Attention Mapping Via Neurosky Mindwave - An EEG Based Brain Computer Interface

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Abstract

With the advent of the Neurosky Mindwave headset, which is a non-invasive EEG based Brain-Computer Interface, the possibilities of studying the brain have enhanced significantly.

We can measure and monitor attention levels of people with ease. This project focuses on using the headset to monitor attention levels of subjects by testing their attention on a dynamic reading interface whose brightness is directly related to their attention level, as reported by the Mindwave Headset.

After training them on psychologically approved tools, we shall try to observe any marked difference in attention levels on the same interface.

This shall open doors to multiple low-cost, user-friendly applications where users can monitor and train themselves at an independent level. It also enables people attempting online tests to ensure their attention remains high during the examination.

1 Motivation

It is a common phenomenon that while reading, humans lose focus very quickly. In today's day of mobile applications and the Internet, many studies indicate that our attention-spans have fallen as low as 8 seconds. Therefore, an application that can enable one to track attention spans is the need of the hour. We have focused upon a novel method to ensure that people can ensure their attention remains high and that they can easily monitor it themselves. By varying the brightness levels of text as a function of the attention value generated by the Neurosky Mindwave, we have been able to ensure that participants can only read the text if they focus upon it properly. Furthermore, we have attempted to create an application that can improve performance levels of participants that appear for online examinations by the same real time neurofeedback approach.

Our approach towards the project is centred on providing users a utility product that can enable people to monitor attention levels at an individual level. By utilising the Neurosky Mindwave device, an EEG(Electroencephalography) based BCI(Brain Computer Interface), we can provide a user-friendly interface on the Android platform. Since the device is compatible with not only Android, but also on Desktop systems based on Windows and MAC, this cross-platform compatibility ensures that the utility product can be reached to a large audience.

2 Literature Survey

EEG

The electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp. The recorded waveforms reflect the cortical electrical activity.

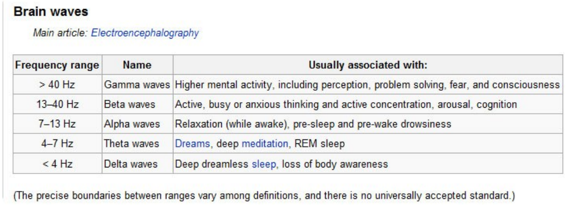
Signal intensity: EEG activity is quite small, measured in microvolts (μV).

Signal frequency: the main frequencies of the human EEG waves are:

Delta: has a frequency of 3 Hz or below. It tends to be the highest in amplitude and the slowest waves. It is normal as the dominant rhythm in infants up to one year and in stages 3 and 4 of sleep.

Theta: has a frequency of 3.5 to 7.5 Hz and is classified as slow activity. It is perfectly normal in children up to 13 years and in sleep but abnormal in awake adults.

Alpha: has a frequency between 7.5 and 13 Hz. Is usually best seen in the posterior regions of the head on each side, being higher in amplitude on the dominant side. It appears


Brain waves

Main article: Electroencephalography

Frequency range	Name	Usually associated with:
> 40 Hz	Gamma waves	Higher mental activity, including perception, problem solving, fear, and consciousness
13–40 Hz	Beta waves	Active, busy or anxious thinking and active concentration, arousal, cognition
7–13 Hz	Alpha waves	Relaxation (while awake), pre-sleep and pre-wake drowsiness
4–7 Hz	Theta waves	Dreams, deep meditation, REM sleep
< 4 Hz	Delta waves	Deep dreamless sleep, loss of body awareness

(The precise boundaries between ranges vary among definitions, and there is no universally accepted standard.)

Figure 1: Types of Brain Waves

when closing the eyes and relaxing, and disappears when opening the eyes or alerting by any mechanism (thinking, calculating).

Beta: beta activity is fast activity. It has a frequency of 14 and greater Hz. It is usually seen on both sides in symmetrical distribution and is most evident frontally.

The EEG signal is closely related to the level of consciousness of the person. As the activity increases, the EEG shifts to higher dominating frequency and lower amplitude. When the eyes are closed, the alpha waves begin to dominate the EEG. When the person falls asleep, the dominant EEG frequency decreases. In a certain phase of sleep, rapid eye movement called (REM) sleep, the person dreams and has active movements of the eyes, which can be seen as a characteristic EEG signal. In deep sleep, the EEG has large and slow deflections called delta waves. No cerebral activity can be detected from a patient with complete cerebral death.

