International Journal of Engineering & Technology, 7 (4.44) (2018) 88-93

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Effect of eye massaging device towards brain rhythms

F. A. Mansor[1]*, R. Sudirman[2]*

[1&2]School of Electrical Engineering, Universiti Teknologi Malaysia, Malaysia
**Corresponding author E-mail: fatinafiqafam@gmail.com*

Abstract

This study aimed to examine the effectiveness of the eye massaging device in promoting mind relaxation state based on alpha rhythm in brain. This study has been conducted involving 35 participants whose their brain signals were captured by an electroencephalography (EEG) machine whilst they undergoing resting state, eye massaging session and visual tasks designed to induced stress. The signal is analyzed using Discrete Wavelet Transform (DWT) and the major concern of the study, relative power of alpha was extracted from channel point O1 and O2. T-test analysis used to validate the differences of relative alpha power produced before and after using the device. Based on the results, the average values of relative alpha power collected for EEG signals before using the eye massaging device has been increased for both channel (O1: before = 17.601, after = 19.765, O2: before = 12.577, after = 14.783) with an increment of 12.29% and 17.54% respectively. However, there is no enough evidence to prove that using the device give positive effect on improving participant's relaxation state as there is only have 51.5% and 58.4% chances that the device might worked on mind relaxation state.

Keywords: *electroencephalography; eye massaging device; mind relaxation state; relative alpha power, t-test analysis*

1. Introduction

One of the most important senses in all living humans is the vision. In order to obtain continuously clear visual, all eye muscles are forced to work hard every time an eye is focused onto something. In a normal extraocular muscles system, there are 6 muscles to control the eye movements include superior rectus, superior oblique, medial rectus, inferior rectus, inferior oblique and lateral rectus [1] (see Figure 1). Whilst levator palpebrea muscle responsibled to control the eyelid elevation [1]. Combination of these muscles will lead to various types of eye movements such as saccade, fixation, visuals, pursuit, vestibular ocular eye, vergence and optokinetic [2].

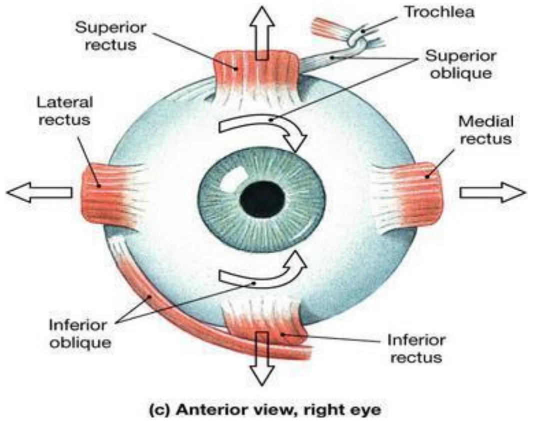

Fig. 1: 6 type of muscles to control eye movements; superior rectus, superior oblique, medial rectus, inferior rectus, inferior oblique and lateral rectus [3]

Nowadays, mobile phone has become a primary device for each individual as it has capabilities to perform Internet-based services and function like a computer (having an operating system capable of downloading and running applications) [4]. These items is 'a must have' item for everyone, either it is just for desire or the necessity. According to Prensky [5], younger generation nowadays are more kinesthetic and visual. Therefore, they commonly used their mobile communication technology for various online activities such as texting via over-the-top (OTT) platform such as WhatsApp, visiting social networking sites and getting information online [6].

However, high dependency on mobile phone also contributed to detrimental effects among youth such as they would go back if they left it back home and easily feel anxious if they did not do so, tend to waking up in the middle of the night just to check their phone, and could not last an hour without checking their phone after waking up [4]. Thus, it is no wonder Coghill [7] defined this device as "the most radiative domestic appliance ever invented".

Hence, the excessive usage of this device may results in eyestrain since the eye muscles tend to overstress due to these behaviors. One of the ways that has been produced to overcome this problem is eye massaging device. This device used the same concept with the massaging chair that uses small push button to massage the muscles around the eyes. It has many advantages such as easy to carry and can be used anywhere and anytime due to its compact size, as well as suitable to be used by all ages.

