EEG Analysis to detect Attention

Caren Nesseem

George Mason University, Fairfax, VA

1. Abstract

The Pomodoro Technique is a time management method that is known to be effective when studying. The technique was developed by Francesco Cirillo in the late 1980; it aims to accomplish the biggest amount of studying in the most efficient time. It is based on a 25-minute of focused studying, broken by a 5-minute break with no electronic use such as phones or T-V during this 5-minute break. Following with a 15–20-minute break upon the competition of 4 work periods, with the approval of electronic use. Inspired by this, the subject of interest is identifying inattentiveness using EEG sensors either hardware or phone sensors. Then analyzing these signals to enhance our knowledge of attention and how long it takes until the subject is distracted, I can essentially use this research to amend our beliefs about attention span. This can also be used for teachers to know when the students need a break without trying to guess from their facial expressions and having solid research that proves an average student would need a break after a certain time. First, I will find a database of EEG recordings of individuals while trying to focus then I will perform a feature extraction process followed by data processing into MATLAB. Finally, I change my time domain data into the frequency domain and use bandpass filters to extract specific bands. This study aims for two goals, to better understand the attention span of everyone, leading to making the Pomodoro technique more customized for each person and to let the user know if they are getting sidetracked and give them the option to either resume focusing or to take a mental break. The expected results are that individuals will have different attention levels and the amplitude will differ from the before and during the state of focusing, proving that the Pomodoro technique needs to be customized for each person's span to be considered the most effective method of studying

2. Introduction

During the average learning process, the span of a student remaining attentive can increase their learning curve. (1) Strengthening the background information about attention span, how it lost attention can last, and analyzing it for different subjects can help in building an argument for educational institutions that classes cannot exceed the average attention span. Otherwise, the information being taught will be merely useless. In this publication, the paper will dive into analyzing EEG using MATLAB to identify the attention of each subject. The EEG data was acquired using the developed EEG detection, and mobile brainwave sensors. Depending on the frequency range, EEG signals are divided into five different wavebands. (1)

- α activity: electromagnetic waves that range specifically between 8 and 13 Hz in frequency. This kind of wave is created in the partial and occipital regions of the brain while the person is conscious, quiet, or at rest. The alpha wave disappears 4[mm/when thinking, blinking, or stimulated also known as the alpha block. PMC1

- β activity: electromagnetic waves that range specifically between 14 and 30 Hz in frequency. This activity occurs in the frontal region when a subject is conscious and alert. This wave is mostly visible when a person is thinking or receiving sensory stimulation.
- θ activity: electromagnetic waves that range specifically between 4 and 7 Hz in frequency. This activity is mainly in the partial and temporal regions of the brain. These specific waves are a result of people expressing emotional pressure, interruption of consciousness, or deep physical relaxation
- δ activity: electromagnetic waves that range specifically between 0.5 and 3 Hz in frequency. Most adults express no δ activity in their conscious state. However, it appears when in a deep sleep, unconscious, or anesthetized (lacking oxygen)
- γ activity: electromagnetic waves that range specifically between 31 and 50 Hz in frequency. Recent studies have found that this wave is responsible for selective attention, cognition, and perceptual activity.
- The data used for this paper was acquired from the physionet database under EEG during Mental Arithmetic Tasks. Since various areas of the brain generate EEG signals, cerebral electromagnetic activity was collected using the international 10-20 electrode placement system, which includes attaching electrodes to 37 locations on the skull. The silver/silver chloride electrodes were placed on the scalp following the 10/20 scheme.

3. Method

3.1 Study Method

Although every person's attentiveness to the same learning content can vary, and their EEG signal can differ, this study aims to identify the changes in EEG signals during learning under normal conditions by using convenient and simple analytical MATLAB methods. The controlled environment will be the attentiveness before mental arithmetic tasks and then the attentiveness during mental arithmetic tasks to better compare. A high pass filter with a 30 Hz cut-off frequency and a power line notch filter of 50 Hz were utilized in the data used for analysis. All EEG recordings are artifact-free with 60-second duration. All participants in this study were classified as normal or corrected to normal visual acuity, and normal color vision had no clinical manifestation of mental impairment or verbal or non-verbal learning disabilities. The exclusion criteria were participants in the use of psychoactive medication, drug, alcohol addiction, and psychiatric complaints.

In this Analytical study, Fp1 was the only electrode taken into consideration when analyzing EEG since the level of attentiveness is controlled by the cerebral cortex in the forehead as shown in Figure 1.

