ELECTROENCEPHALOGRAM (EEG) STUDIES ON HUMAN PERCEPTION IN COLOURS

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ABSTRACT: This manuscript presents an investigation of human perception on colors using the Electroencephalogram (EEG) device. Studies of the human perception using EEG is expanding in various discipline that links electronics to many fields of study interest. The aim of this study is to observe the human perception and its level of calmness in the brain. Observation was made on the alpha band that was generated from various kinds of colors to different human. This study further focused on the EEG frequency of Alpha brainwaves and its relation to the brain lobes. In this experiment, the low-cost Emotive Epoch EEG neuroheadset device with 16 channels of electrodes were used. Subjects were instructed to look into different colors displays during the experiment. The EEG data was analyzed using the Fourier transform of Power Spectral Density (PSD). The results were observed from all the lobes but focusing were made on the occipital lobe and the averages of the alpha waves Power Spectral Density in two channels of the occipital were obtained. The analysis result from this study showed that the alpha wave produced from different participants are affected through different colors. This observation further depicted that human are calm through their color of interest.

KEYWORDS: *Colors; EEG; Human Perception*

1.0 INTRODUCTION

Color is the perception of human senses, and the color measurement technology must state it in descriptive and understandable quantities. The overall section of the brain can be depicted as shown in Figure 1 [1-3]. Light sensations are received in two parts of the brain namely cortical cerebral and hypothalamus [4-5].

i. Cerebral cortex, which is the center of mental process perception activity. It works to receive information.
ii. Hypothalamus, it functions as a biological stimulus to the nervous system [6-8].

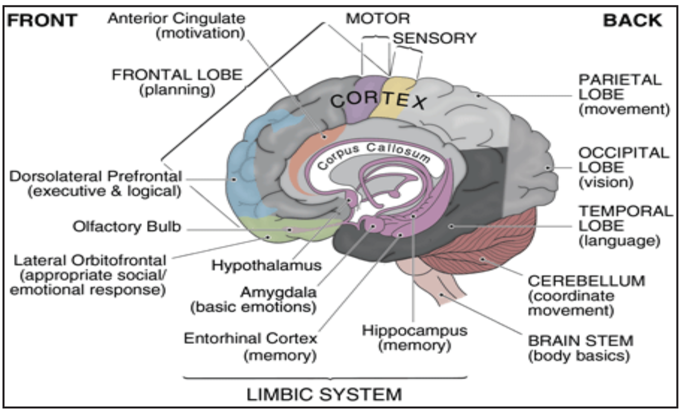


Figure 1: The Section of human brain [1-3]

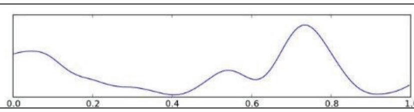
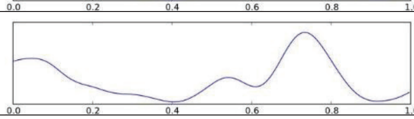
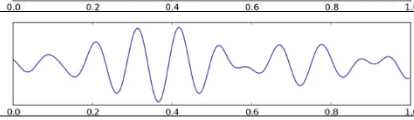
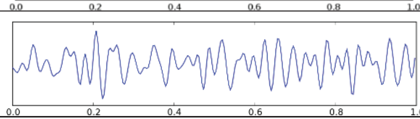
In this study, the Electroencephalogram (EEG) is used for the purpose of measuring the brainwave signal [9]. EEG is the most suitable device used to measure of the human brain behavior [10-13]. Previous studies of EEG applications in colors has shown positive findings in emotions and its effect in environment [14-15]. Hence, this study intends to explore and investigate the relation of brain electrical activities to human perception on colors. The project focused on the EEG frequency of the alpha band and its relation to the brain (occipital) lobes. Type of brain waves and its various frequencies can be summarized as shown in Tables 1 and 2. The main objective of this research is to observe the level of calmness in human brain and prove that the alpha band can be generated from various kinds of colors to different human. Specifically, the study aims to accomplish the following:

i. To relate the EEG signal frequencies with human emotions when the participant was instructed to look at A2 colored papers.
ii. To observe the pattern of the signal increment and decrement between different colors.
iii. To identify the differences of frequency activity in when participants or subjects are instructed to look at different colors.

