

Statistical Analysis of Cognitive Attention in Students during Learning using Neurosky Mindwave II

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Abstract—Brain-Computer Interaction (BCI) has become a popular field of research interest. It has some applications such as medical diagnosis, emotion recognition, performance assessment and education are one of them. When used consistently with various learning methodologies for higher academic accomplishment in terms of cognitive attention, BCI-based Neurosky mind wave wireless technology may enhance students' learning and cognitive abilities. It can provide a thorough grasp of how the brain functions, which could enhance learning techniques and boost brain-based talents. This paper shows the analysis of attention of students with respect to various learning activities such as Gaming and Math solving using Neurosky mind wave device. So, according to our result analysis, were showed that girls are more attentive in math solving whereas boys are more attentive in Gaming, and also Final statistics of attention such as mean, max and min values of attention is more in Gaming as compare to math problem solving. This study will help students to analyze the cognitive state of attention during learning activities and also to boost the student's mental reasoning process.

Index Terms— Neurosky Mind wave, Cognitive Attention, Learning Activities.

I. INTRODUCTION

The Brain-Computer Interface (BCI) links the mental and physical worlds of humans by translating brain impulses into orders that can be recognised by electronic gadgets. Cognitive neuroscience is a key area of study in BCI. Numerous technologies have been used in recent research to track students' cognitive states and seek to deliver adaptive interfaces and materials in order to increase students' learning efficiency [1]. The area of study one of the key areas of the neuroscience field is cognition. The act of thinking or reasoning is known as cognition. The mental process of learning through thoughts, experiences, and sensations is referred to as a cognitive state. A cognitive state or skill can be attributed to a variety of processes and functions, including attention, working memory, reasoning, engagement, perception, problem-solving, and others.3]. This study focus on investigation of cognitive attention in students during learning activities such as Math problem solving and gaming using wireless Neurosky Mindwave device. We are collected data using EEG technology with the help of Neurosky device in which we are able to find out attention level in students by giving them critical tasks. Here results of study showed that the attention level of students is more in gaming as compare to math solving. It can help students in study and learn more effectively by improving attention Also It will help student in future to increase their attention and prove their ability towards in any task.

II. RELATED WORK

Many researchers have worked on the Analysis of Cognitive activities such as Memory, Learning, Problem-solving and attention etc., Using Brain Computer Interface Technology at both National and International levels. Kavitha P Thomas, A. P. Vinod, [2013] the authors explore the effect of neurofeedback put together BCI game with respect to the improvement of attention and intellectual abilities of healthy subjects and the trial aftereffects of this examination show that the proposed neurofeedback preparing model starts the player to extend his entropy scores, upgrade attention level and achieve higher focuses in the game.

Geeta U. Natalya, Rahul D. Gavas, [2014], point of this investigation is to detail a technique with the assistance of brain Computer Interface game to help the coaches notice and assess the attention levels of the students at regular intervals during the preparation time frame. For this examination reason, the gaming climate is planned utilizing Open-Source Graphics Library (OpenGL) package and the game control is through the cerebrum waves of player's using the Brain Computer Interface (BCI) innovation.

Poulami Ghosh, Ankita Mazumder et.al [2015] the target of this investigation was to assess the cognitive state of the brain. They concentrated on memory and attention state. They used Support Vector Machine for this classification purpose and acquired 79% classification precision.

Xiaowei Li, Martyn Ratcliffe et.al., [2015] describe Real-time EEG – based BCI framework which estimates attention level. In this investigation they contrast their methodology and conventional methodologies, three consideration levels were ordered by a KNN classifier dependent on the Self-Assessment Manikin (SAM) model.

KHIMTOA with correspond Kok SWEE SIM [2015] In this paper, they constructed the relationship between EEG and attention level. This study aims to introduce a more effective learning algorithm to measure attention level using EEG. They studied monitoring using experiments with webcam and eye tracking algorithm using EMOTIVE instrument which records electrodes. Since our study is about brain responses in attentive and inattentive behaviour analysis, only electrodes in the frontal cortex (AF3 & AF4) and parietal cortex (PZ) are used, with the help of deep learning model like (AMNN, RNN, CNN & LSTM).

