Brain Activity in Reading From Paper and From Screen
Archaeology of Intelligent Machines

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Abstract

In this project, our aim is to find possible differences in the way the brain is activated and whether attention and comprehension differ when reading on paper or on a digital screen. We are using a portable 8 channel OpenBCI Cyton Biosensoring board in order to gather electroencephalograms, printed paper and a smartphone to read from. The data is analyzed using the MNE Python Library.

1 Introduction

Contributions:

- Alex: gathered the data, developed the code
- Ilinca: interpreted the results, composed the report

In the era of technology, the question of whether reading from a smart screen has the same effect as the old paper has always been up for debate. In an effort to gain more insight and a deeper understanding of the answer, the team decided to take this project.

Alex, while measuring its brain activity with the biosensor board, read a fragment of a book, first on a paper, then on his smartphone for approximately 5 minutes. To have a frame of reference, he also measured brain activity when he held his eyes open and closed, staying relaxed. The electroencephalograms were then interpreted in Python. The PSD - statistical instrument, was calculated for each of the 4 states (reading on paper, reading on the smartphone, relaxing with eyes opened and relaxing with eyes closed). The results indicate that cognitive activities such as reading from paper or a screen are associated with increased brain activity compared to resting states like eyes closed or eyes open. This finding is expected, given the mental engagement required for these tasks. However, the data shows that average power is generally higher during paper tasks than screen tasks, suggesting that paper-based activities might involve a different or more intense level of cognitive engagement. This could be influenced by various factors such as the room's lighting, the text size on the screen, or the physical discomfort of holding paper.. The results that have been plotted highlight the distribution of the frequencies for each state.

2 Approach

A band-pass filtering was applied for 0.5-30 Hz, as other frequencies would not serve the scope. We used Power Spectral Density (PSD)- a statistical instrument that is based on the Fourier Transform, as it transformes the signals from time domain to frequency domain. The signal is divided into overlapping segments, Hanning function is applied for smoothing, then all segments have PSD computed and averaged for a smooth estimate.

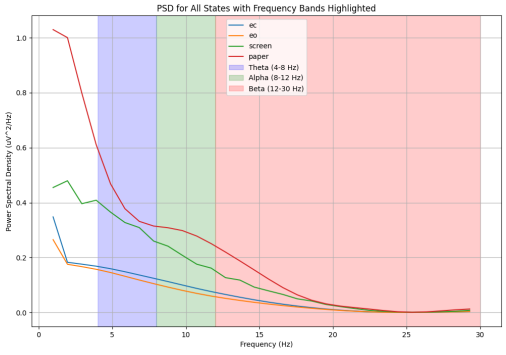

Figure 1: PSD

There are 3 bands of interest we focused on, activity in each representing different states and functions of the brain. Theta - 4-8 Hz is associated with relaxation, meditation or daydreaming, creativity, emotional connection and memory formation, Alpha - 8-12 Hz indicates relaxation but in a alert state, mental coordination and readiness,

whereas Beta - 12-30 Hz is indicates high-level cognitive function such as learning and memory, problem solving and heightened perception. When comparing reading activities with relaxation states, it is evident that reading engages the brain more intensively, with notable differences between reading from paper and from a screen.

The observations from the plot reveal the following:

Theta frequencies (4-8 Hz): Higher PSD values in the Theta band are noted during tasks labeled as 'paper' and 'screen', which are attributed to activities demanding high attention and involving memory processing.

Alpha frequencies (8-12 Hz): Higher PSD values in states labeled 'paper' and 'screen' compared to 'eyes closed' and 'eyes open' indicate that cognitive activities are associated with this band. Additionally, the PSD values for paper are higher than those for screen, possibly due to external factors such as holding the paper and turning pages.

Beta frequencies (12-30 Hz): The 'paper' state (red curve) exhibits the highest power in the Beta band, which is linked with focused attention, problem-solving, and active mental engagement. This suggests that reading from paper requires more sustained attention compared to other states. The 'screen' state (green curve) also shows significant activity in the Beta band, indicating attention, albeit less intense than the paper state. This difference might reflect varying cognitive demands between the two mediums.

Cover at least the following aspects:

1. https://github.com/alexncrsc/Brain-Waves-in-Reading-A-Comparative-EEG-Study

2. tools used: openBCI GUI, cyton 8 electrodes EEG

3. total time of recording: 1 min eyes closed/opened, 5 mins per reading env, 1 min per pause between states

4. algorithms used: Fourier transform, PSD, filtering

3 Limitations

While we are open to different types of limitations, we tried to do our best to get the best results. Using just 8 electrodes gathers less input than using 32 electrodes like the high advanced new gen EEGs machines. Also trying to record the data while reading from the paper was pretty difficult due to noise factor, Alex changed the page and hold the book while he was reading from it trying to be relaxed at the same time to not influence the recordings in any way.

4 Conclusions and Future Work

- Now that we finished this project, thinking back on our work we could set better recording conditions like helping each other when recording one to hold the book and changing the page to avoid noise, or maybe reading text fragments that were more neutral to us than a childhood book. To obtain more relevant results, we could have collected electroencephalograms from multiple individuals while analyzing a diverse set of texts, enabling us to work with a more generalized dataset.

- This project can be improved by adding more electrodes to the Cyton and trying to record more significant data

- Project was really interesting, analyzing brain frequencies is a different type of work, being able to work with an EEG technology is really something different.

- We were capable of understanding better how PSD, Fourier transform and brain frequencies work, and of course that reading from paper is higher demanding that screen reading over short periods of time.

- We found the project interesting and enjoyed working on it. For Alex, brain activity is an area of interest, as he also chose the subject of his bachelor's thesis around it. The results of the experiment really intrigued him. Ilinca enjoys understanding and working with data. She was interested in learning about the statistical instruments used and being able to apply the ones she studied.