Table 1: Types of the brain waves

Wave	Delta Wave	Theta Wave	Alpha Wave	Beta Wave
Frequency range	0Hz to 4Hz (Slowest)	4Hz to 8Hz (Slow)	8Hz to 13Hz (Moderate)	13Hz to 30Hz (High)
Too much	Brain injuries, Learning problem, Severe ADHD	ADHD, Depression Hyperactivity Inattentiveness	Inability to focus Too relaxed	Adrenaline Anxiety High arousal Inability to relax
Too little	Inability to rejuvenate body, Inability to revitalize the brain	Anxiety, Poor emotional awareness, Stress	Anxiety high stress Insomnia	ADHD Depression Poor cognition
Optimal	Immune system, Natural healing, deep sleep	Creativity, Emotional connection, Intuition, Relaxation	Relaxation	Conscious focus Memory Problem solving
Increase wave	Depressant Sleep	Depressant	Alcohol Relaxants Some antidepressants	Coffee, Energy drinks Various stimulants

Table 2: Types of the frequency wave and its waveform

Types of the frequency wave	Waveform
Delta	
Theta	
Alpha	
Beta	

The project investigates an alternative way human can do in order to reduce stress. By looking at the various types of colour leads someone to becoming more relaxed and calmed which is obviously good for their own health. By this way, colour therapy is a good choice whenever people are having stress. Moreover, in these days especially when we are living in this modernization era, it is easy to find any kind of colour at anytime and anywhere. This kind of therapy can help user to make the best choice to reduce stress as it is less time consuming and does not require much money.

2.0 METHODOLOGY

This study used the low-cost EEG Emotive Epoch+ headset to measure the brain activities. The reflection of color stimuli is produced and monitored by EEG and video camera. Figure 2 shows the flowchart of the whole experiment process and the flowchart of applying the neuroheadset is shown in Figure 3.

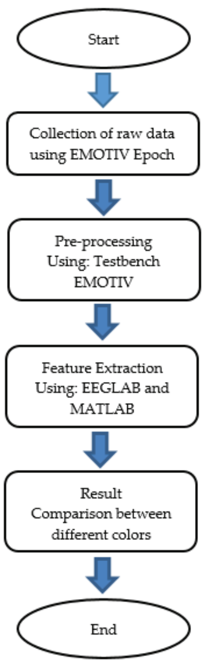


Figure 2: Flowchart of the whole process in obtaining EEG signal

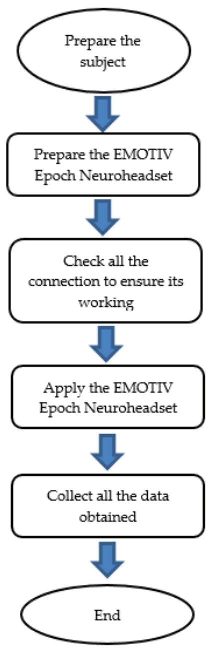


Figure 3: Flowchart of applying the EMOTIV Epoch Neuroheadset on subject's head

2.1 Hardware

In this study, there is numerous precautions need to be taken thru the test. First thing is to prepare the subject. Five subjects participated in this study. They had normal color vision. All of them are free from any disease and medicine. The experimental procedures were fully explained to them before start the experiment. The subject with short hair is considered for better attachment of electrodes and must ensure that they did not put any gel or wax to their hair before start the experiment. This is to prevent interrupts during collecting the data. The hardware headset used is shown in Figure 4.

Figure 4: EMOTIV Epoch+ and 16 electrodes used on the scalp

The device electrodes were moistened with solution before they are put on the subject's head. This is because to make sure all the connection between the subject's scalp and the electrodes of the EMOTIV give good signal.

2.2 Software

Three types of software used in obtaining and examining the data which are Camtasia 9, EMOTIV Testbench and MATLAB – EEG toolbox were used in this experiment. Camtasia 9 is the video editor that been created by TechSmith to record the stimuli and setup the program for the whole process for further purpose of EEG acquiring system. During the recording session, Camtasia 9 is also used to monitor the subject condition during the experiment by the camera of the Camtasia 9. The experiment was designed in Camtasia using Camtasia 9 software. A sequence of five colors was displayed on the Camtasia screen for two minutes per color display.