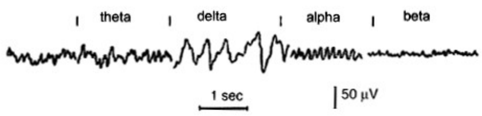


Figure 2: Brain Waves Structure

Neurosky Headset

The MindWave Mobile headset safely measures and outputs the EEG power spectrums, NeuroSky eSense meters (attention and meditation) and eye blinks. The device consists of a headset, an ear-clip, and a sensor arm. The headset's reference and ground electrodes are on the ear clip and the EEG electrode is on the sensor arm, resting on the forehead above the eye.

Among all the other possible alternatives, it is the most affordable brainwave - reading EEG headset available with best performance/cost ratio.

The values given by headset :
1. Poor Signal
2. Raw data value
3. eSense values
a. Meditation
b. Attention

Attention is the behavioural and cognitive process of selectively concentrating on a discrete aspect of information, whether deemed subjective or objective, while ignoring other perceivable information. It is the taking possession by the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought.Focalization, concentration of consciousness are of its essence. Attention has also been referred to as the allocation of limited processing resources.

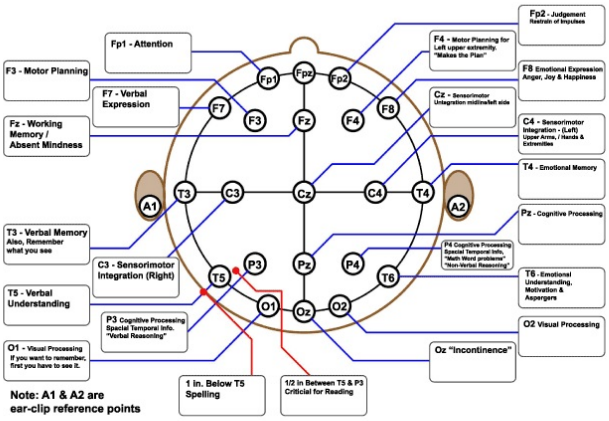


Figure 3: Brain Lobes and Functions

3 Related Research Developments

Lai,Lai and Cheng[1] have reasoned the value of reading and how heavy workload has enhanced stress levels that have impacted attention spans of people. They emphasised upon the role of music as a tool to improve individual attention and how a customized playlist may enhance user's productivity. However, customizing is a task that is entirely dependent upon a particular person. Therefore, it makes it challenging to provide a uniform solution to the problem at hand.

Sezer,Inel,Seckin,Ulucinar[2] evaluated a positive correlation between students' average attention values and class participation by converging quantitative and qualitative research techniques across 21 freshmen. However, with the increasing advent of online courses and E-learning, we must also bring attention values of students studying online into consideration.

Muhyi and Lee[3] created a 3D simulation model based upon Mathematical questions that tested the attention level and maximum workload of a person by making him attempt Mathematical problems of different difficulty levels. By focussing on the Beta waves, they analysed the time taken for the test, they used signal processing to filter the results and produce a simulation showing user performance.

Shirazi,Hassib,Henze,Schmidt,Kunze[4] worked upon a Bayesian classifier to predict user's mental activity as reading/relaxing based upon single electrode BCI. Salabun[5] dealt with the processing and spectral analysis of the raw EEG signal, leaving scope for neurofeedback.

Mendes and Freitas[6] created an attention model based on EEG readings and utilized user response to create a motivation model that performed appropriate actions on a virtual world simulation.