Human brain can be divided into 3 major parts known as brain stem, cerebellum and cerebrum (see Figure 2). The brain stem is important for basic vital life functions such as heart rate, blood pressure, breathing, respiration system and consciousness [8], whereas the cerebellum which attached to the brain stem responsible for controlling motor functions, maintaining body balance and interpreting the information receive from sensory organs [9].

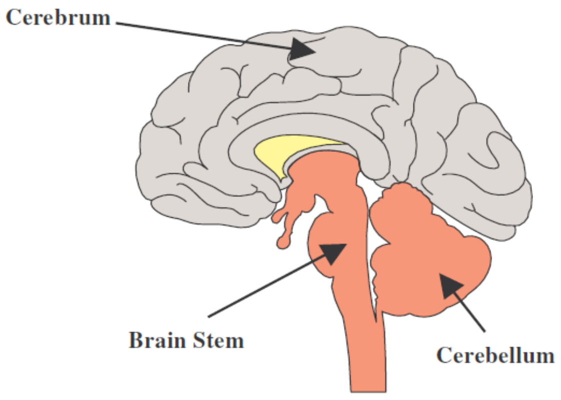

Fig. 2: 3 major parts in human brain [10]

Meanwhile, cerebrum whose also the largest part of the brain is divided into 4 lobes; frontal, parietal, temporal and occipital (see Figure 3) which specialized for performing respective functions as in Table 1 [8]. As the visual information is processed on the occipital lobe, this study used channel points O1 and O2 in EEG systems analysis.

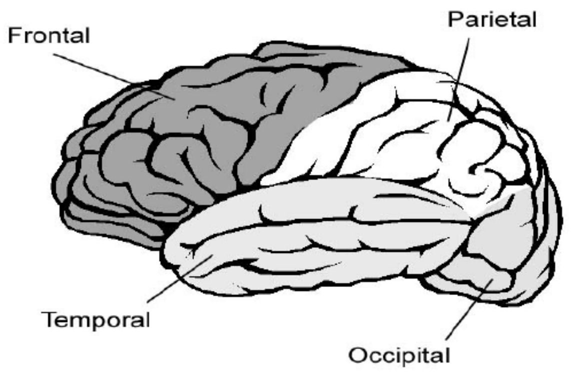

Fig. 3: 4 lobes in the human brain [10]

Table 1: Brain lobes and their respective functions [8]

Lobe Region	Function
Frontal	Controls voluntary muscular functions, aggression, moods, motivation and smell reception
Parietal	Evaluate sensory information of pain, touch, taste, temperature and balance
Temporal	Center for abstract thoughts and judgment decisions, involve in memory processes and evaluated hearing input and smell
Occipital	Receiving and interpreting visual input

EEG is a process of capturing brain signal in the form of electrical waveform at various interest points on the head. The waveform is easily described as voltage fluctuations for every ionic current flow within the neurons and the brain [11]. The International Federation of Societies for Electroencephalography and Clinical Neurophysiology has recommended the conventional electrode setting (also called 10- 20) for 21 electrodes [12] as shown in Figure 4. Each and every part of the point determines the different area of response from the brain. Hence, the areas of posterior region, both occipital lobes (channel points O1 and O2) which were affected by the visual tasks were specifically included during data analysis.

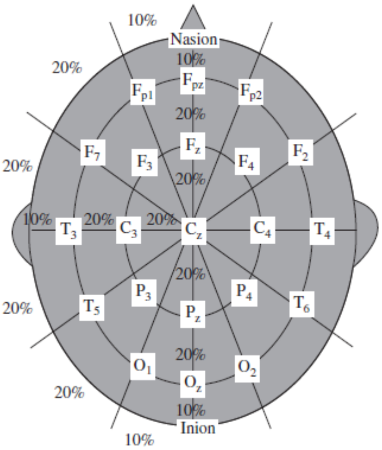

Fig. 4: Position of electrode on the EEG scalp with point labeled [12]

2. Data acquisition

2.1. Materials and method

35 participants aged between 20 to 25 years old from School of Electrical Engineering, UTM with no history of medical condition participated in this experiment. They need to answer blind colour test and basic questionnaire before undergoing the experiment. The questionnaire is designed to obtain their basic personal information and recorded their daily activities to detect if there is any factors that could affect the data collected such as eye fatigue due to less sleep and any heavy activities that may affects their eye muscles before undergoing the experiment.