The EMOTIV Testbench came with the EMOTIV Epoch headset to run as an acquiring system of EEG data. The function of this software is to recognize the quality of the connection between the contacts of electrode to the subject's scalp. The sensor signal will turn all to green when all the electrodes are fully contact with the scalp. The EEG raw data obtained by the EMOTIV Testbench were saved in .edf Format. The EEGLAB tool was used to extract the data acquire from the EEG Testbench which is in .edf format. In the EEGLAB toolbox, it can analyze each of the electrodes of the EMOTIV Epoch Neuroheadset. This toolbox also can set the data range that needs to be taken for the experiment. In EEGLAB tool it has several tools for analyzing the raw data signal. One of the tools used is the baseline remover. After removing the baseline of the raw EEG signal data, the signal can be plotted. The signal is plotted in time frequency for every channel.

Figure 5: Camtasia 9

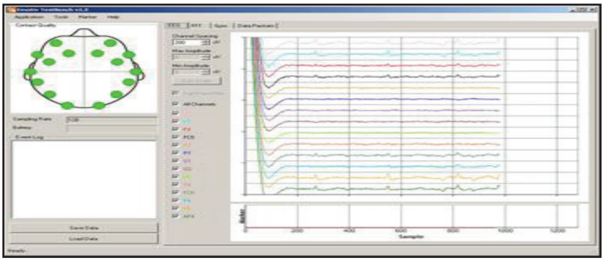


Figure 6: EMOTIV testbench

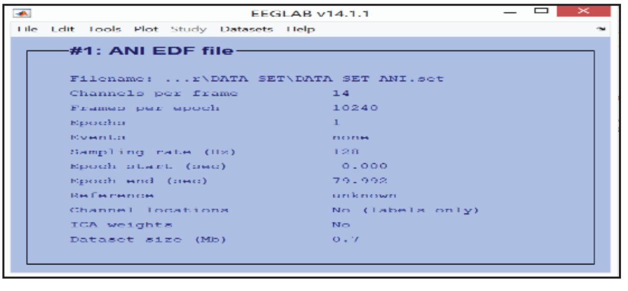
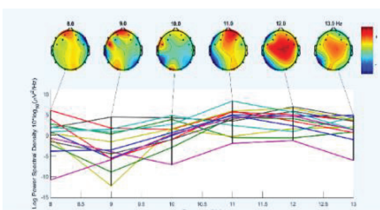


Figure 7: MATLAB – EEGLAB toolbox

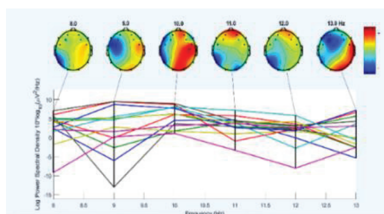
The Fast Fourier Transform (FFT) was applied during the signal in time frequency to obtain the Power Spectral Density (PSD). To plot the signal in time-frequency, the frequency limit needs to be set. To obtain the alpha band, the frequency range set to 8 to 13 Hz. All the data is extracted in every channel of the electrode that have been analyzed and saved in Microsoft Excel.

3.0 RESULTS AND DISCUSSION

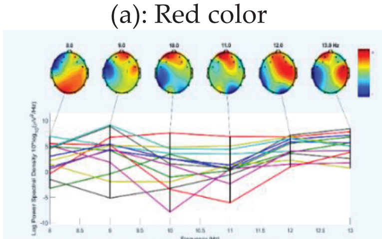
The results were examined from 14 channels of electrodes. EEG data of visual task was divided into 5 parts namely Red, Blue, Green, Black and Yellow colors. The range of frequency of the alpha brainwave that was measured in this experiment was within 8-13 Hz. Analysis of EEG data using Power Spectral Density (PSD) of each color stimulus for the alpha band of each subject was made. The subject is considered to achieve the calm condition depending on the colors they loved. Power Spectral Density shows the colors based on the occipital lobe. The analysis of Power Spectral Data and the topographic maps observation in every subject are depicted in Figures 8(a)-(e) for Subject 1, Figures 9(a)-9(e) for Subject 2 and Figures 10(a)-(e),11(a)-(e),12(a)-(e) for Subjects 3, 4 and 5, respectively.