Ng Wei Bin, Saidatul Ardeenawatie Awang, et.al, [2019] this paper aimed to determine the informative EEG channel/s and brain region for typing activity. Twenty healthy right-handed subjects from Universiti Malaysia Perlis (UniMAP) were enrolled in this study. Typing task was performed for 3 trials and 5 minutes per trial. In EEG signal processing, Notch filter and Butterworth bandpass filter were used to remove powerline artefact and filter the signal into alpha (8-13Hz) and beta waves (13-30Hz). Welch method was applied to extract features from typing task. The obtained results were then undergoing statistical analysis before loading into the K-Nearest Neighbour (KNN) and Linear Discriminant Analysis (LDA) classifier. They found that channel P3 in parietal region and channel T6 in temporal region give highest accuracy which was 99.44% for typing task activity.

Dan Ni, Shuo Wang and guocheng Liu, [2020] This paper has made an empirical case study on differences in learner's attention when using three different learning media. EEG technology used to measure mobile learning attention and process them to determine learners learning and memory during learning and cognitive load. Also pointed learning style in mobile learning which could access by learners from anytime any place in any form. Founded that attention value in both male and female have a higher attention of text media.

Sarwar marshad, Md. Rabiuzzaman Mazumder, et.al, [2020] In this research paper they used neurosky mindwave2 is a mobile lightweight and low-cost EEG device it is mainly used for education and research work. This device also gives attention, meditation and eye blinking. Neurosky mind wave mobile 2 is possible implementation error by doing preprocessing in the device. In data analysis, they controlled and collected data were divided into groups according to the age at 10-20 and above 29 & also men and women. They got six data types: alpha, beta, gamma, attention, meditation, and eye blinking from Neurosky mind wave mobile 2. They also show the mean, threshold level and attention, mediation and eye blink according to age group of men and women.

III. DATA ACQUISITION

A. Neurosky Mindwave Mobile II

Neurosky Mindwave Mobile II is a low-cost, user-friendly wireless EEG device which is available to general people such as students, teachers and researchers. However, it is a single-channel BCI headset, giving super mobility during the usage time. The headset can be linked to any device using Bluetooth technology and can be controlled from PC or android applications. The device paired to the headset is an android mobile. The sensors

mounted on the headset can detect faint brainwave signals safely and passively. This device uses a non-invasive method of recording brain waves. The technology embedded in the NeuroSky headset interprets the meaning of these recorded signals. Here we have used the eegID android application and can get various data such as raw EEG data, frequency band magnitude Alpha, Beta, Delta, and Gamma. Moreover, this device also gives Attention, Meditation and Eye Blinking data statistics. Neurosky Mind wave mobile II diminishes possible implementation error by doing preprocessing in the device[5].