This experiment is fully conducted in a dark and closed room. Several precautions have been taken into account to minimize the noises such as the participant is advised to remain still and avoid any body movement while collecting the data. Further, strong electronic interference from a nearby emitter source (e.g. mobile phone) may created the interference sources. Thus, the mobile phone must be kept away from the equipment or turned off during experiment.

The materials and tools used for this experiment were fixed for the whole time. Neurofax EEG-9200 machine and bipolar jack (see Figure 5) are connected together in order to acquire EEG signals. Both position and distance of all equipment used throughout this experiment is also labelled properly and is placed at the exact position for the whole time to minimize parallax error. The distance between the chair placed in front of the screen is 1 meter and is marked by the 'X' spotted on the floor (see Figure 6) is fixed throughout the experiment.

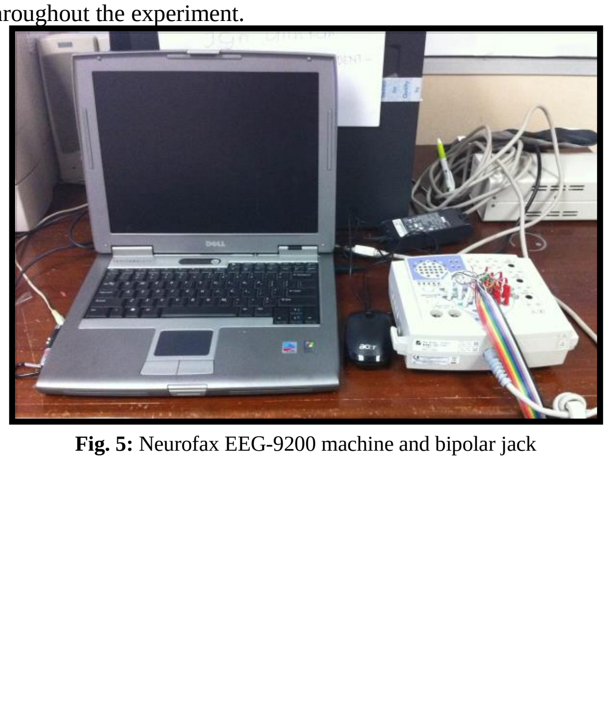

Fig. 5: Neurofax EEG-9200 machine and bipolar jack

Fig. 6: Distance of 1 meter is marked by the ‘X’ on the floor

2.2. Experimental procedure

The experimental procedure on EEG data acquisition was illustrated in Figure 7. Firstly, participant is required to seat comfortably on the chair and the scalp electrode was attached on participant’s head. Then, their eyes need to be closed for 60 seconds in order to acquire EEG signals before using the eye massaging device. In relaxed condition, the eye muscles do not need to work hardly in order to give the best eye signals. Therefore, the signals should be in lower amplitude compared to stress condition.
Then, the participant needs to undergo 3 visual tasks designed to create eye tiredness in this study. Each participant needs to undergo all of the tasks in order to stressed out the eye muscles and interrupting their mind relaxation state. After the last task, they need to wear the eye massaging device for 5 minutes. Lastly, the EEG signals are recorded after the massaging session denoted as EEG after.

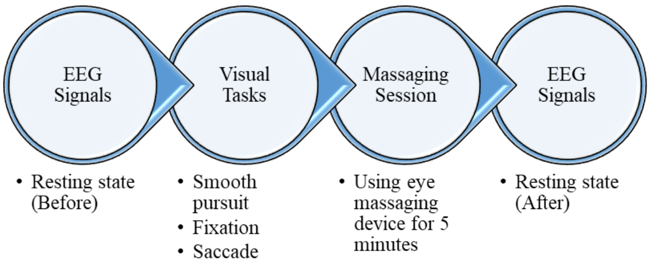

Fig. 7: Experimental procedure on EEG data acquisition

2.2.1. Eye massaging device

The eye massaging device used in this study is shown in Figure 8. This device helps in reducing the eye strain, eye fatigue, insomnia, headache and improving the blood circulation of the eyes. This vibration massaging device is adapted from an ancient Chinese acupuncture treatment method with small push button to massage around the eyes. The massaging concept in this device is quite similar with the massaging chairs that use vibration to move the virtual ‘hand’ to massage the user. This device has 7 different type of vibrations with 3 modes for timer; 3, 5, and 10 minutes for each full cycle of usage.

