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QUANTITATIVE ANALYSIS OF EEG SIGNAL PATTERNS WITH RESPECT TO AGE AND GENDER

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ABSTRACT---

This research is aimed at analyzing EEG data streams from FP1 and F7 channels that reflect activities of the left side of the human brain with respect to age and gender. It is mainly focused on finding significant variations in brainwave patterns which are emitting from frontal Parietal positions of children and adults in both genders. EEG data gathering, data extraction, data cleaning, and data filtering technologies were used to observe variations in brainwave patterns with children and adults especially in regions of the brain associated with logical thinking and linguistics. *Keywords— EEG, Classification, Filtering, Band Pass, Butterworth, 10-20 System*

INTRODUCTION

The brain is the most important and the most complex human organ that is responsible for all the functions that we do in our routine life Moreover, the brain consists of millions of neurons that utilize electro-chemical signals to transmit information to other parts of the body. Whenever a neuron triggers an electrical impulse to another neuron, it will generate electricity which is referred to as an EEG wave which can be measured by a sensitive device.

Therefore, numerous experiments have been conducted to analyze EEG pulses to find out the relationship between several human mental states and EEG wave patterns to recognize human behavior and characteristics. In this study, we analyze such brainwaves obtained from individuals within same environmental conditions to uncover hidden relationships in age and gender.

The goal of this research was to identify the differences in brainwave patterns between genders as well as among different age groups. We conducted the study in three main steps, namely data gathering, data cleaning & processing, and result observation.

After collecting individual EEG data streams, we created a sample space which consisted of four subjects with EEG data streams but all the data contained significant amount of noise which were added at the data collection stage which lead to the next important step of the research which was named as data cleaning and processing.

We will be explaining the data cleaning and information extraction part in a separate section in this paper. For the data cleaning process, we used an open source tool called EDFBrowser and MATLAB with Excel tools for data extraction and visualization.

EEG Data Gathering

In this stage, data of 22 healthy humans were collected from publicly available sources. All the related information was gathered by investigators from Children's Hospital Boston (CHB) and the Massachusetts Institute of Technology (MIT). who then created and published this database on Physio Net [3]. It contained information on 5 males and 17 females whose ages ranged from 6 to 22 years. All the data was recorded with 256 Hz within a 16-bit resolution.

During data collection, the electrodes were placed in accordance with the international 10-20 system [Figure 1] which is a widely accepted standard for electrode placement in EEG related studies. For this research, we used FP1 and F7 channel data. Our sample data set (given in Table 1) contained EEG data gathered from four subjects with nine data samples from each. All the data were collected at random times points.

From the existing data set, we selected four special subjects for our study and data gathered from two specific channels (FP1 and F7) as shown in Figure 1. The primary objective of this research is to find out whether there is a difference between males and females regarding EEG signal patterns emitted from the front left brain during logical and linguistic tasks.

Since all the data were gathered from one research project, we can assume that the environmental conditions are identical for all subjects. Also all brainwave data were taken from a highly reputed data sources to reduce errors which can occur during data collection. Because all the data were recorded in .edf file format, we used an external tool to visualize the recorded data and apply filtering techniques to our data set.

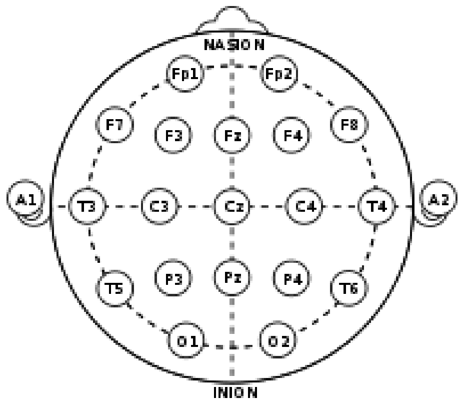


Figure 1: International 10-20 system. [2, 10]

Table 1: Extracted Subject Overview [3]

Subject	Age (y)	Gender	Sample size	Total records
A	11	M	9	2304
B	11	F	9	2304
C	22	M	9	2304
D	6	F	9	2304

III. METHODOLOGY

As all EEG data used in this project were in .edf file format [3], data gathering, cleaning and processing involved several additional steps.

