THE ANDREW & ERNA VITERBI FACULTY OF ELECTRICAL ENGINEERING

SIPL
Signal and Image Processing Lab

TECHNION Israel Institute of Technology

Brain activity during reading a text from a screen vs reading a text from a paper

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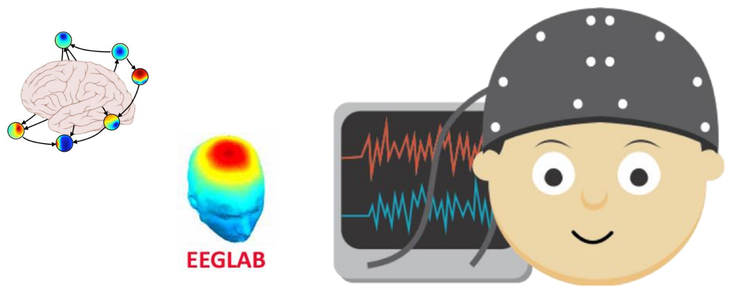
Introduction

- The literature focuses on the behavioral differences between reading from paper and reading from screen.
- Previous spectral analysis studies on EEG data suggested that exposure to screen is related to high spectral energy at certain frequency ranges (theta and theta\beta).
- However, there is a gap in knowledge regarding the neural correlates that underlie the behavioral differences between reading from paper and reading from screen.



Participants

15 typically developing 6-8 years old children.

Behavioral findings

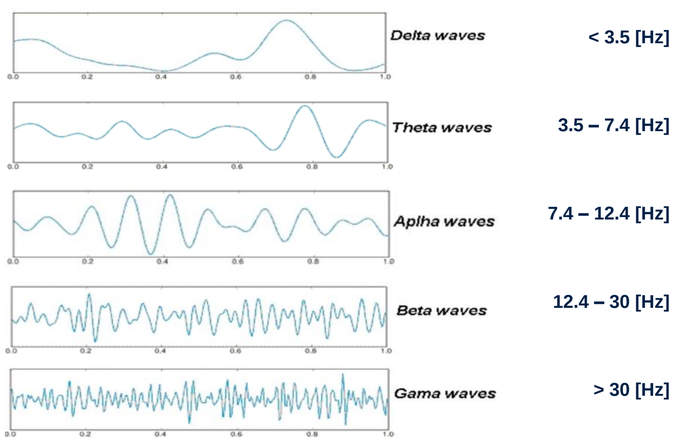
In the comprehension tests no difference was found between reading from paper and reading from a screen.

Goals

- Studying the differences in the brain's electrical activity using EEG between two reading conditions reading from paper vs. reading from screen.
  - EEG signals pre-processing
  - Spectral analysis to compare between the two conditions
  - Connectivity analysis to compare between the two conditions
  - Statistical analysis

EEG signals

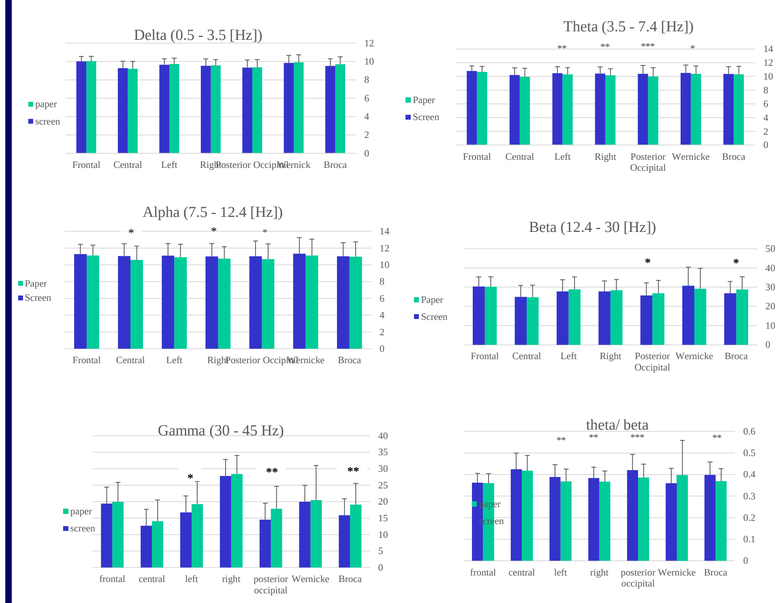
- The EEG is typically describing in terms of rhythmic activity and transients.
- The rhythmic activity is divided into bands by frequency.
- Lower frequencies are associated with a state of relaxation and "levitation".
- Higher frequencies with a state of concentration.