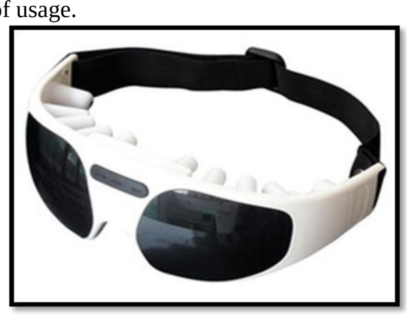

Fig. 8: Eye massaging device

2.2.2. Visual tasks

In this study, visual tasks have been designed based on 3 eye movements such as smooth pursuit, fixation and saccade to create eye tiredness. Each participant needs to undergo all of the tasks in order to stressed out the eye muscles and interrupting their mind relaxation state. The tasks were projected on the white screen using Microsoft Power Point slide throughout the experiment to avoid systematic error.
Firstly, in smooth pursuit task, participant needs to look at the pen that is placed at the center of the screen. This position is marked as the reference point. The pen will move slowly to the right side and coming back to its reference point. The time taken for this movement is 30 seconds. From the reference point, the pen moves slowly to the left side of the screen for another 30 seconds. The total time duration for this task is 60 seconds.
Secondly, fixation task is designed to look for another four eye movements; looking up right, looking up left, looking down right and looking down left. At the first moment, a red dot is appeared at the center of the screen. This position is marked as the reference point. The dot is then disappearing and it was consecutively reappear at different position randomly. The total time duration for this task is 60 seconds.
For the last task, saccade is defined as fast and non-smooth tracking movements of the eyes [13]. One of the easiest ways to observe this type of eye movement is when the participant reads a text of paragraph. In order to stress out the eye muscles, the text is designed based on these specifications; small font size text and light grey contrast. The total time duration for this task is 60 seconds.

3. Data processing and analysis

Firstly, Neurofax EEG-9200 machine is used to acquire the EEG signals. Then, they are converted to ASCII format to make it readable and easy to use in the analysis. In this study, value of relative alpha powers of the signals before and after using the eye massaging device at channel point O1 and O2 have been extracted and analyzed using MATLAB software. T-test statistical method is used to validate the results obtained. Flowchart of this process is shown in Figure 9.

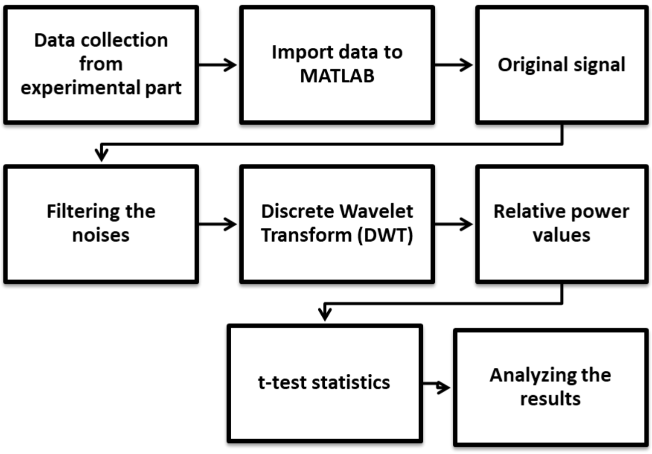

Fig. 9: Flowchart of data analysis

3.1. Discrete Wavelet Transform (DWT)

In DWT, the original signals have to pass through both low pass and high pass filter before it decomposed into gamma, beta, alpha, theta and delta rhythm respectively. Table 2 summarized the decomposition level with its related frequency and brain rhythm.
The db4 chosen as a mother wavelet due to its capability to detect the changes occurred in EEG signals as well as give better accura-

cy [14]. Since the sampling frequency of this experiment is 500 Hz, the 7 decomposition level was used to extract brain rhythms aforementioned. According to Nyquist rule, the original signal have to be down-sampled by 2, hence the output signals having half the frequency's bandwidth of original signals. Decomposition at level D1, D2 and D3 were considered as noise. Whilst decomposition at level D4 represents gamma rhythm, D5 represents beta rhythm, D6 represents alpha rhythm, D7 represents theta rhythm and A7 represents delta rhythm. Since alpha rhythm is the only major concern in this study, only signals at decomposition level of 6 (D6) was extracted in data analysis.