In the first phase we applied a filtering process to clean the EEG data set of young male and female subjects. Subsequently, we converted the .edf files to .csv numerical format and then using MATLAB, hidden patterns in the cleaned data set were identified. Finally, we calculated and compared the standard deviation of the wave power in every individual sample with respect to gender.

Entire Data Flow Process

Figure 2 illustrates the six steps involved in the process starting from EEG data download and up to extraction and comparison of results. For this purpose, a pipeline of routines such as data gathering, data cleaning, sample extraction, data visualization, feature identification, feature extraction and deriving conclusions are used.

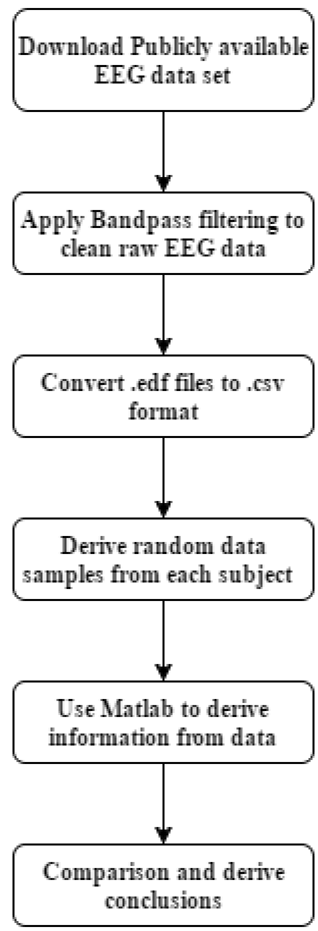
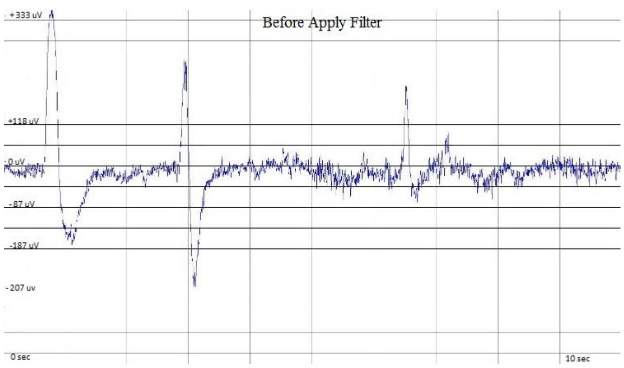


Figure 2: Overall process.

First we gathered data from each subject that contained 81 MB of data per record. However, the data files were in human readable .edf format. Therefore, an EDFBrowser was used to convert .edf file data to a numeric domain. Using such an EDFBrowser, we were able to convert .edf data to .csv format containing time domain data of EEG waves as shown in Figure 3 (a).

2. Data Filtering and Cleaning

Raw EEG data usually contains a certain amount of noise added to the signal during eye movement, vibrations, etc. As such noise may lead to erroneous results, a filtering process must be utilized to clean the data. We used the **Butterworth** filter to pass frequencies in between lower and upper bound frequencies as given in Figure 3 (b).



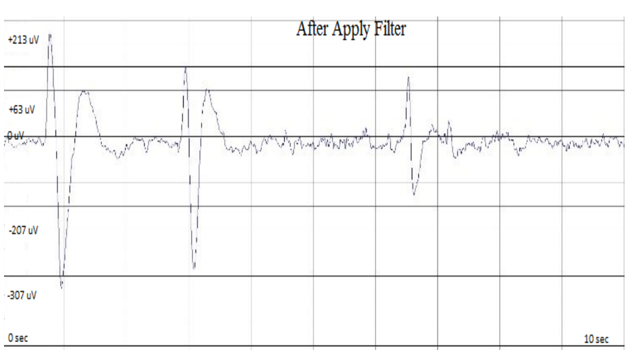


Figure 3: EDFBrowser EEG visualization from FP1-F7 channels (a) Before apply filter (b) After apply butterwort band pass filter with 1 Hz-15 Hz range.

When we compare Figure 3 (a) and 3(b), to verify the importance of filtering the original dataset.

Extracting sample data from random time ranges

In this research, we considered EEG data gathered from probes located near frontal parietal regions of the brain known as FP1 and F7 in the 10-20 international electrode system [9]. The channel odd numbers were recorded from left side of the brain.