Artifact rejection

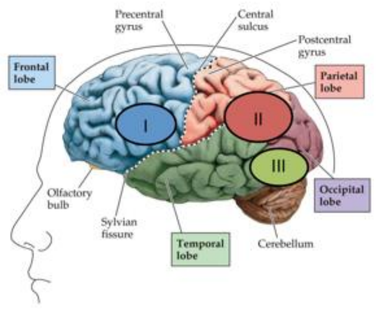
This is an example for channel rejection

Results – spectral analysis



- Higher spectral power at the low frequency ranges (alpha, theta, theta/beta) when reading from a screen compared to reading from paper, which indicates less focused attention.
- Higher spectral power at the high frequency ranges (beta and gamma) when reading from paper compared to reading from a screen, which indicates higher concentration.

Connectivity analysis - Lobe mapping



Frontal lobe – speech production, fluency reading and grammar comprehension.
Parietal lobe – connecting letters into one word, linking the parts of the brain in reading task.
Occipital lobe – processing of visual information.
Temporal lobe – decoding / diagnosis in sounds.

Effective Connectivity

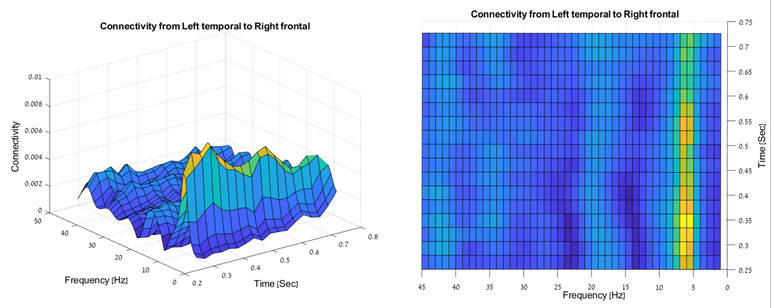
Frequency domain – The information about the connectivity will be contained in the matrix:

$$H(f,t) = A^{-1}(f,t) \;\; , A(f,t) = \sum_{k=0}^{p} \widehat{A^k(t)} e^{-j2\pi kf}; \;\; A^0 = I$$

$$dDTF(f,t) = \frac{|H_{ij}(f,t)|^2}{\sum_f \sum_{k=1}^{M} |H_{ik}(f,t)|^2}$$

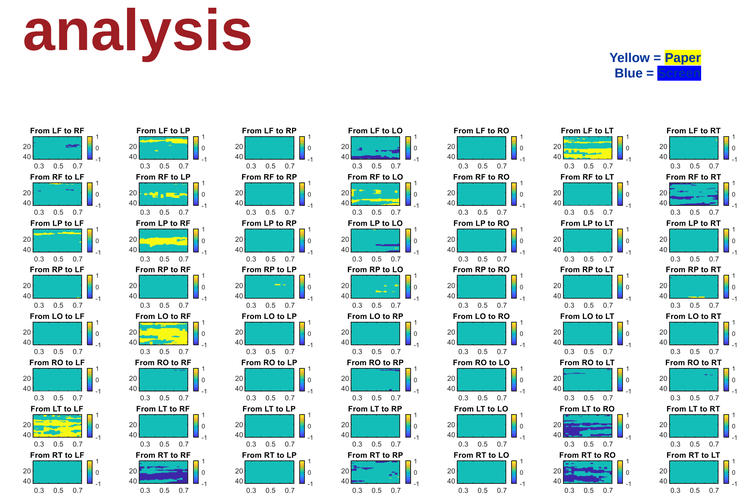
While i, j, k $-$ *brain areas indexes* , M $-$ *number of brain areas*

Connectivity analysis - example



This is an example for connectivity flow from left temporal lobe to right frontal lobe for random subject
yellow – high connectivity value,
dark blue – low connectivity value

Results – connectivity analysis



- High connectivity between the frontal areas (right and left) and the left side of the brain for reading from a paper.
- Higher connectivity between the right temporal region and the right side of the brain for reading from a screen.
- In the connection between the left temporal lobe and the left frontal lobe there is a significance for reading from a paper.

Conclusions

- A pipeline for EEG data preprocessing was successfully applied using MATLAB**.**
- In the comprehension tests no difference was found between reading from paper and reading from a screen.

Spectral analysis conclusions:

- At low frequency ranges (alpha, theta, theta/beta) one can see significance increase in the spectral power when reading from a screen vs. paper, which indicates less attention.
- At high frequency ranges (beta and gamma) one can see significance increase in the spectral power when reading from a paper vs. screen which indicates a higher concentration.

Connectivity conclusions:

- Putting together with previous literature, we found a positive connection between left frontal (which related to language) and left temporal (related to visual word) areas while reading from a paper, which indicates a better reading ability in paper reading.

June 2021