ELECTROENCEPHALOGRAPHY (EEG) APPLICATION IN NEUROMARKETING-EXPLORING THE SUBCONSCIOUS MIND

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ABSTRACT: This article presents how the human brain makes a decision and the influence of subconscious mind when observing different brands in advertisement. The study of the human brain using EEG is related to electronics, psychology, and cognitive neuroscience to study the human behavior on problem solving and decision making. In this paper, we particularly investigate the decision making of the human brain in a short period of time. The study is focused on which band wave is dominant when use for decision making and subconscious mind. The EEG was used to study the cognition in different states of mind because EEG can analyze the brain activity directly from the scalp. Experiments were conducted to examine the wave of the brain by using the 14-channel EEG Emotiv Epoch device. The brain memory recalls and makes a decision of what they want or experience. The result shows that the human brain can recall a product by experience and beneficial to their understanding. This proves that subconscious mind and decision making has always been and existing in our daily lives. The result from the experiment showed that theta band wave was dominant during subconscious mind and decision making.

KEYWORDS: *Decision Making; Subconscious Mind; EEG; Neuromarketing; Human Brain; Cognitive Neuroscience*

1.0 INTRODUCTION

This article presented how the human brain makes a decision and the influence of subconscious mind when observing different brands in advertisement. Recently, EEG has been applied to the field of

marketing [1-2]. The integration of EEG as a neuroscience tools has brought up to a birth of consumer neuroscience [3-5] or commonly coined as neuromarketing. The focus is generally to understand the human behaviour and on their decision making when choosing a product. Previous work generally focused on decision when purchasing a product [6]. The science of neuromarketing involved the human consciousness state of mind. The EEG can be used to study the cognition in different states of mind because EEG can analyze the brain activity directly from the scalp [7]. During neural activity, EEG will show voltage fluctuations due to the current flows within the neurons of the brain [8]. The EEG signals are used in Brain-Computer Interface systems to analyse the brain activities [9].This study focused on which band wave is dominant when use for decision making and subconscious mind.

There are three types of decision making; that is decision making with the conscious mind, subconscious mind, and the unconscious mind [10]. Decision making cannot be taught by learning but by experience or action. Emotions play essential role in decision making. When we make a choice, a variety of mental images or thoughts regarding that choice appear and disappear continuously in our consciousness. We also experience some feelings related to the choice. Hence, quantifying decision making in human consciousness may be very challenging but promising and useful to both marketers and consumers. As the subconscious mind holds current information from day to day life, such as current recurring thoughts, behaviour patterns, habits, and emotions [11-12], the EEG brain activities may give an insight on any recall of the brain memories. One common example of the subconscious mind is the process of driving a car. The action of driving seeps into the subconscious mind and will automatically avoid obstacles, change gears when required while could be doing something simple at the same time, like talking to friend in the car, listening to music etc. [13]. Thus, similar results are expected when human as consumer, subconsciously act upon any given advertisement stimuli. The brain is generally categorized to four lobes. Figure 1 depicted the four sections of the brain lobes [14].

Each lobe has its unique function and can be recorded by EEG to observe the neural activities. These activities arising from the brain is displayed in the form of brainwaves. The state of mind can be represented by the brain waveforms; Beta, Alpha, Theta and Delta. Conscious mind is when our brain is fully aware at any point in time. The wave that the conscious mind will produce is Beta wave. The brain

produces beta wave of 15 Hz to 40 Hz. On the other hand, Alpha wave triggered when the brain is in partial conscious and subconscious at the same time. Next, the conscious mind is around 75% switched off on theta wave. The subconscious will take over and flourish. Examples are deep relaxation, dreaming, and sleep. Theta wave operates at 5 Hz to 8 Hz. When we become less aware of our surroundings, the visualization, suggestion and ideas will take place. Lastly, Delta wave is when the subconscious totally operates such as in extremely deep relaxation/sleep. Delta wave produced by the brain is 1 Hz to 4 Hz. During delta wave, healing and regeneration are stimulated [15].