4 Working Methodology

The Study was conducted in a quiet room. The environment was kept uniform for all the participants. Participants were waiting outside the room and were called in turn. Two groups, each consisting of 12 female and 18 male subjects between the age group of 18 and 21 years, participated in the study. The entire demographic belonged to college going students. Prior to the first session, they were asked to complete and return a series of questionnaires, which included general questions inquiring about factors that could affect the result of the tests conducted in any way. These factors included - Total hours of sleep prior to the test, Medications the participant is undergoing; if any, Distracted Mind during the test, Physical environmental distractions, participants' expectations from the experiment.
Then the subjects were tested in the first session. For the session, subjects were made to wear the Mindwave EEG Headset. Once the Headset was properly connected, they were made to read the 1st part of a prose on the Android Application developed by our team. During the time they read, they had to maintain a high attention to be able to see the prose clearly. As soon as the attention drops, the visibility of the prose also becomes more invisible, thus, making the reader aware about the drop in their attention. Until the user will concentrate hard, the visibility of the text would be poor. This initiates a neurofeedback which encourages the participant to focus harder in order to successfully read the content of the text.

Figure 4: Neurosky Mindwave Headset

After the session, the subjects were made to play a Pattern Backward-Retrace Android Brain Game. This game is a psychologically approved tool which stimulates the brain regions pertaining to the Attention and Spatial Cognition regions i.e. stimulants of Beta Waves. The game was self-adjusting, therefore, dependent upon the ability of the user, it adjusted itself so as to ensure the user is not only stimulated but also improves gradually. Following the game, the subjects were made to read the 2nd half of the prose with identical conditions and environment as during the 1st half. A comparison graph was shown between the attention values during the 2 halves, thus showing if any effect of the Brain Game was observed as an increase in attention. The candidates were also made to read a prose normally, without the blur effect, like a normal text.
In the end a comparison between the attention values during the Blur effect and during the Non-Blur effect is demonstrated on a graph to compare the different conditions respectively.

In the second part of the experiment, we simulated an online test environment. With many organizations opting for online tests, the expanse of its usage has significantly skyrocketed. However, there is a drastic difference in appearing for a normal pen and paper test versus an online examination. Therefore, we created two similar tests based on Language Comprehension and Mathematical Assessment. One test was administered to the participant in the normal online test format wherein they attempted the questions and provided answers. In the second part, they were provided with real time neurofeedback on the online test. If they weren't concentrating hard enough, the brightness of the text material was diminishing. The attention recordings were observed along with the time taken to finish the test. Moreover, the participant was also asked to provide feedback relevant to the gadget such as the distraction experienced as a result of the device, whether the participant felt conscious, whether the participant felt the feedback made a difference in their attention, whether the participant would be willing to wear a gadget like this for an examination etc.

5 Analysis and Results

Analysis of the recorded attention values can be done by plotting a Comparison graph between the attention values during different periods of reading a prose. From the data, we can also obtain the Maximum, Minimum values of attention the candidate reached during the test period. Average attention span of each participant can be understood. Also, same effects can be studied in different environments such as with different type of music playing in the background.

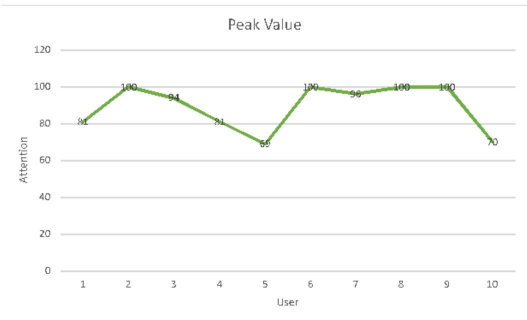


Figure 5: Peak Attention Values of Participants

Majority of the candidates experienced an increase in the attention value firstly due to the presence of the blur effect, and also after playing the Brain game. Thus, this technology can be made available to people to improve attention as the access of the data is proportional to the level of the attention of the subject.

Moreover, this enables us to move forward to the next phase of the project which shall deal with incorporating attention with its retention and recall. This, when collaborated together, will be able to offer a utility application to users

