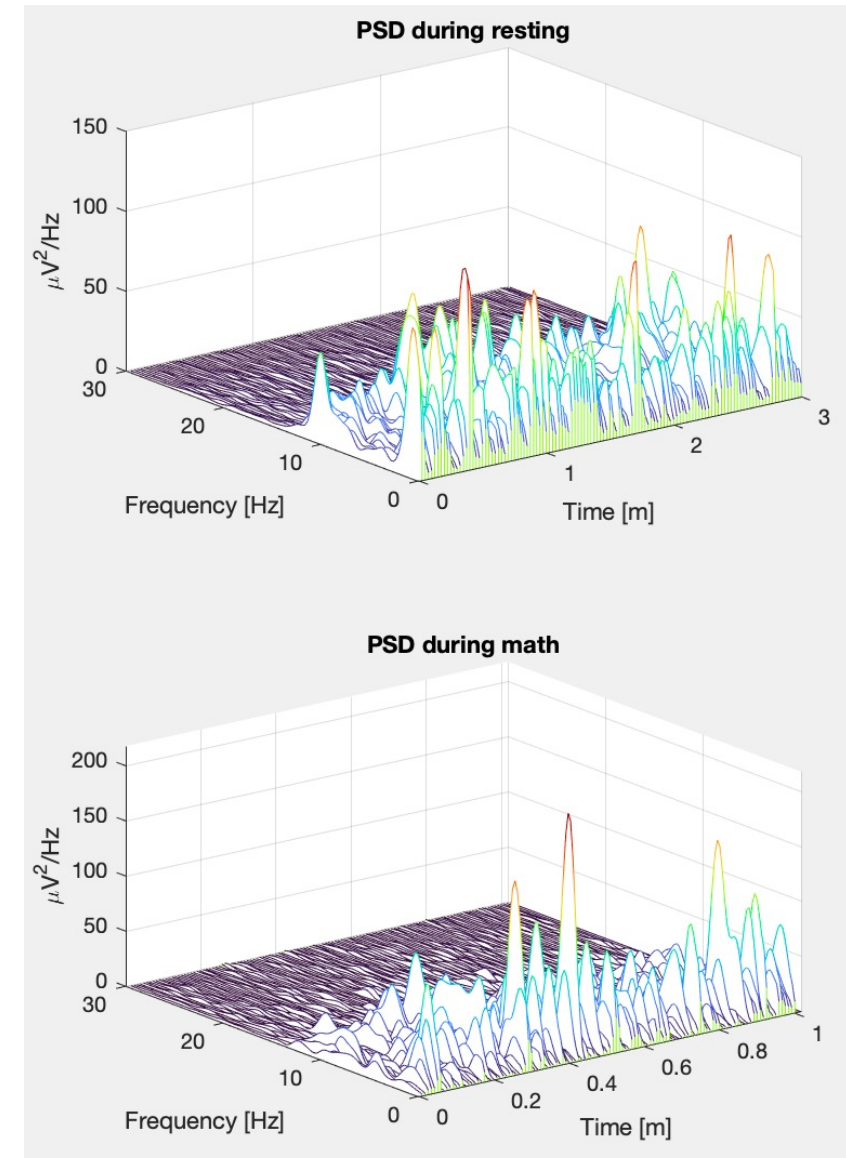- 50% overlap

CUMULATIVE SPECTRAL ANALYSIS (CSA)

To capture the evolution of power across different frequencies over time

- Shown using waterfall

BANDS' POWER DISTRIBUITON

To highlight the variation of the contribution of alpha, beta and theta with cognitive states

- Trapezoidal rule, averaging across each region
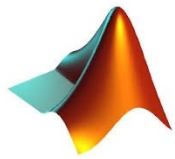- Shown using piecharts