Table 2: Decomposition of EEG signals into different frequency bands (Fs = 500 Hz)

Frequency Range	Decomposition Level	Frequency Band
250 – 500	D1	Noise
125 – 250	D2	Noise
63 – 125	D3	Noise
31 – 63	D4	Gamma
16 – 31	D5	Beta
8 – 16	D6	Alpha
4 – 8	D7	Theta
0 – 4	A7	Delta

Particularly for this study, alpha rhythm is included in the data analysis as it indicated relaxed awareness without any attention or concentration and it most frequently appeared in the posterior half of the head, usually found on the occipital region of the brain [12]. Hence, by comparing the EEG signals before and after using the eye massaging device at both channel point O1 and O2, relative alpha power for EEG signals after massaging session should show an increasing trend to prove that the participants were more relaxed and calm after using the device as higher alpha values leads to higher relaxation.

Another major concerned in this study is beta rhythm whose most significantly appeared indicating active thinking, attention, focus on the outside world or solving concrete problems [12]. This particular brain rhythm is chosen to be investigated in this research because the participants were in active condition when undergoing the assessments, implying that they were fully awake as their brain were working actively compared to the asleep condition [16]. Therefore, the presence of beta rhythm is further analysed to investigate if the visual tasks can produce a stress condition towards mind relaxation state.

4. Results and discussion

4.1. Relative power of EEG signals

4.1.1. Beta rhythm

For this experiment, visual tasks were designed to induce stress towards eye muscles. In order to identify the effects of visual tasks towards brain signals, beta rhythm which indicated the tense-activity of the brain cortex were analysed at channel point O1 and O2 as the visual tasks were related to visual processing.

For the first task, participant is required to follow the direction of the pen slowly but steadily without moving his head, whereas the last task required them to read a text with small text sizes and low-contrast grey text. The average values of relative beta power for Task 1 and Task 3 for both channel points were illustrated in Figure 10.

Based on the figure below, for Task 1 condition, the average values of relative beta power for O1 (3.813) and O2 (2.500), meanwhile beta values for Task 3 condition were O1 (2.500) and O2 (3.344). The values of the percentage changes when comparing both tasks did not showed not much difference in value, both with an increment of 37.84% and 33.76% respectively. As the average values at the end of visual tasks were higher, thus it can be conclude that the participant did undergo slightly pressure, psychological discomfort, tension, anxiety and uncomfortable condition [17].

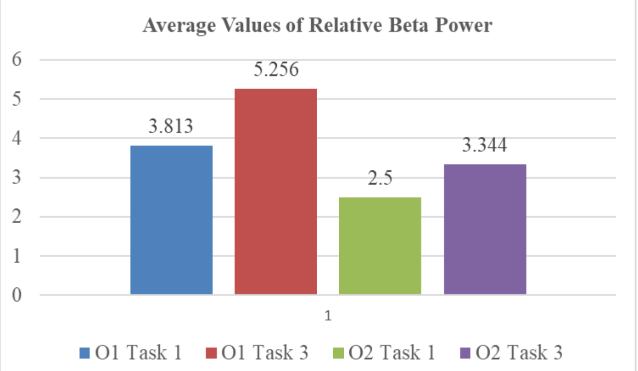

Fig. 10: Average value of relative beta power for EEG signals at both channel point O1 and O2

However, they were many factors that could affect the data collected such as eye fatigue due to less sleep and any heavy activities that may affects their eye muscles before undergoing the experiment. This is supported by the answered given by participants in the questionnaires obtained. 43% of the participants slept before undergoing the experiment, followed by 40% have attended the class and 17% have eaten beforehand. Therefore, there is an uncertain factor in the fatigue condition felt by the participant at the beginning of Task 1.

Besides, another factor to take into consideration is the average hours of sleeping at night. Only 32% of the participants were taking a good sleep at night, compared to 68% of the participants were less sleep the night before undergoing the experiment.

The mean and standard deviation values of the relative beta powers for each task were summarized in Table 3. The results obtained reflected that the sample data have the lowest variation of dataset, thus the degree of data variation towards the main value were higher. Both results for each tasks tabulated below showed low standard deviation values, indicating that most of the data were very close to the average.