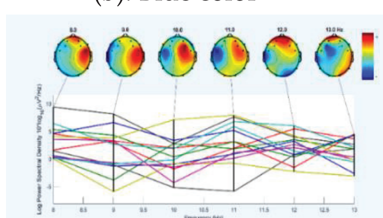
(a): Red color



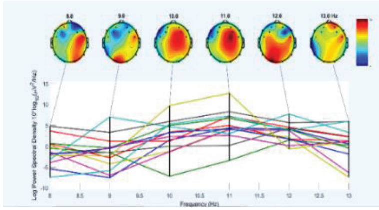
(b): Blue color



(c): Green color

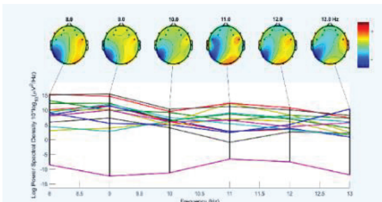


(d): Black color

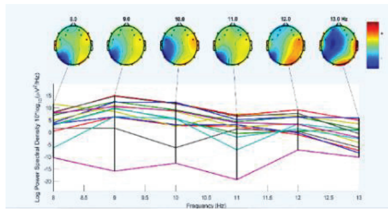


(e): Yellow color

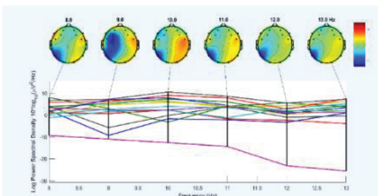
Figure 8: The power spectral density shows a very high peak PSD value of 5, 6.5 and 7 within the alpha range at 8Hz, 9Hz and 12Hz, respectively for O1 and O2 of the yellow color (Subject 1)



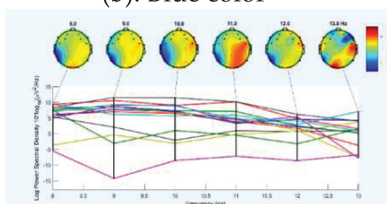
(a): Red color



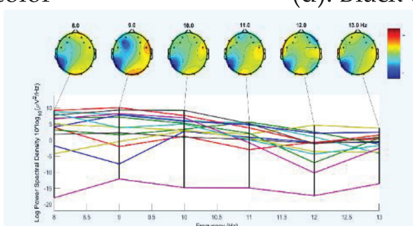
(b): Blue color



(c): Green color

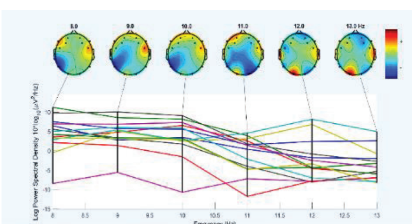


(d): Black color

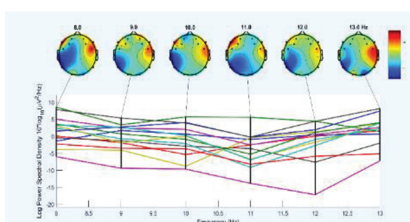


(e): Yellow color

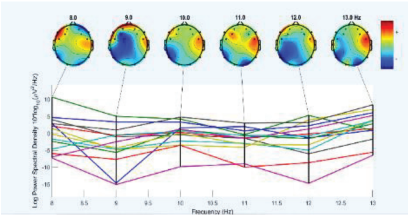
Figure 9: The power spectral density shows a very high peak PSD value of 10 and 7 within the alpha range at 11Hz and 13Hz respectively for O1 and O2 of the black color (Subject 2)