According to previous research,(2) there are interrelations between α and β activities. Ideally, α activity indicates that the brain is in relaxation while β activity is related to stimulation. In that same study, it states to observe the change in the mental state of the subject, the ratio of α and β is assessed to isolate the level of mental attentiveness. This study produced the following feature value using the

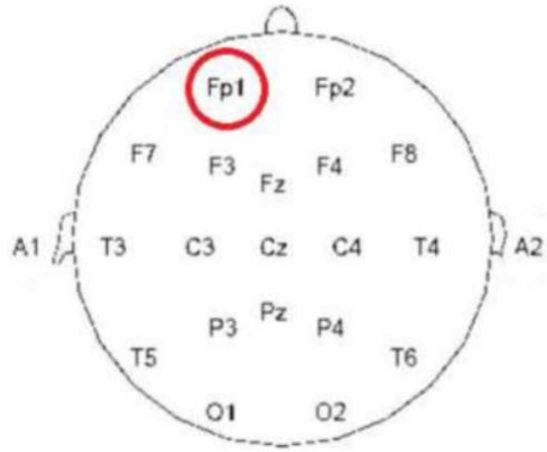

Figure 1. International 10-20 electrode placement system

3.2 Feature Extraction

To ease the data processing method, EEG data was first isolated for the first 500 seconds in 1-second increments. Then, a 2nd order Butterworth filter with a bandpass from 8-13 hertz for the Alpha Band then using the filtfilt function in MATLAB to plot the Alpha filter in the time domain. Directly after, the alpha filter is passed through a Fourier transfer function to change into the frequency domain to better isolate the frequency bands. The same process is performed but with a bandpass from 14-30 hertz for the Beta Band. After isolating the Alpha and Beta bands, the ratio of these two is the mere attention of the subject. (PMC) Refer to figure 1, R represents the level of attention where $E\alpha$ is the EEG signals from frequencies 8-12 Hertz refer to figure 2. and $E\beta$ is the EEG signals varying frequencies from 14-30 Hertz. (refer to figure 3.) While Pfreq is the Power Spectral Density after FFT. (Refer to figure 4.)

$$R = \frac{E_\alpha}{E_\beta}$$

Figure 1. Level of Attention

$$E_\alpha = \sum_{freq=8}^{13} P_{freq}$$

Figure 2. EEG of Alpha Waves

$$E_\beta = \sum_{freq=14}^{30} P_{freq}$$

Figure 3. EEG of Beta Waves

$$P(n) = \frac{F(n)F*(n)}{N}$$

Figure 4. Power Spectral Density

After the ratio of Alpha and Beta Bands is acquired, the data is graphed using the time domain to ease the visually. In order to prove that the program can identify attention, this program was performed on EEG Data before doing any arithmetic tasks and during working on the arithmetic task, to compare the data and spot how attention can be seen in graphs. Below is the illustration of only one subject before and during performing arithmetic tasks but the analysis was tested on 20 Subjects for accuracy reasons.

4. Results

4.1 During Mental Arithmetic Tasks

The result of the analysis proves that the attention of one can be identified from before mental arithmetic tasks to during. The plain Fp1 electrode signal was first graphed to plot the raw data, refer to figure 5. In addition, to visualize the filtered FFT of the signal, while isolating Alpha Band (8-13) was also graphed in figure 6, and Beta Band (14-30) in figure 7.