Table 3: Mean and standard deviation of beta rhythm during visual tasks

Channel Point	Task 1		Task 3	
	Mean	Standard Deviation	Mean	Standard Deviation
O1	3.813	2.742	5.256	3.331
O2	2.500	1.444	3.344	2.790

4.1.2. Alpha rhythm

The results obtained from this study were significant and consistent of alpha values at occipital lobe before and after using the eye massaging device. From Figure 11, 68% of the participants showed positive values, whilst another 32% show the negative value. Positive values indicated that the power for alpha value is higher (more relaxation) after using the eye massaging device and vice versa.

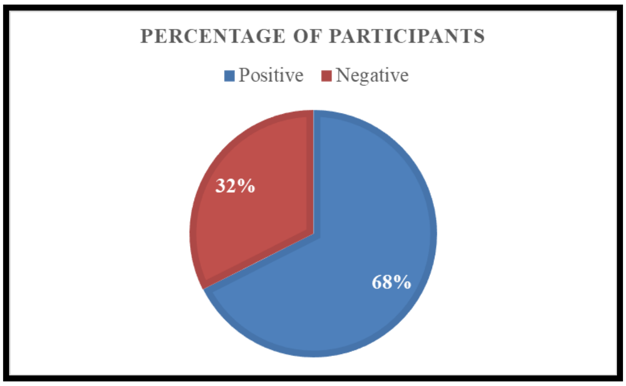

Fig. 11: Percentage of participants based on positive and negative effects of eye massaging device

Referring to Table 4, the relative power of alpha rhythm around the channel point O1 (17.601) was significantly lower represents relaxed awareness state without attention and concentration at this time and the power value was slightly increased by 12.29% after massaging session. Whereas at channel point O2 (12.577), the average value of EEG after increase by 17.54%.

Table 4: Average values of relative alpha power for EEG signals at both channel point O1 and O2

Channel Point	Average Value of Relative Alpha Power	
	EEG Before	EEG After
O1	17.601	19.765
O2	12.577	14.783

4.2. Statistical analysis

For this study, t-test statistical method chosen to validate the preliminary results obtained from EEG data acquisition in order to compare two different conditions (to see the significance or difference between them) [15]. The hypotheses made for this study was to deduce the effects of eye massaging device towards brain relaxation states as follows:

a) Null hypothesis, H0: Using eye massaging device has no effect on improving participant's relaxation state.

b) Alternative hypothesis, H1: Using eye massaging device has a positive effect on improving participant's relaxation state.

H0 will be **REJECTED** if it fulfilled either one or both of these conditions:

a) t-statistical > t-critical two-tails
b) $P(T \leq t)$ two-tails $\leq \alpha$, where $\alpha = 0.05$

Referring to Table 4, null hypothesis for both channel point O1 and O2 were accepted since the values of t-statistical and $P(T \leq t)$ two-tails did not fulfilled both conditions mentioned before. Therefore, there is no enough statistical evidence to reject the null hypothesis. Hence, this test cannot be used to proof that using the eye massaging device give positive effect on improving participant's relaxation state as there is only have 51.5% and 58.4% chances that the device might worked on mind relaxation state based on these 2 channel points.

Table 4: The acceptance or rejection of null hypothesis, H0

Channel Point	Condition		Null Hypothesis, H0
	t-statistical > t-critical two-tails	$P(T \leq t)$ two-tails ≤ 0.05	
O1	1.868 < 2.040	0.071 > 0.05	Accepted
O2	0.899 < 2.040	0.376 < 0.05	Accepted

This is supported by the findings obtained from the questionnaires answered beforehand. 17% of the participants felt energetic and fresh after using the device, whereas there is also another 17% of the participants felt tiredness. However, more than half of the total participants for both groups (66%) claimed they felt dizziness after the massaging session.

Furthermore, based on the personal opinion on the effects of the device afterwards, range of the satisfaction showed that minority of the participants (25%) felt that the device is really effective in promoting relaxation, followed by 37% of the participants felt that the device is ineffective in promoting relaxation, whereas majority of the participants (38%) felt neutral after using the device.