Figure 1. Neurosky Headset

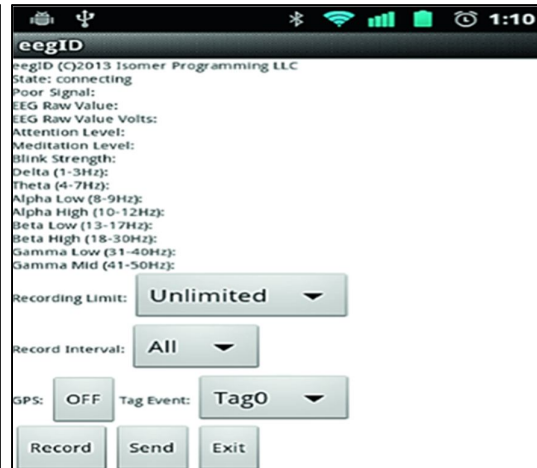


Figure 2. Screen of eegID interface

	Timestamp	poorSignal	eegRawValue	attention	meditation	blinkStrength	delta	theta	alphaLow	alphaHigh	betaLow	betaHigh	gammaLow	gammaMid	tagEvent	location
2	1.666+12	0	54	1.19E-05	50	35	45	1182275	39803	4113	7720	15575	18764	14542	3787	Tag0
3	1.666+12	0	121	2.86E-05	42	35	45	264796	228925	14314	67336	16829	13600	7811	5577	Tag0
4	1.666+12	0	56	2.23E-05	44	43	36	80723	42227	66370	30578	22399	14879	5630	12058	Tag0
5	1.666+12	0	57	2.25E-05	38	35	36	275283	1679689	7549	9404	16918	7133	8496	3892	Tag0
6	1.666+12	0	39	1.30E-05	34	53	36	185338	92672	16748170	31724	9027	14499	8068	5423	Tag0
7	1.666+12	0	42	9.23E-06	47	57	36	89713	16753352	11258	27296	30288	16122	3842	3958	Tag0
8	1.666+12	0	85	1.87E-05	48	50	38	203390	39144	8954	27624	8890	13553	37963	9448	Tag0
9	1.666+12	0	92	2.02E-05	64	50	38	298296	24282	8548	4395	5188	26777	7993	6200	Tag0
10	1.666+12	0	58	1.27E-05	70	35	38	393828	22008	1303	1075	7135	5880	7994	3255	Tag0
11	1.666+12	0	42	9.02E-06	67	23	38	345256	16763993	5989	4398	7952	8277	10872	3600	Tag0
12	1.666+12	0	-424	-9.32E-05	82	23	38	5618	8044	3179	1847	4551	4621	5928	956	Tag0
13	1.666+12	0	116	2.55E-05	64	23	38	2035818	75379	13432	6373	10787	8287	3960	429	Tag0
14	1.666+12	0	-316	-6.94E-05	47	37	42	16794381	15834	7247	2547	1307	467	1039	224	Tag0
15	1.666+12	0	3	6.59E-07	38	34	42	839983	737660	18348	16769082	16756155	16751070	16758022	19318	Tag0
16	1.666+12	0	66	1.40E-05	29	38	42	514243	16753352	23438	9562	12422	12282	5903	2689	Tag0
17	1.666+12	0	113	2.48E-05	30	30	42	1325217	145089	8535	10700	18870	18083	11152	3277	Tag0
18	1.666+12	0	-294	-8.48E-05	40	24	39	60343	28682	1935	6526	899	2754	3781	856	Tag0
19	1.666+12	0	28	6.15E-06	44	29	39	325706	84803	9515	6234	7987	7895	13289	4547	Tag0
20	1.666+12	0	44	9.67E-06	47	35	39	225635	22197	26522	13040	13448	13237	6378	5492	Tag0
21	1.666+12	0	38	8.35E-06	42	53	39	198544	74037	16759113	13539	4782	8842	19579	4222	Tag0
22	1.666+12	0	79	1.80E-05	48	57	39	16754885	14993	2725	5487	3794	1084	4913	4882	Tag0
23	1.666+12	0	22	4.82E-06	62	66	39	80445	11259	3025	5481	4397	8226	4820	3089	Tag0

Figure 3. Raw data of Neurosky in excel format

IV. EXPERIMENTAL WORK

In this work, An BCI-based Neurosky Mindwave device was used for Data acquisition of brain signals for analysis of the attention state of students from Learning activities such as Mathematical Problem Solving and Gaming. An experimental framework of the proposed work is given in Figure 04.

For this proposed experiment, the data has been collected from 20 (10 Male, 10 Female) postgraduate students participants from the Department of CS and IT, Dr B.A.M.University, Aurangabad. Participants' ages were between 20 to 26 years. The workspace where we experimented was completely quiet and had no external disturbances; before starting the data collection all participants with informed written consent before the experiment. The data have been recorded using the Neurosky device. For this device's connection with the computer, we first need to turn on Bluetooth on both devices and then pair them. After pairing them Neurosky