PSD during resting

PSD during math

MATERIAL AND METHODS : MSC

COHERENCE FOR EACH SUBJECT FOR EACH FREQUENCY BAND

- Mscohere function

- Hamming windows

- 50 % overlap

RESULTS REPRESENTATION

- Imagesc:
  coherence of each pair of channels
- Topoplot:
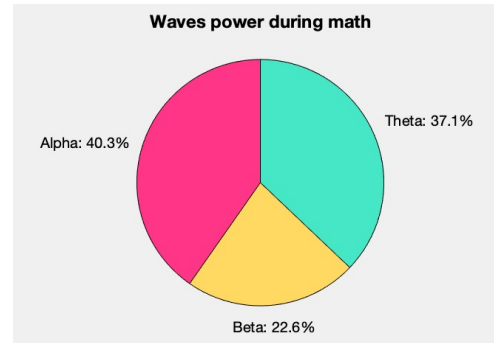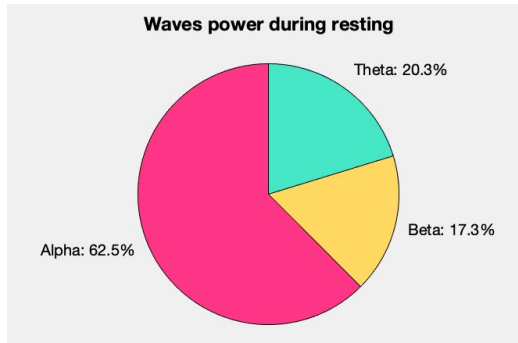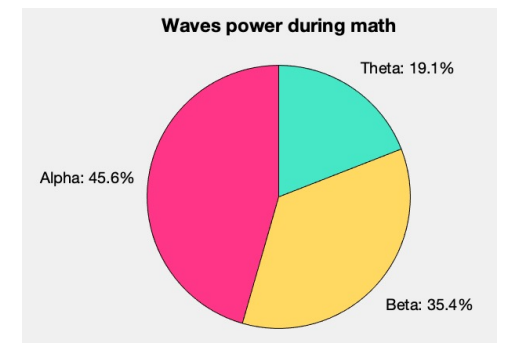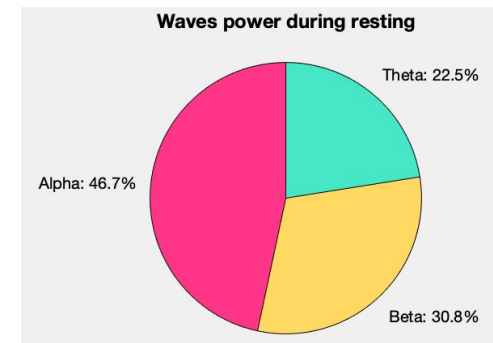 mean coherence value of a single channel