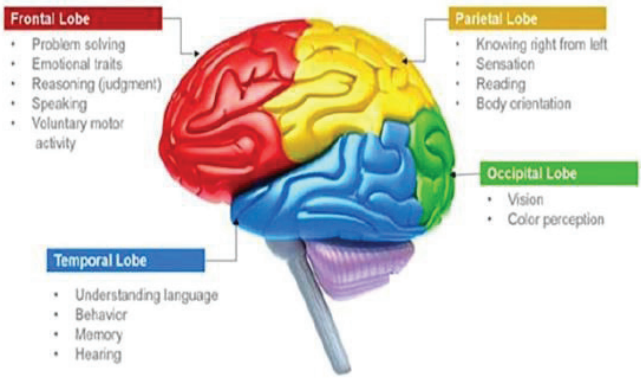


Figure 1: Section of brain lobes [14]

2.0 METHODOLOGY

This section described the materials and procedure taken for this experiment.

2.1 Project Flow

The subjects were briefed on the experiment's protocol. Figure 2 shows the flowchart of the procedure.

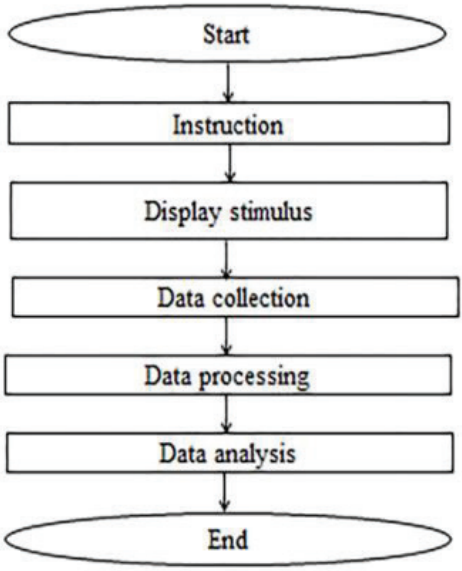


Figure 2: A flow chart of the experiment

2.2 Subjects

There were 5 participants in this study which age between 21-24 years old. They were randomly selected to respond and participated in this study. The experiment was conducted inside a closed room at the Bio-Cognition Laboratory, Malaysian-Japan International Institute of Technology. The experiment's protocol was briefed and consent form was signed by each subject before the start of experiment. Subjects have been advised to minimize their movement to reduce the noise.

2.3 Materials

The EEG Emotiv Epoch hardware as in Figure 3, was used in this experiment. The hardware is cost effective and scalable for human brain research [16]. The EEG signals were recorded by Emotiv Neuroheadset from 14 channels. The location of the electrodes follows the International 10/20 convention and the numbering for each electrode location is depicted in Table 1. Before experiment started the Emotive Conductors need to be soak with saline. Then, the soaked Emotiv conductors is inserted into its headset. The Emotiv dongle is then plugged into the computer and turn on the Emotiv EPOC Neuroheadset by sliding the switch at the top of the Emotiv.

Figure 3: Emotiv Epoch neuroheadset

Table 1: Emotiv channel and number sets

EMOTIV Channel	Channel Number
AF3	1
F7	2
F3	3
FC5	4
T7	5
P7	6
O1	7
O2	8
P8	9
T8	10
FC6	11
F4	12
F8	13
AF4	14

2.4 Experiment Procedure

A sequence of five images was displayed on the monitor screen by using Camtasia Studio software for 1 second per image. The TechSmith Camtasia Studio software is the application to edit and used to setup the stimuli [16]. The respondents needed to choose the product that they recalled by their memories by pressing '1' for the product on the left, and '2' for product on the right. The images represent different parameters in order to find whether the brain has recalled its base experience, or that will be beneficial for their wellbeing. The experiment is repeated three times or an Event Related Potential. These parameters were checked by Test Bench to check that the electrodes are placed properly on the head of the respondents.

Emotiv test bench is the software that link the Emotiv Epoch device to this software [17-18]. All the 14 electrodes must be green before the

experiment started to get a stronger waveform. In this software, the contact quality of the electrode placement also can be recognize which follow the color as shown in Figure 4. In Emotiv Test bench software, it also shows the sampling rate which the sampling rate fixed to 128 samples per second. In this software, it also shows the battery status of the Emotiv Epoc device. Duration video is about 10 seconds. There will be short interval after each parameter. After the data is collected from the respondents, the raw data that we got from Emotiv testbench that is in .edf format been extract using EEGLAB [19].