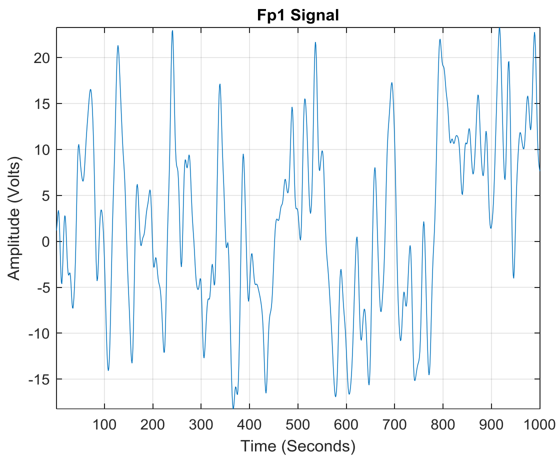

Figure 5. Fp1 unfiltered signal

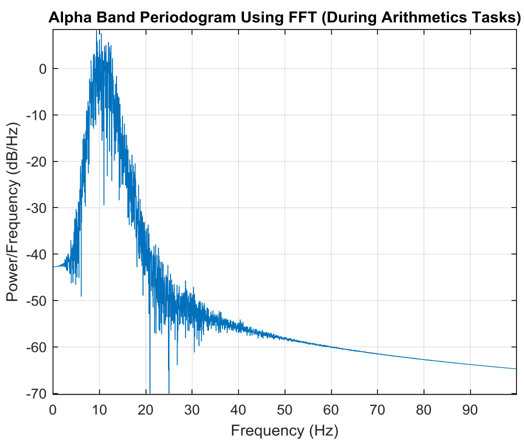

Figure 6. FFT of Alpha Band in Power Spectrum

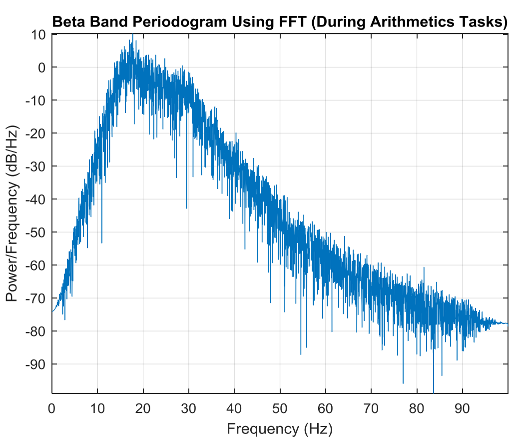

Figure 7. FFT of Beta Band in Power Spectrum

As Illustrated above in figure 6, the frequency peak spikes between 8-13 Hz for the Alpha Band and in Beta Band, its peak spike is 14-30 Hz. To acquire the attention mentioned earlier, the ratio of the Alpha and Beta band is programmed and then graphed in the time domain to facilitate its visualization. Refer to figure 8 below; Subject three was used for example.

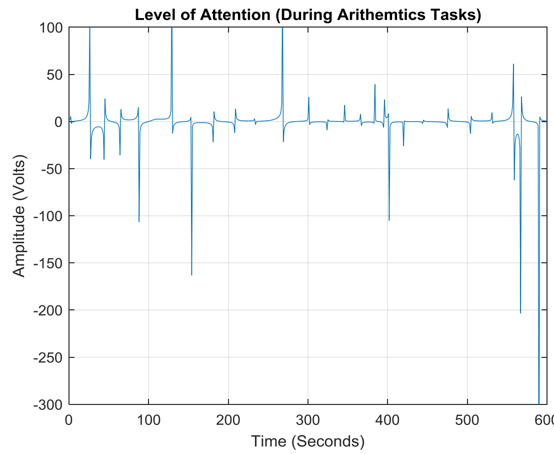

Figure 8. Attention of Subject 3

4.2 Before Mental Arithmetic Tasks

As discussed in the above section, the same process was performed before the session to boldly spot and compare the differences between the two stages. The Alpha Band before the session was graphed to be compared in figure 9, before any filtering. After using the Butterworth band pass filter and the filtfilt MATLAB function, the FFT of the Alpha band is illustrated below in figure 10 and Beta Band in figure 11.

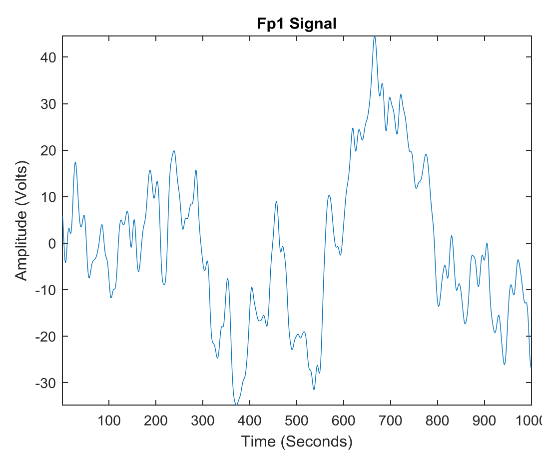

Figure 9. Unfiltered Fp1 Signal (Before mental Arithmetic tasks)