MATLAB

EEGlab
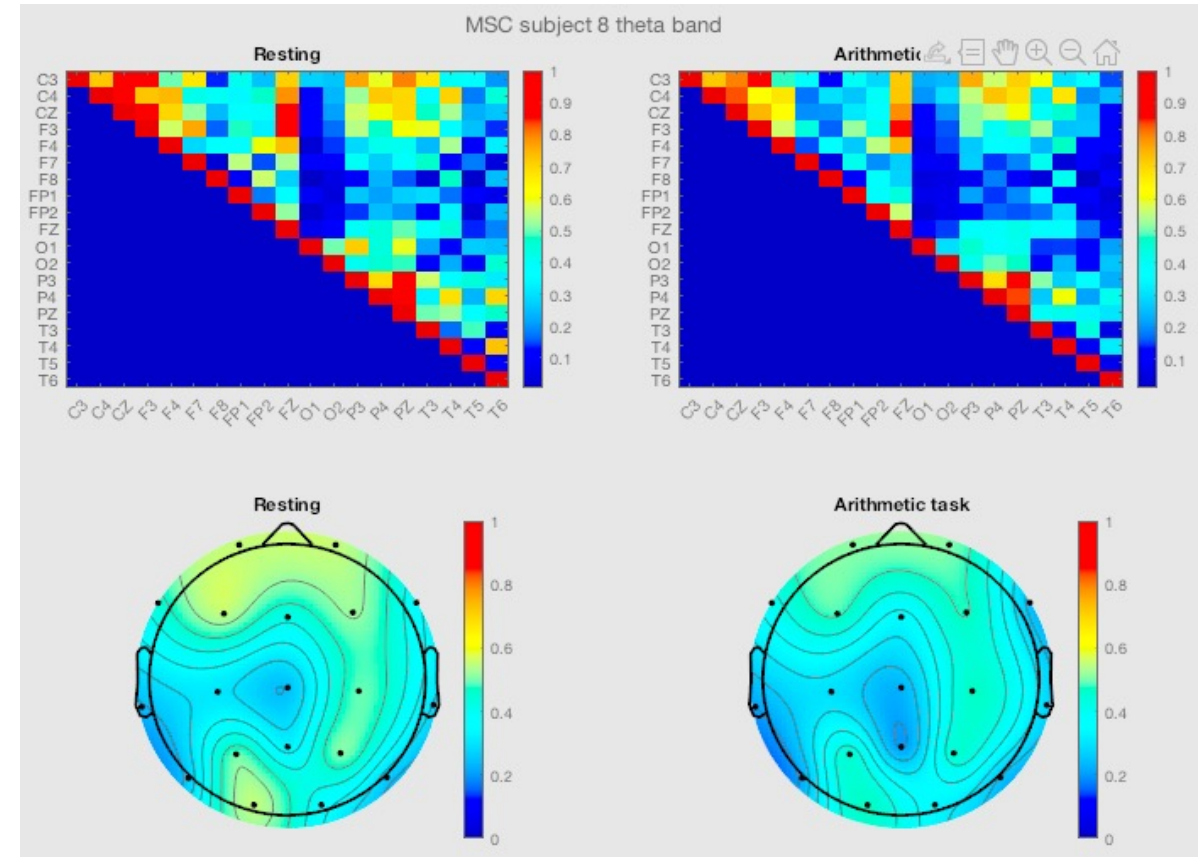
RESULTS : POWER SPECTRAL ANALYSIS
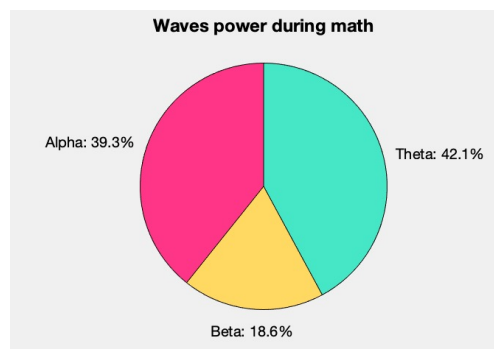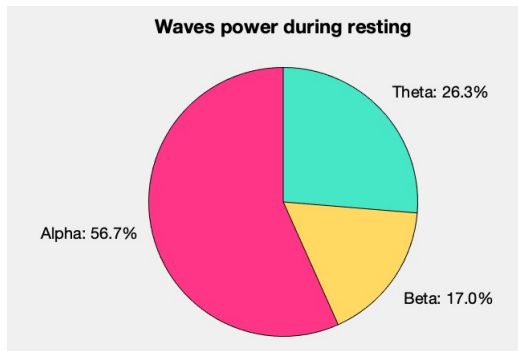
INCREASE IN BOTH BETA AND THETA (5 AND 8)

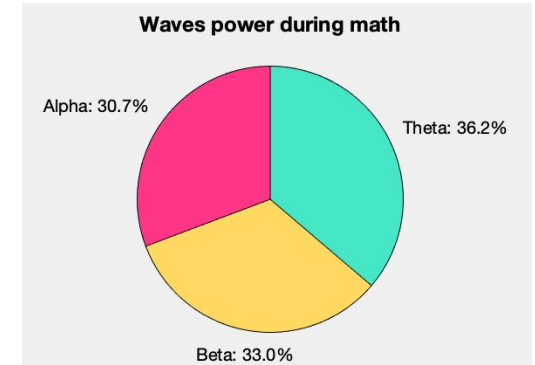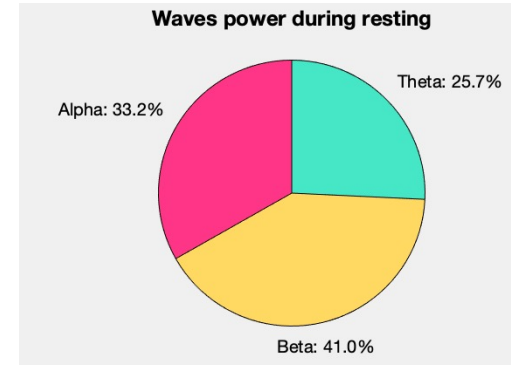INCREASE IN BETA, DECREASE IN THETA (2)

FOUR DIFFERENT PATTERNS

BETA STABLE, INCREASE IN THETA (3 AND 7)