5. Conclusion

Based on the results, 68% of the participants did undergo positive effects of eye massaging device, whilst the remainder showed negative effects toward the usage of this device. The average value of relative alpha power collected for the EEG signals before eye massaging session has been increased for both channels used (O1: 12.29%, O2: 17.54%). However, there was no enough evidence from the statistical test to support the statement of the eye massaging device help to reduce the stress level in human brain.

This study has several limitations such as it only focused on 3 types of eye movements that are smooth pursuit, fixation and saccade. Therefore, it is highly recommended that the visual tasks used to induce stress towards eye muscles should include another types of eye movements such as vestibular ocular eye, vergence and optokinetic.

Besides, this study only focused on the teenager's age of group. Thus, the scope of the participant can be broaden by including children, pre-teen and seniors in the future study.

Acknowledgement

The authors would like to express sincere gratitude to all of the participants involved in this study. Our appreciation also goes to Universiti Teknologi Malaysia for allowing and funding this study under vote project number 13H25.

References

[1] B. R. Frueh, A. Hayes, G. S. Lynch and D. A. Williams, "Contractile Properties and Temperature Sensitivity of the Extraocular Muscles, the Levator and Superior Rectus of the Rabbit", *Journal of Physiology*, (1994), pp.327-336.

[2] A. Bulling, J. A. Ward, H. Gellersen and G. Troster, "Eye Movement Analysis for Activity Recognition using Electrooculography", *IEEE Transaction on Pattern Analysis and Machine Intelligence*, 33(4), (2011), pp.741-753.

[3] J. G. Betts, P. Desaix, E. Johnson, J. E. Johnson, O. Korol, D. Kruse, B. Poe, J. A. Wise, M. Womble and K. A. Young, "Anatomy and Physiology", OpenStax College, Rice University, Texas, (2017), pp.464-466.

[4] "Hand Phone Users Survey 2017", Malaysian Communications and Multimedia Commission, (2017), pp.9 & 54-55.

[5] M. Prensky, "Adopt and Adapt School Technology in the 21st Century", (2005), Edutopia.

[6] "Internet Users Survey 2017", Malaysian Communications and Multimedia Commission, (2017), pp.9 & 12-13.

[7] N. M. Rosley, I. Ismail and H. L. Visvernardan, "Students' Acceptance on Mobile Phone Usage and SMS Learning", *Malaysian Journal of Distance Education*, 13(2), (2011), pp.49-59.

[8] D. C. Rizzo, "Introduction to Anatomy and Physiology", Cengage Learning, (2011).

[9] M. S. Sweeney, "Brain: The Complete Mind: How it Develops, How it Works, and How to Keep it Sharp", (2009), National Geographic.

[10] "CleveLabs Laboratory Course System Version 6.0", Cleveland Medical Devices Inc., Cleveland, OH, (2006), pp.1-11.

[11] E. Niedermeyer and F. L. Silva, “Electroencephalography: Basic Principles, Clinical Applications, and Related Fields”, 5th Ed, Philadelphia: Lippincott Williams & Wilkins (2005).

[12] S. Sanei and J. A. Chambers, “EEG Signal Processing”, John Wiley & Sons, Ltd, (2007), pp.11, 15-16.

[13] "Human Electro-oculography (EOG)", Teaching Instrument, ADInstruments, (2004), pp.1-8.

[14] A. Subasi and E. Ercelebi, "Classification of EEG Signals using Neural Network and Logistic Regression", *Computer Methods and Programs in Biomedicine*, 78, (2005), pp.87-99.

[15] Z. M. Khalid, N. M. Ismail, A. Bahar, I. Mohamad, M. H. Lee, N. Ismail and N. Ahmad, “Introductory Statistics for Engineering Students”, Department of Mathematical Sciences, Faculty of Science, Universiti Teknologi Malaysia, (2012), pp.93-94.

[16] A. R. Clarke, R. J. Barry, R. McCarthy and M. Selikowitz, "Excess Beta Activity in Children with Attention-deficit/Hyperactivity Disorder an Atypical Electrophysiological Group", *Psychiatry Research*, 103(2-3), (2001), pp.527-538.

[17] H-L. Fu and T-M. Kuan, “Under Different Conditions of Learning Memory in the Electroencephalograph (EEG) Analysis and Discussion”, *2nd International Conference on Power Electronics and Intelligent Transportation System*, (2009), pp.352-355.