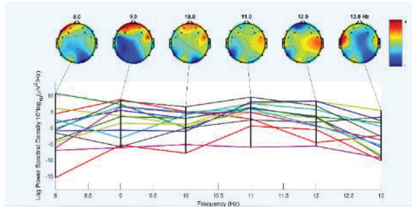
(a): Red color



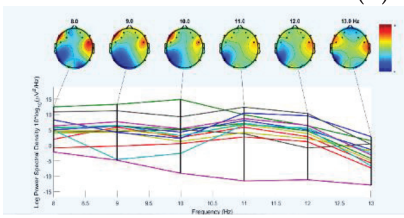
(b): Blue color



(c): Green color

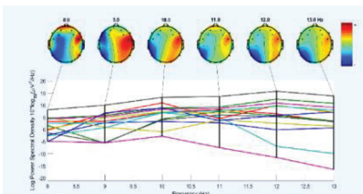


(d): Black color

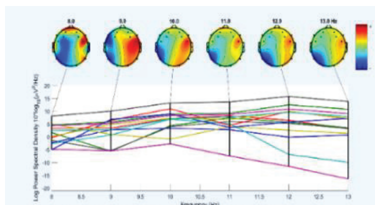


(e): Yellow color

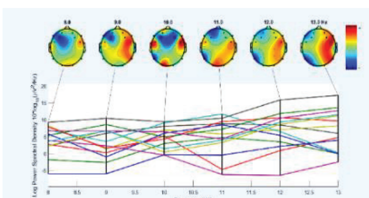
Figure 10: The power spectral density shows a very high peak PSD value of 5 and 7 within the alpha range at 13Hz and 12Hz respectively for O1 and O2 of the red color (Subject 3)



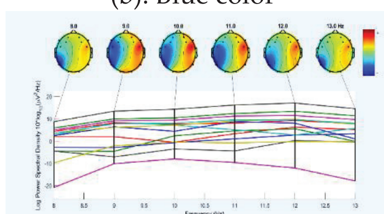
(a): Red color



(b): Blue color



(c): Green color



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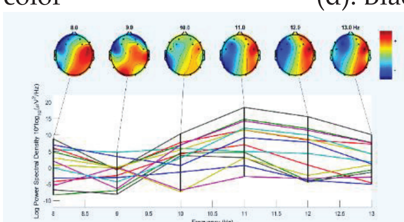
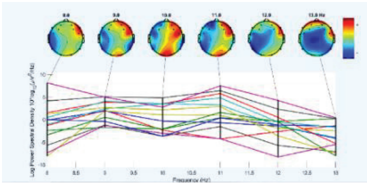
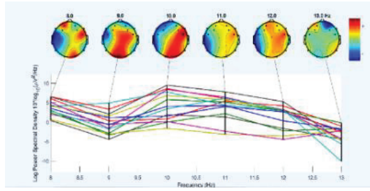


(e): Yellow color

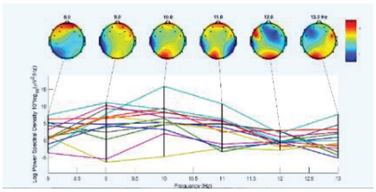
Figure 11: The power spectral density shows a very high peak PSD value of 5, 10 and 13 within the alpha range at 9Hz, 13Hz and 8Hz respectively for O1 and O2 of the yellow color (Subject 4)



(a): Red color



(b): Blue color



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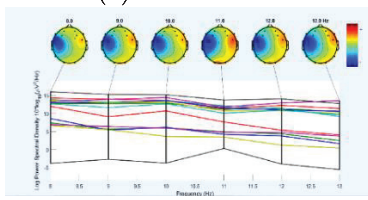

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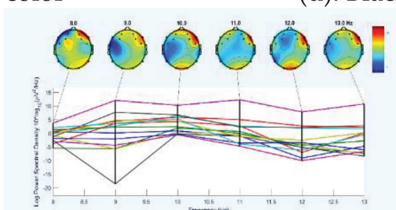

(e): Yellow color

Figure 12: The power spectral density shows a very high peak PSD value of 2, 7, 11 and 16 within the alpha range at 12Hz, 13Hz, 11Hz and 10Hz respectively for O1 and O2 of the green color (Subject 5)

4.0 CONCLUSION

The experiment concluded the study hypothesis that different colors do have effect on different individuals. Alpha wave was detected by the Electroencephalogram (EEG) and predominantly originated from the brain lobe. When the strength of the alpha wave was high during observation, the participant is considered in relax mode and in calm condition. The analysis of the results also showed the alpha wave is high when showing the different color to the different participant. High activation of the Power Spectral Density (PSD) obtained at the high alpha frequency. The experiment also observed the ladies showed high excitation when they saw some colors compared with men. Thus, it proved that the alpha band can be generated from various kinds of colors to different human. Among the brain lobe, occipital lobe found out high alpha band thus it proved that the electrode channel of O7 and O8 involved color recognition. The analysis also showed the alpha wave is produced from the different participants are affected through different colors. This observation depicted that human are calm through their color of interest. In future, the study suggested to include several emotion parameters during implementing the experiment.

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