EEG during mental task analysis

Group Number: 17

Mattia

Pezzano

Maurizio

Tirabassi

*Abstract*— The human brain engages in complex neural processing during mental arithmetic tasks. Electroencephalography (EEG) offers a valuable means of examining these cognitive mechanisms on a broader scale. This paper presents a comprehensive analysis of EEG data collected during repeated mental subtraction, with a specific focus on examining power spectral density and coherence. The study investigates how different brain regions behave and interact with each other during the given mental task.

Keywords—SN, beast.

# Introduction (*Heading 1*)

You guys ever try to do mental arithmetic? It's like, "Hey, let's play a game. I'm gonna throw some numbers at you, and you have to answer real quick. But here's the catch, you can't use a calculator, and you can't look stupid. Man, I don't know what it is about math, but it's like our brains just turn into mush. You ever try to split a bill at a restaurant with your friends, and suddenly, you're staring at the receipt like it's the Rosetta Stone? And then there's always that one friend, right? The "Mental Math Master." They're like, "Yeah, I got this, guys. The bill's $137.38. So, with tax, tip, and that random appetizer Karen ordered but didn't eat, that's $17.82 each." And you're sitting there like, "Wait, what? How did you…?" And then, there's me. I'm just staring at the check like it's some ancient scroll. My friends are like, "Shane, what's your share?" I'm like, "Uhh... I think it's 42 gold doubloons, a donkey, and a promise to mow your lawn for a year." Mental arithmetic, man, it's a battlefield out there. It's a struggle. And the worst part is, you can't hide it. You're out there in public, trying to add 7 and 8, and you're like, "I think it's... purple?" People look at you like you're an alien. "Are you even from this planet, bro?" But you know what? We're all in this together. We've all been in that mental math foxhole, fighting for our lives, and the only way out is to mumble some random numbers and hope it works out. So, next time you're at a restaurant, just remember, we're all a bunch of math misfits, and it's okay to be the guy who can't count past five without taking off your shoes.

# Materials and Methods

## Experiment Design

The dataset was acquired to explore EEG correlates during a mental arithmetic task that involved serial subtraction. Participants were seated in a controlled, soundproof environment where they initially underwent a 3-minute period of adaptation, remaining in a relaxed state with closed eyes. Following this adaptation phase, a 3-minute EEG recording was obtained to capture baseline activity during rest. Subsequently, participants engaged in a 4-minute mental arithmetic task, of which 1 minute was provided as data.

## Data Collection

The EEG recordings were obtained using a 23-channel system provided by XAI-MEDICA, Ukraine, with electrode placements conforming to the International 10/20 scheme. All channels were sampled at a rate of 500 Hz. The data was supplied in a partially preprocessed state, involving the application of a high-pass filter with a 0.5 Hz cut-off frequency, a low-pass filter with a 45 Hz cut-off frequency, and a power line notch filter set at 50 Hz.

## Data Preprocessing

Upon conducting an initial visual analysis of each channel, our observations revealed the presence of artifacts, notably an excess of 1000 samples, which we subsequently decided to omit. To ensure the temporal stability and stationary nature of our stochastic signals, we adopted a methodology involving the extraction of a 45-second window from the central portion of the available data. This approach was chosen to capture the most representative aspects of the two distinct neurological activities under investigation. Consequently, the total sample count was reduced to 22,500, constituting a 75% reduction for the resting state and a 25% reduction for the active cognitive engagement state. **Figure II.1** provides a concrete example of EEG signal preprocessing, illustrating the data before and after this step. Sample rate was kept as such because reference\*.



Figure . Example of time series preprocessing

## Power Spectral Density

The power spectral density of the signals was computed using the Welch method (reference a Welch 1970). The window size (5000 samples) and overlapping (10%) was decided by copying the reference paper xd.

Normalization of the work power spectral density with respect to the rest one to highlight the differences and logarithmic scale for easier visual analysis.

Highlighting the already filtered out instrumentation noise at 50 Hz.



Figure . Example of normalization

Division for frequency bands and calculation of the energy level for each relevant frequency band.

We decided to choose the bands from literature and consider the split in the beta one as the reference paper did:

alpha beta gamma etc etc.

## Coherence

Je sais pas mon frére.

# Results

As we were able to deduce from the topographical maps the trend among subjects was that of higher activation of the occipital cortex for alpha bands and frontal for beta.

A group of circles with different colored circles

Description automatically generated

References to band literature\*\*

References to hemisphere literature\*\*

The boxplots show how psd values are distributed among subjects per different frequency bands relatively to lobe. It’s interesting to notice how the right and left temporal lobes, even if far apart, behave almost in the same way.



Figure . Boxplot

Five boxplots. We decided to consider the central and parietal lobes as one (reference to paper that examines similar behavior for alpha and beta between the two lobes xdxdxd\*).

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*a**b* 

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##### Acknowledgment *(Heading 5)*

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##### References

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