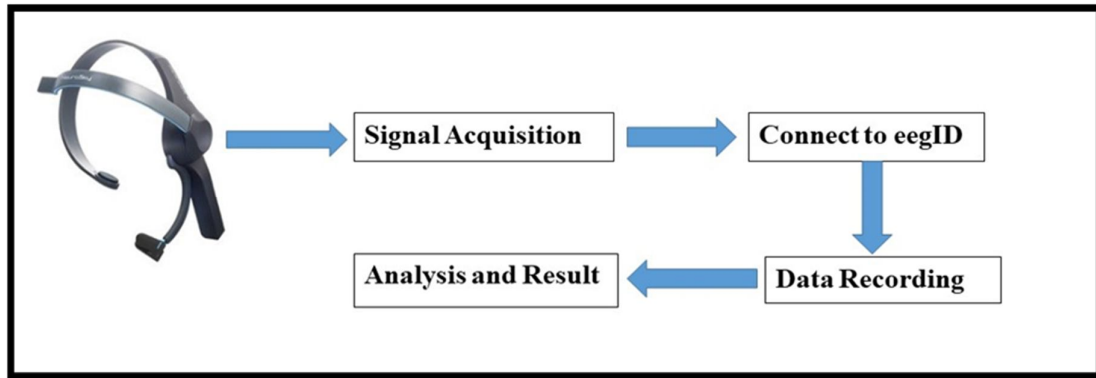


Figure 3. Experimental Framework

headset should be worn properly in the head. It's one probe must be on a hairy scalp. And another is in the earlobe. EEG is an android application that is connected to the Neurosky Mindwave device. The readings obtained from the Mind wave device are recorded and delivered through email by this application. The raw data is in CSV or excel format for further evaluation. In this study, we focus on two Learning activities, Mathematical Problem Solving and Gaming for analyzing attention. This procedure involved each of the participants to do 3 sessions of each activity. Those are given below-After starting the session, firstly, Participants were asked to listen to light music for 2 minutes in order to relax and get used to the learning environment.

A. Mathematical Problem Solving

Participants were asked to do single-digit multiplication, two-digit multiplication and three-digit multiplication with wearing the headset.

B. Gaming

Participants were asked to play three different games as Word searching, Water Sort Puzzle and Temple run. Three sets of data were collected from a participant with a little time break so that all data were generalized. Three data sets were collected from three sessions of each activity. We got 06 records of both activities with a time duration of 6 minutes. Each activity was a duration of 03 minutes, 1 minute for one session for collecting one set of data. In order to generalize the data acquired during this session, participants were requested to remain Relax and calm.

V. DATA ANALYSIS

Collected data were divided into two groups according to activities and also gender. The Attention and Meditation data are simply divided by 100 since these values are already scaled to be between 0 and 100 by the headset. These data are (approximately) normally distributed. All data from the headset are plotted as they are received. We got six types of data (Alpha, Beta, Gamma, Attention, Meditation, Eyeblink) from Neurosky Mindwave Mobile II. But not all of them are used in this experiment. Only Attention values are used here. We only paid cognitive attention to data because of having research work relating to this. In this paper, we considered the statistical parameters such as mean threshold value, maximum value and minimum value for analysis purpose. Here for cognitive attention analysis we have consider two activities one is mathematical problem solving other is Gaming activities and for analyzing these activities we again consider sub three task of each activity and for this comparison we have focus on M.Sc Students(Girls and Boys) with different age groups and In below section graphical representation shown the all statistical analysis as per our study observations and consideration. Firstly, here we have taken comparisons for Cognitive attention of girls and boys in both activities so the mean value of attention for only Girls in Gaming and mathematical problem solving all sessions shown in figure 5a or 5b.

Whereas Mean value of attention of only Boys in Gaming and Mathematical problem solving is shown in figures 6a and 6b.

After this we move to second observation that is comparisons of Girls and Boys for both activities for all sessions and Figure 7 shows the Mean result of attention for all participants in both activities for all sessions.