Table 2: Content of one sample [3]

Sample No	Sample Time	Number of Records

1	0s to 1s	256
2	1s to 2s	256
3	2s to 3s	256
Sample 4 to 7		
8	20s-21s	256
9	100s-101s	256

Previous researchers have found out that the left side of the brain controls our right side of the body and logical tasks [12]. Finally, after filtering all the data, we were able to take 9 random samples from the dataset as given in Table 2. (Every data set contains 1s of EEG signals which consists of 256 record points).

4. Band Pass - Butterworth filter

The Butterworth filer is designed to extract and reject unwanted frequencies lying outside the range of cutoff frequencies. This filter generates a maximally flat frequency range in between the cutoff frequencies. Moreover, these frequencies generated have no ripples in the pass band and converge towards the zero band. It must be noted that the response of the first order low pass filter rolls off at -6 dB per octave, the second order filter at -12 dB per octave and the third order filter will start decreasing at -18 dB per octave.

When we compare the Butterworth filter with other linear filters used for signal normalizations, we observe a slight non-linear phase response in the Butterworth filter than other linear filters and also a quick roll-off around the cutoff frequency. In addition, the smoothness of the curve increases with the order. [4]

$$H_{(j\omega)} = \frac{1}{\sqrt{1+\varepsilon^2\left(\frac{\omega}{\omega_p}\right)^{2n}}}$$

n^{th} order Butterworth filter [5, 6]

Where n represents the filter order $\omega = 2\pi f$ and ε is the maximum pass band gain f is the describe signal frequency. The above equation can be simplified as below.

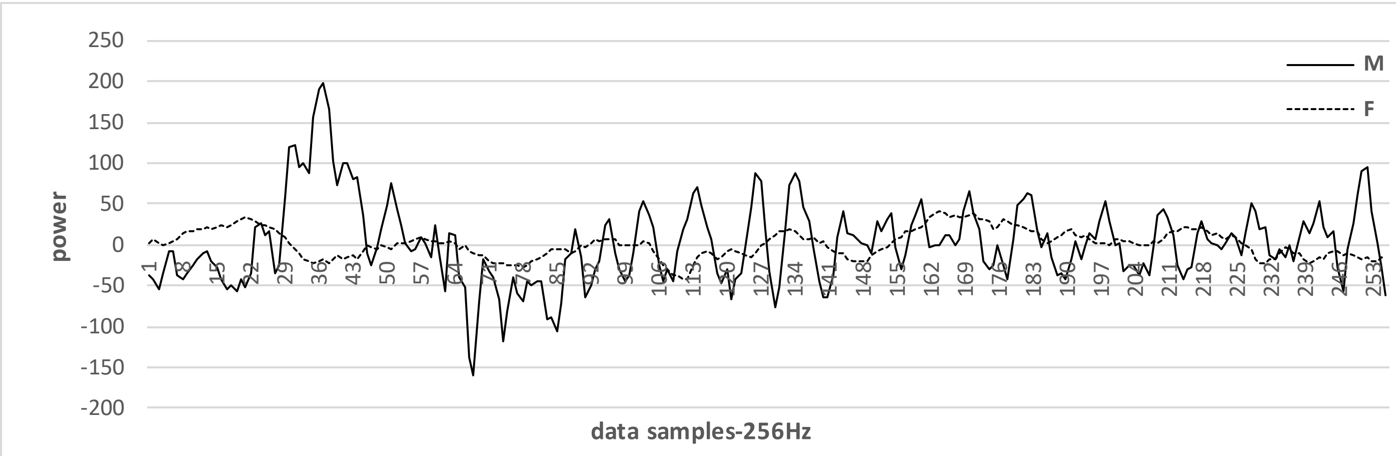
$$H_1 = \frac{H_0}{\sqrt{1+\varepsilon^2 a}}$$

Where H_0 = the maximum pass band gain and H_1 = minimum pass band gain.

RESULTS AND DISCUSSIONS

EEG Wave comparison

Figure 4 depicts the comparison results between male and female subjects between ages of 3 to 22 years. For comparison perspective we added frequency response in three different time domains only.