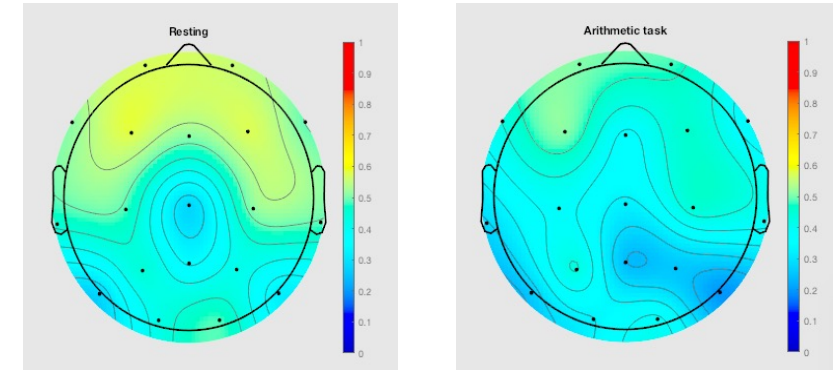DECREASE IN BETA, INCREASE IN THETA (1)

RESULTS : MSC

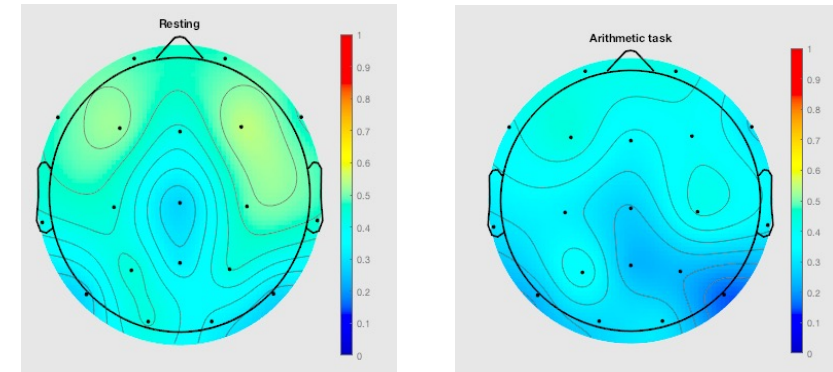## DIFFERENCES BETWEEN FREQUENCY BANDS

- Lower values in beta band in all subjects

- Decrease in subjects 1,3,8 for both theta and alpha band

- Increase in subject 2 for both theta and alpha bands

- Increase in theta band and decrease in alpha band in subject 5 and 7
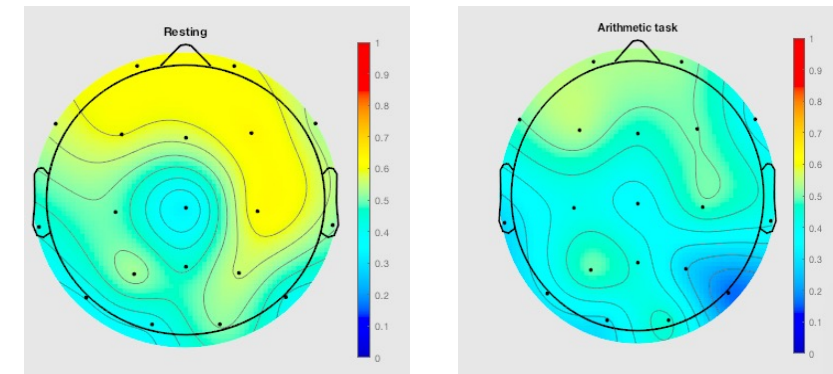
Mean MSC Subject 1:

RESULTS : MSC

DIFFERENCES BETWEEN BRAIN AREAS

FRONTAL AND SYMMETRICAL ANTERIOR FRONTAL
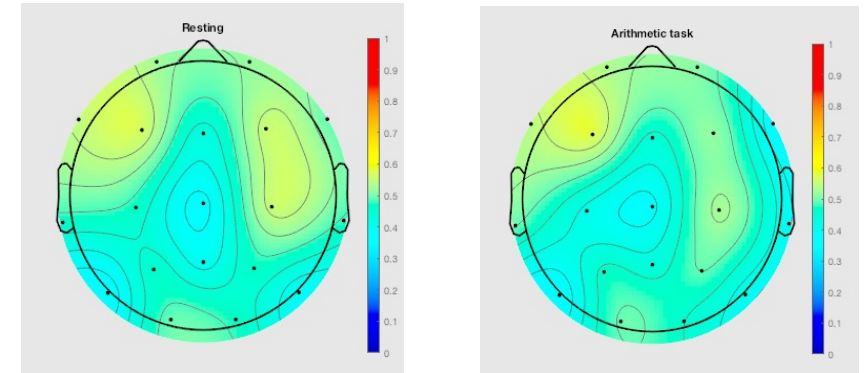- Higher values of mean coherence