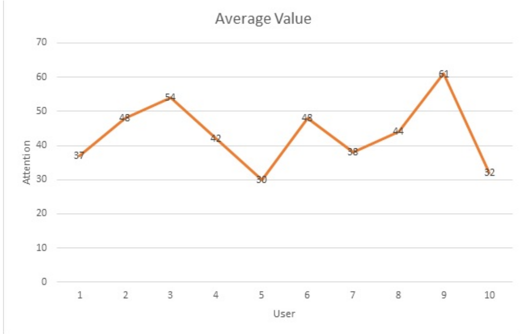


Figure 6: Average Attention Values of Participants

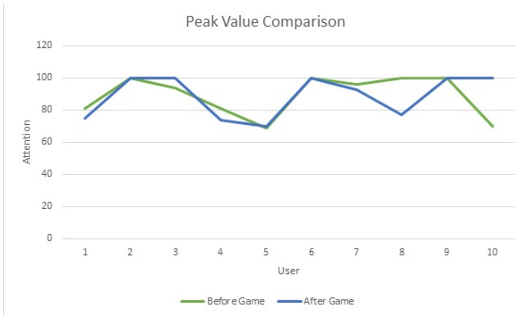


Figure 7: Peak Value Comparison pre and post training game

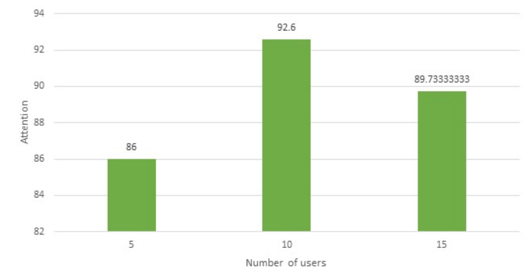


Figure 8: Average Peak value Observed

that will enable them to monitor their attention independently and use training methodologies to improve it at an individual scale itself. There is certainly a lot of scope for a service that shall belong to this category.

6 Drawbacks Of The Project

The main disadvantage of EEG is that it's hard to figure out where in the brain the electrical activity is coming from. By putting lots of electrodes all over the scalp (in most labs 64 or 128 electrodes are used), we can get some idea of where the ERP(Event Related Potential) components are strongest. This doesn't really tell us where in the brain the signals are coming from, but it can be useful in telling us whether

two ERP components come from the same place or not.
The device we are using is comprised of only one electrode and hence the data obtained, however probable, is not absolutely accurate. Better devices, such as Emotiv EPOC headset (14 channel) or Muse (4 or 6 channel) consists of many non-invasive electrodes which are placed evenly across the head to give the user a better reading.

Signal-to- noise ratio is poor, so highly sophisticated data analysis and relatively large number of subjects are needed to extract useful information from EEG. Also, since electrodes are non-invasive the reading obtained is also comprised of noise which gives data that must be processed before evaluation.

The device cannot be used for measuring neural activity that occurs below the upper layers of the brain (cortex). The neural activity inside brain has a very weak signal and cannot be picked by the EEG headset.

Attention itself can be influenced by a number of factors. The participants' attention can vary dependent on their emotional state of mind, the interest level they feel with the topic of the text chosen, amount of stress experienced by them, external distractions, noise, movement, number of hours of sleep etc. Therefore, as conclusive as we can try to be, we are limited by these parameters in drawing conclusions towards the hypothesis.

7 Future Scope Of The Project

Our project includes mapping attention levels and hence we can extend it further by providing this application to other users for them to monitor their attention levels daily by assessing their attention graphs. By recording and analysing their attention they can observe their improvements.

Also another area for expansion is an examination environment, where users are able to observe their attention and use it to improve their score. Also we would extend this project by integrating this feature to online educational sites.

We can also extend this by providing users with a variety of topics so that users actually get their attention levels higher than their average values across all domains.

Another dimension for extending this project is to develop applications that help not only to monitor attention but also improving it. A user-interactive game like application can be embedded into the current application which improves user-attention by getting them to completely focus.

Another domain where this project can be expanded is the correlation between stress and attention. An Optimum level of stress can boost attention and performance of an individual. By mapping attention at different levels of external stress situations simulated for the user, we can predict the optimum attention level for a user in a stress situation.

8 Conclusion

Quantitative EEG, a technique for analysis of brain electrophysiological data, has been proposed for use in the diagnosis of various psychiatric disorders. However, the clinical significance of these distinctive patterns of brain wave activity is still unknown. Thus the role of quantitative EEG in diagnosis, evaluation of disease progression, and treatment of these conditions has yet to be elucidated. By incorporating techniques and frameworks of computer science technologies with EEG, we can hopefully create systems and programs that can assist not only in the mapping and improvement of attention spans for users in the near future but may also aid in detection and remediation of various diseases related to the brain in the time to come.

9 References

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