Figure 5.a. Attention of Girls in Gaming

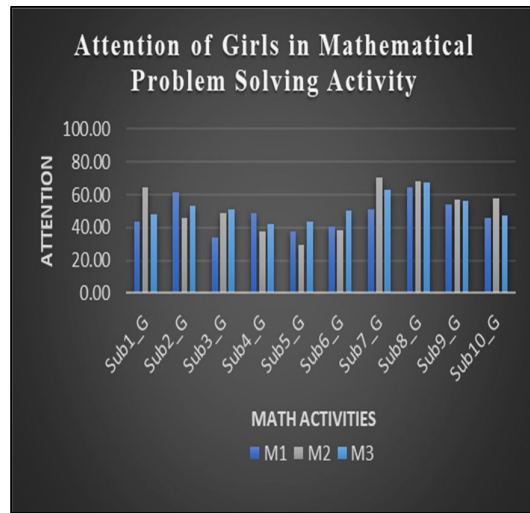


Figure 5.b. Attention of Girls in Math activities

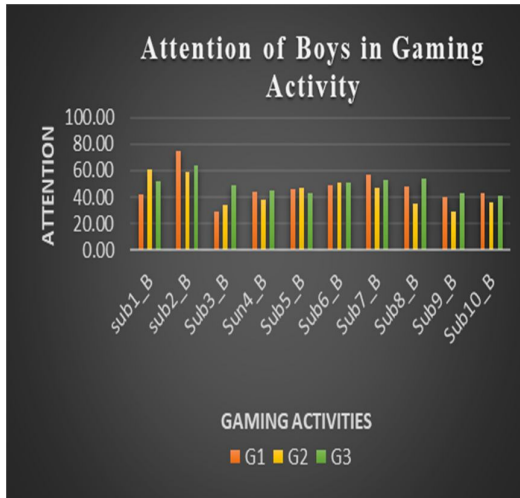


Figure 6.a. Attention of Boys in Gaming

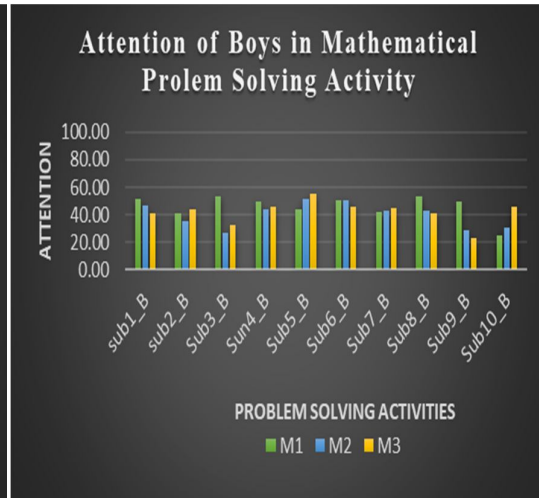


Figure 6.b. Attention of Boys in Math activities

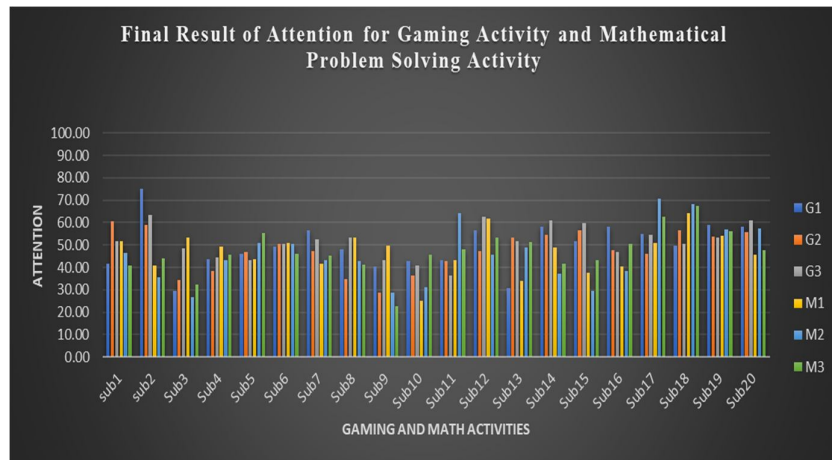


Figure 7. Mean result of Attention for all participants in both activities for all session

Whereas Figure 8 shown the Cognitive Attention of both group for given activities such as Gaming and Problem solving for all sessions with Statistical representation as Mean, Maximum value and Minimum values.

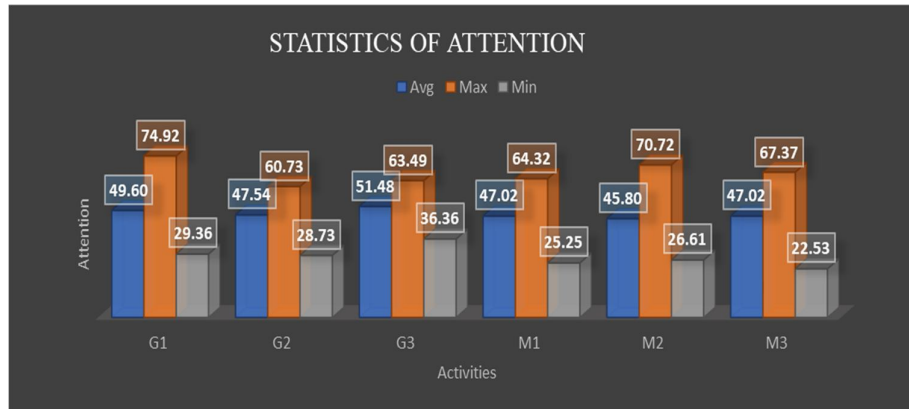


Figure 8. Statistics of attention for both activities

Finally, we got the Final result analysis of cognitive attention in Gaming and Mathematical problem solving which shown in figure 9.