250
200
150
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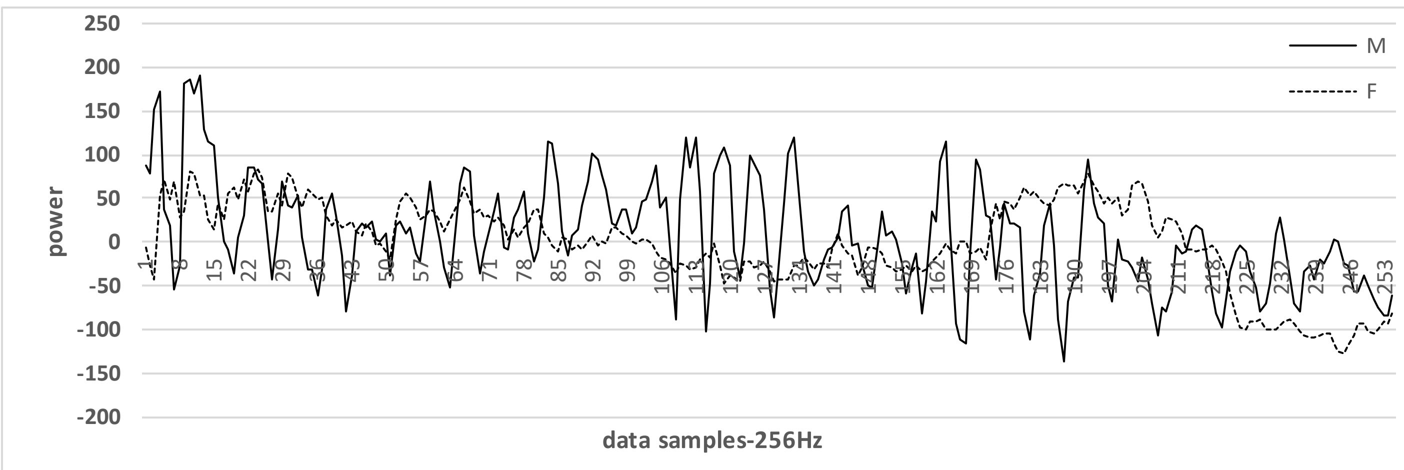
50
0
-50
-100
-150
-200
power
M
F
data samples-256Hz