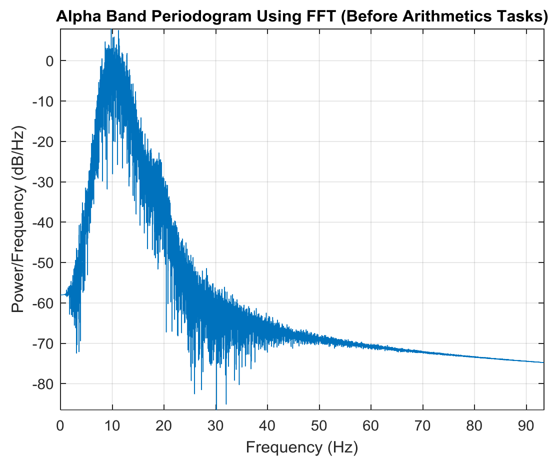

Figure 10. FFT of Alpha Band

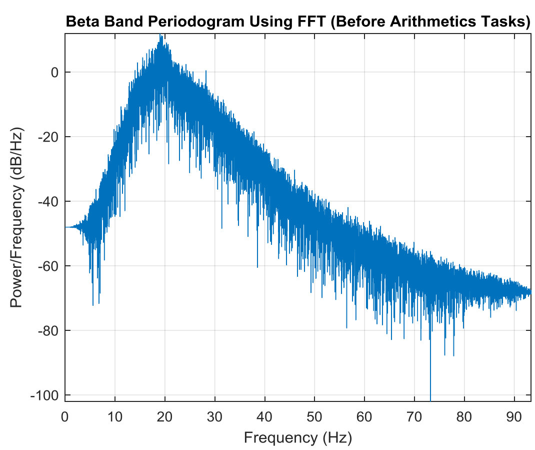

Figure 11. FFT of Beta Band

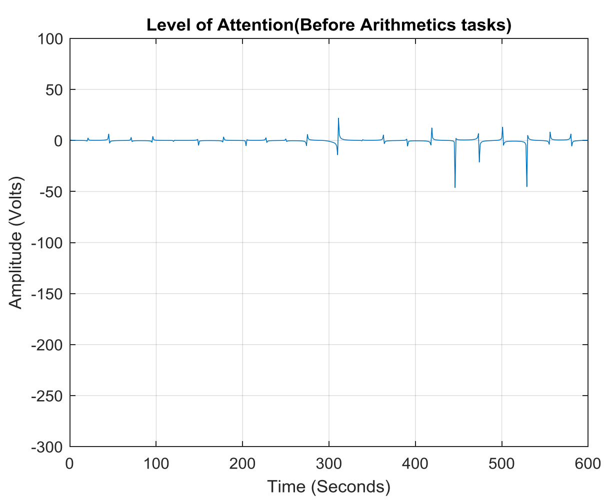

Figure 12. Attention Before Mental Arithmetic Tasks

Finally, the ratio of the attention before the Mental Arithmetic tasks was calculated to compare it to the during session to prove the program can help identify it. Referring to figure 12 above, Subject 3 continued.

5. Discussion

To discuss the results above, one needs to comprehend that these can vary from one subject to another, but the base results hold their validity. In the frequency domain, the comparison between the before and during the session was neither notable nor identifiable by the eye. However, there was a spotting difference when the ratio of Alpha and Beta was calculated in time domain. To compare the during and the before the session, the during session has a lot more spiked and higher spike amplitude than the before the session which clearly has a much flatter amplitude and barely any spikes. This can tie the conclusion of the research analysis that attention can be visualized in the time domain when calculating the ratio of Alpha and Beta bands and can be later utilized for attention identifier applications.

6. Conclusion

In traditional manners, identifying if someone is attentive or not had to be a guessing game. However, this program serves as an identifier of whether one is attentive and how long is that person is attentive for which can be utilized in classroom settings or for self-improvements. Another proof is that the Pomodoro technique can be more efficiently used if each person can customize their focus time based on their own attention span since it varies in each person which was proven by testing this program on more than 15 subjects. The study results indicates that the so-called state of attentiveness is a continuous phenomenon, and that the observation of data is limited to arithmetic tasks but only research can prove if that differs with other tasks. Furthermore, attention is easier to spot and identify compared to signals of inattentiveness; this is because signals of inattentiveness contain more information. This program can be utilized in actual applications in student learning environment or self-learning environment. Some future improvement is using machine learning to build on this program using classifiers such as KNN, artificial neural network, decision tree, or random forest to accurately recognize the rate of attention using EEG signals from mobile sensors.

Acknowledgments

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