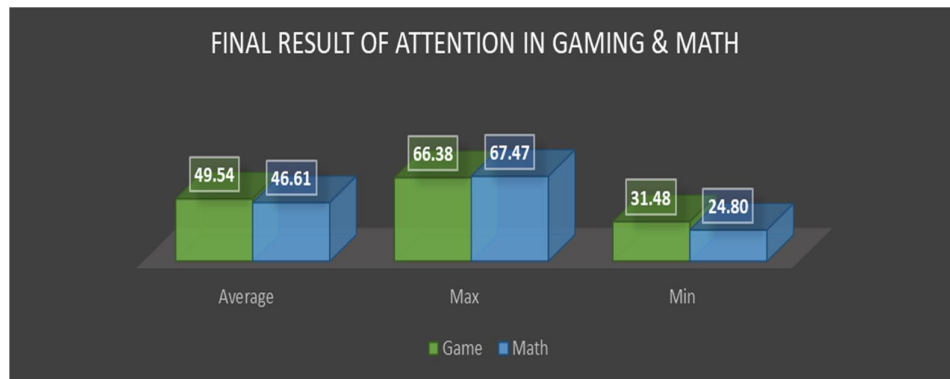


Figure 9. Attention in both activities

VI. RESULT

As per our work consideration finally we got some observations and here the results are discussed. As discussed in previous section we have focus on Cognitive Attention and for analysis of this we considered two different activities. Finally, according to our statistical result observation below results are discussed.

1. The final recognition accuracy of Attention for Girls in all sessions of Gaming (G1, G2, G3) are as 52 %,51.40%, 53.76% & in all sessions of Mathematical Problem Solving (M1, M2, M3) 48.05% ,51.74%,52.20%.
2. Whereas for Boys in Gaming (G1, G2, G3) are as 47.21%,43.67%,49.20% & in Math (M1, M2, M3) 45.99, 39.86%, 41.83%.
3. We also focus on maximum values of attention and minimum values of attention in both activities. So firstly, we discussed the Mean value of attention for all subjects in Gaming as 49.60, 47.54, 51.48 and in Math, 47.02, 45.80, 47.02.
4. In contrast, maximum value of attention of all subjects in Gaming are 74.92,60.73,63.49, in Math 64.32,70.72, 67.37 and Minimum values of attention in Gaming 29.36,28.73,36.36 & in Math 25.25,26.61,22.53.
5. Finally, we got the Mean value, Max value and min value of attention in Gaming as well as in Math such mean of game is 49.54 %, the max value is 66.38, and the min value is 31.48 whereas for Math mean 46.61%, max value 67.47 and min value 24.80 respectively.

VII. CONCLUSIONS

This paper emphasizes to monitor student's cognitive attention during their Learning Process. Learning skills is very play an important role in students' life and also in Cognitive states. Cognitive states consist of various activities such as memory, logical reasoning, attention etc. All cognitive activities are very important in Human life, but here we focus only on attention. Aim of this study to analyze the Attention level of student with respective to learning activities such as Gaming and Problem solving using Neurosky Mind wave wireless Device. According to our graphical result analysis here, we concluded some points 1) as per comparison between the attention level of girls and boys in Gaming and Math problem solving, this study showed that the Girls are more attentive than boys in Math problem solving and less attentive in gaming. In contrast, Boys are more attentive in gaming rather than girls and less attentive in Math solving. In addition, the analysis also showed that the final statistics of attention such as Max,Min values and Mean of Attention of all participants in both activities is 49.54 % for gaming and 46.61% for math solving .Here we say that participants are more attentive in gaming than math solving. This work contributed to checking students' attentiveness with respect to learning and also helpful for student's development in terms of attention. Future research will be required to explore different levels of cognitive activities and age group for comparison purposes.

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