(a)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power
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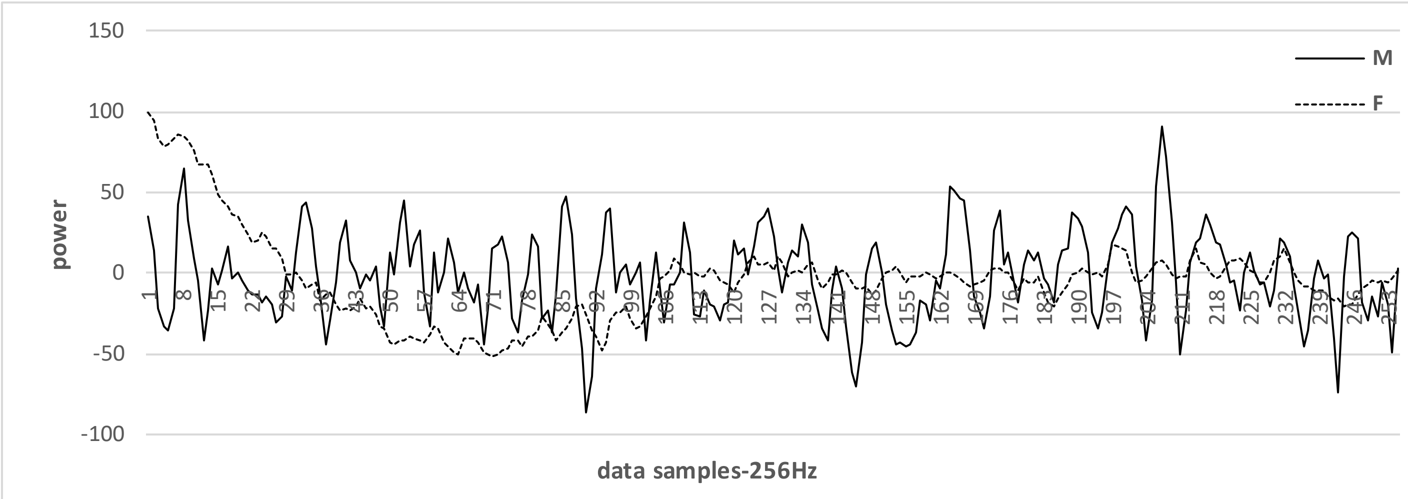
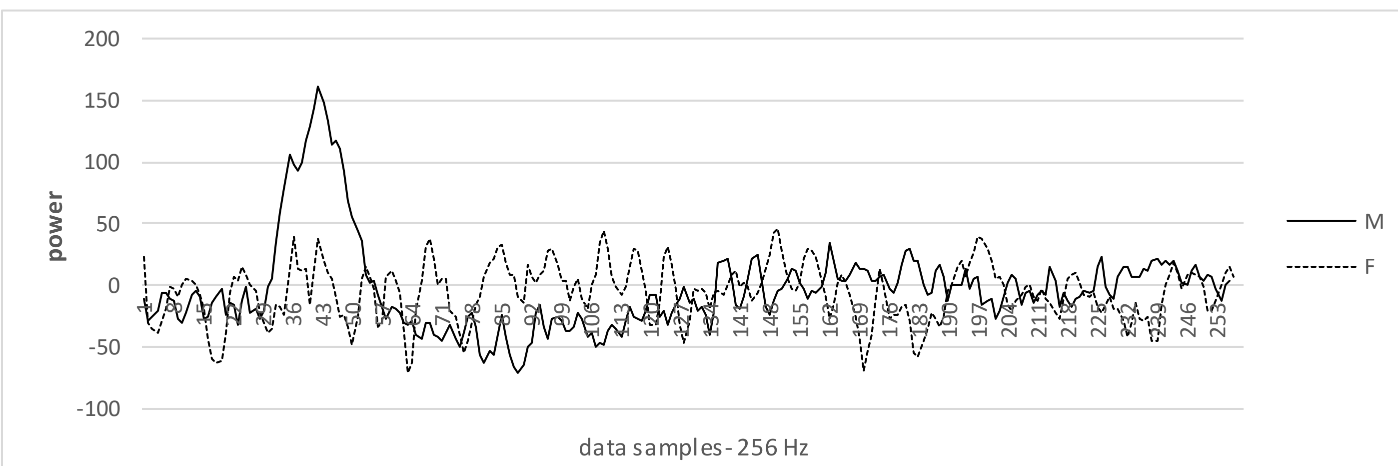
data samples-256Hz

(b)

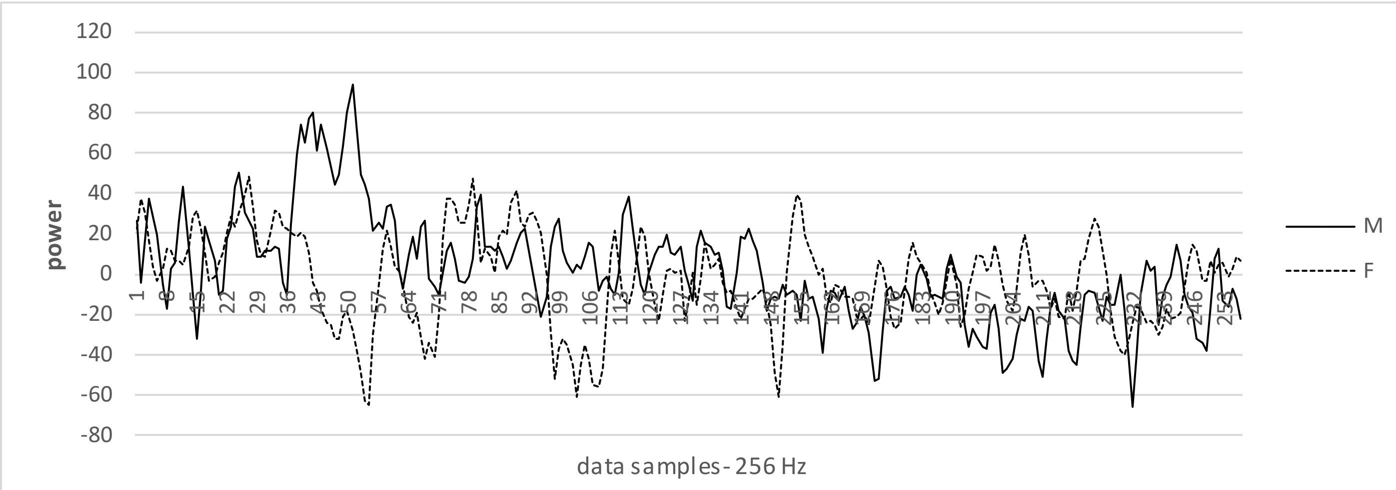


(c)