CENTRAL
- Lower values of mean coherence
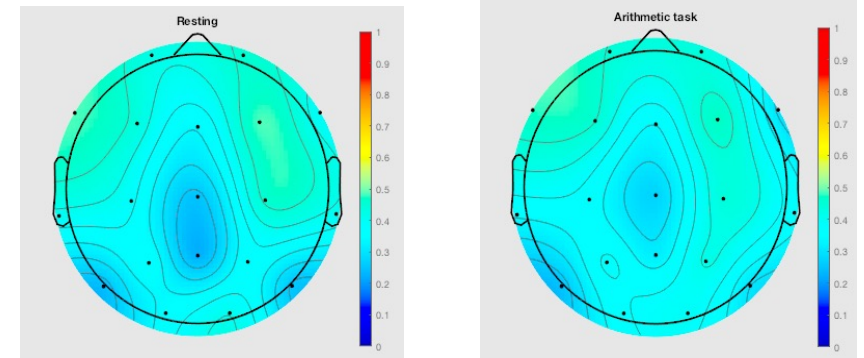
TEMPORAL, OCCIPITAL AND PARIETAL
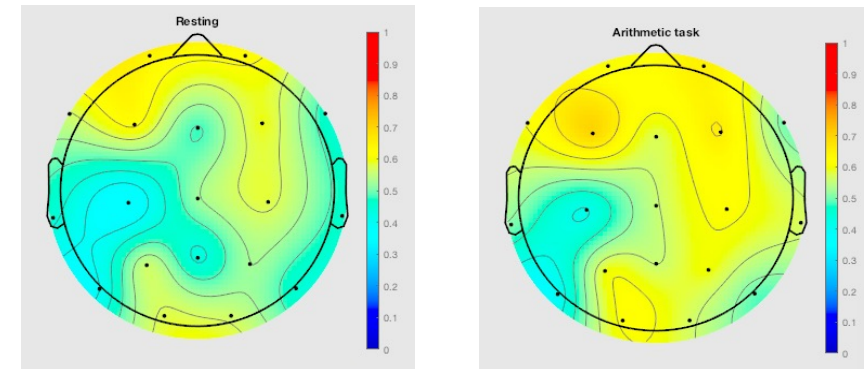- Different behaviour in different subjects

Mean MSC Subject 7 :
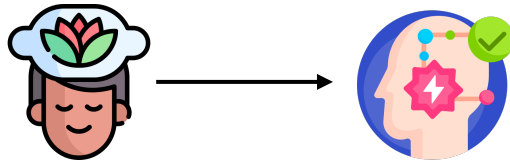
Band alpha:

Band beta:

Band theta:

DISCUSSION

ALPHA

Higher power and connectivity during resting than arithmetic

BETA AND THETA

Changing behavior due to differences in emotional state, level of concentration, individual predisposition to arithmetic task and perception of the task complexity
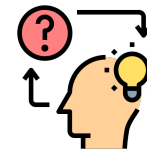
PSD

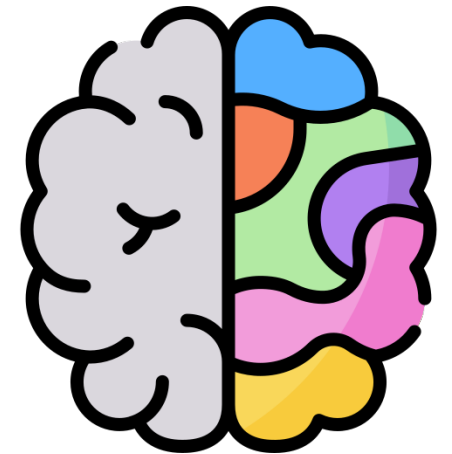No substantial differences in EEG power across the six brain regions
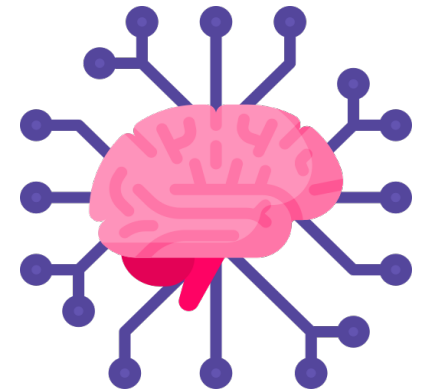
MSC

Greater connectivity values in

Frontal area

Temporal area

THANK YOU FOR YOUR ATTENTION

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