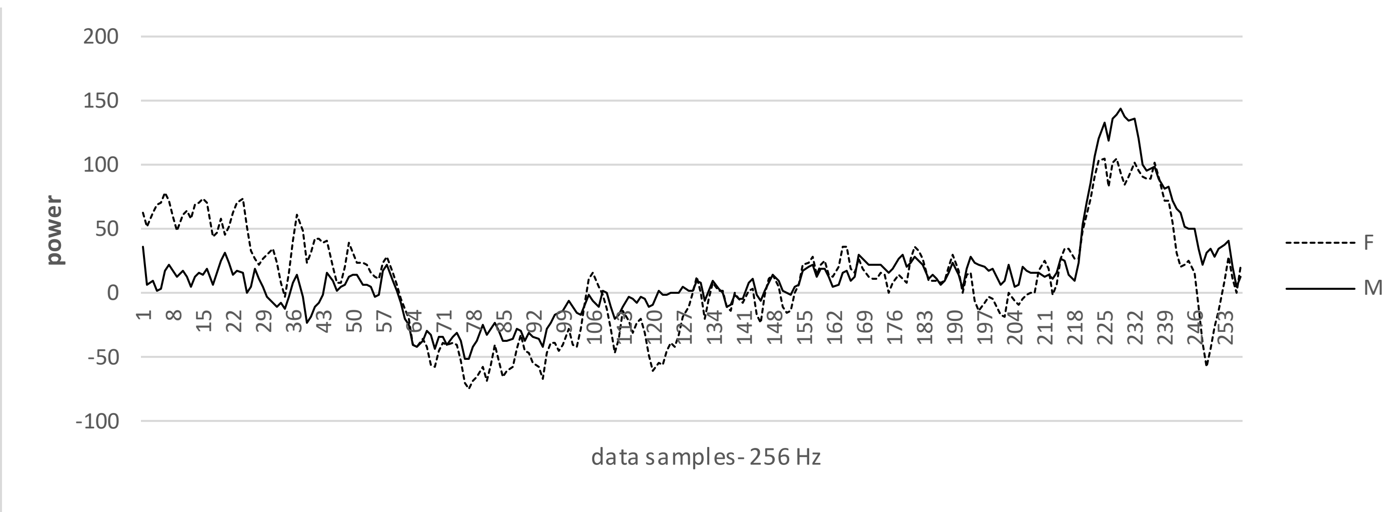
Figure 4: Age 11y Male and 11y Female FP1-F7 EEG sample wave comparison: (a) 256 records in between 2s-3s, (b) 256 records in between 11s-12s. (c) 256 records in between 21s-22s.



(a)



(b)



(c)

Figure 4: Age 22y Male and 6y Female FP1-F7 EEG sample wave comparison: (a) 256 records in between 2s-3s, (b) 256 records in between 11s-12s, (c) 256 records in between 21s-22s

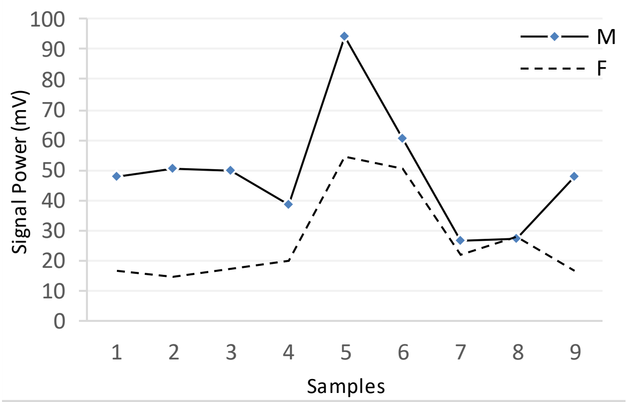
We ignored the first 256 samples which captured during 1s-2s time period to compensate for possible errors added to the main brainwave during head movements and early adjustments.

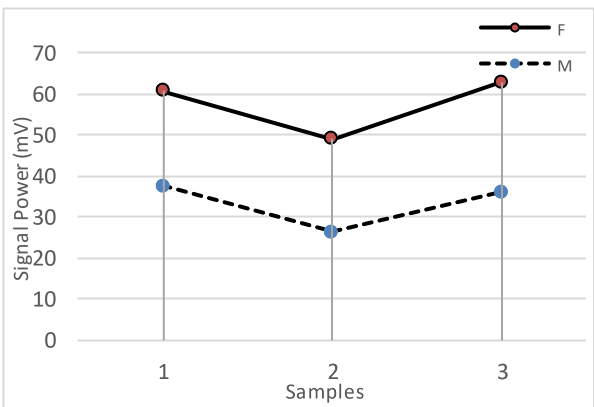
Figure 5 gives brain wave patterns of a male and a female subject who were 22 and 6 years, respectively.

EEG Wave Deviation Comparison

As seen in Figure 6(a), we derived that in male subjects, brainwave fluctuations were greater than female subjects in the age 11. Also, Figure 6(b) demonstrates the signal variations of a male and a female who were 22 and 6 years of age.

In this research, we primarily tested two hypotheses. The first one is whether there are variations in brainwaves between male and female children and the other is whether variations occur in brainwaves between male and female adults.





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Several studies have demonstrated that left side of the brain is directly connected with logical thinking as well as linguistic functions in human species [9,13].

We measured standard deviation of EEG signal patterns from young male and female subjects who were between 6 to 22 years of age. Using the analysis, we were able to identify behavioral information that more active brain signal patterns occurred from front left area of the brain in young male subjects than in female subjects. Using previous assumptions, we can come to the conclusion that young male subjects are more active in logical subjects and linguistic activities than female subjects in their age.

It is important to do more clinical trials with subjects in several age groups to come to a more definite conclusion.

REFERENCES

M. Mahfuzah, "The analysis of eeg spectrogram image for brainwave balancing application using ann," Computer Modelling and Simulation (UKSim), 13th International Conference on. IEEE, 2011.

A. Manzoor, A.Kumar, M. J. Vidya, et al. "Analysis of EEG using 10:20 electrode system," the online International Journal of Innovative Research in Science, Engineering and Technology, vol. 1, no. 2, pp. 308-319, 2012.

A. L. Goldberger, L. A. N. Amaral, L. Glass, M. Jeffrey, Hausdorff, C. H. Plamen, Ivanov, Roger G. Mark, Joseph E. Mietus,B. George, P. Chung-Kang, and H. Eugene Stanley. et al. "Physiobank, physiotoolkit, and physionet," vol. 101, no. 23, pp. 215-220, 2000.

A. Shoeb (2017, April 01), [online]. Available: https://www.physionet.org/pn6/chbmit/

I. W. Selesnick, S. Burrus, P. P. Mohamad, et al. "Generalized digital Butterworth filter design," IEEE Transactions on signal processing, vol. 46, no. 6, pp. 1688-1694, 1998.

G. Alarcon, C. N. Guy, and C. D. Binnie. et al. "A simple algorithm for a digital three-pole Butterworth filter of arbitrary cut-off frequency application to digital electroencephalography," Journal of Neuroscience Methods, vol. 1, no. 1, pp. 35-44, 2000.

D. J. Doyle, and M. L. Hyde. et al. "Analogue and digital filtering of auditory brainstem responses," Scandinavian audiology, vol. 10, no.2, pp. 81-89, 1981.

J. C. Doyle, R. Orstein and D. Galin, et al. "Lateral Specialization of Cognitive Mode," Psychophysiology, vol. 11, pp. 567-578, 1974.

S. Helmuth, G. Fürst, and B. U. Meyer. et al. "Craniocerebral topography within the international 10–20 system," Electroencephalography and clinical neurophysiology, no. 6, pp. 499-506, 1989.

R. D. Bickford, G. Adelman, et al. " Electroencephalography," Encyclopaedia of Neuroscience, pp. 371-373, 1987.

M. C. Corballis, P. Biol, "Left Brain, Right Brain: Facts and Fantasies," et al. 2014, e1001767, [online]. Available : https://doi.org/10.1371/journal.pbio.1001767