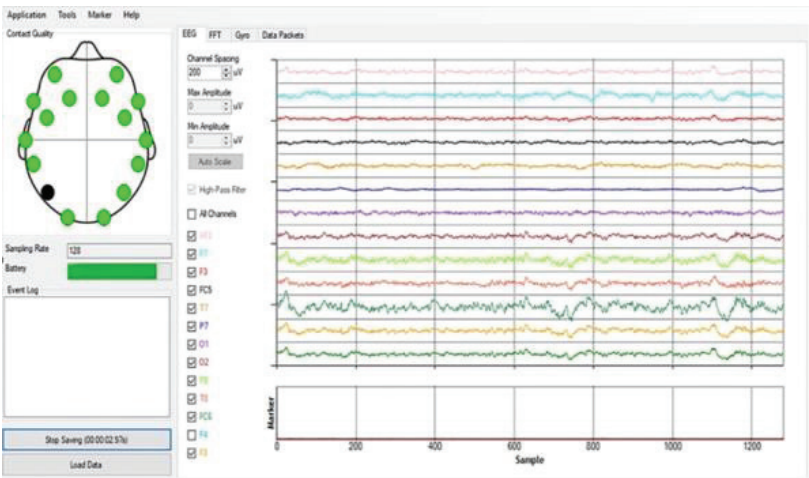


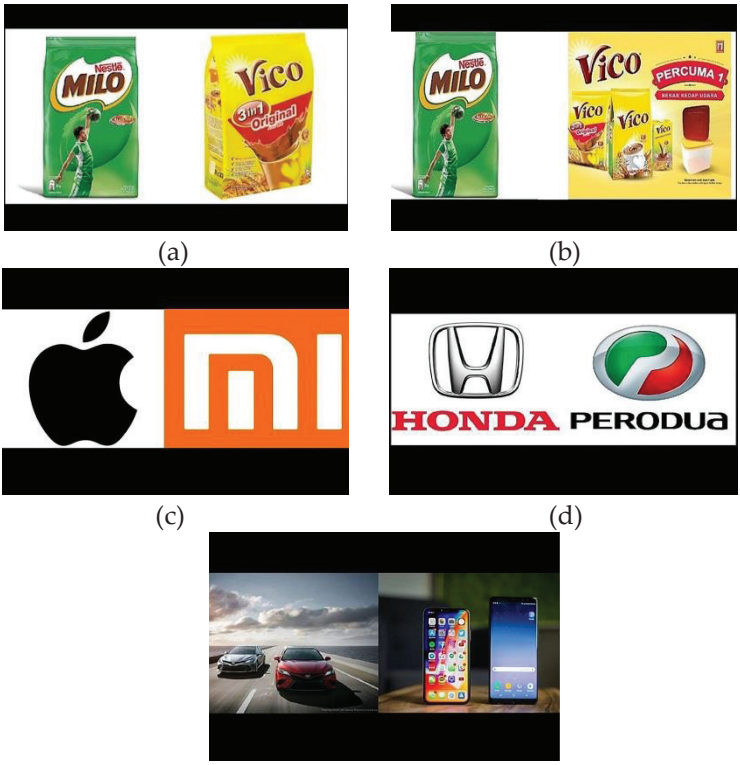
Figure 4: Emotiv testbench

2.5 Stimuli

Five different images are selected according to their attractiveness, brand and type of the items. Figure 5 shows the selected images.

2.6 Data Stimuli

The EEG raw data was transformed and filtered from .edf format into Power Spectral Density (PSD) which is computed using Fast Fourier Transform based on specified brainwaves [18]. The result showed in the channel spectra and maps. Based on the International 10/20 system, eight channels of the frontal lobes were specified as in Figure 6.



(a) (b) (c) (d) (e)

Figure 5: (a)-(e) Stimuli 1-5 were used in the experiment

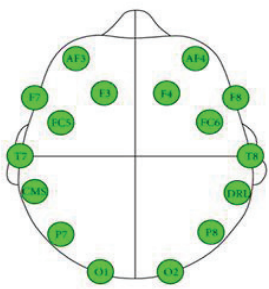


Figure 6: 14 Electrodes of Emotiv Epoch [14]

3.0 RESULTS AND DISCUSSION

The Power Spectral Density (PSD) results had shown similar effects to all stimuli (Figure 5) used for this experiment. For the sake of brevity, Stimulus 1 results are illustrated in Figures 7 to 9. The right hemisphere of the subject's brain is the most activated during the experiment and the power spectrum of frequency 0~8 Hz is for the subconscious mind

which fall under theta wave (undergoing subconscious) and delta wave (total subconscious). During the first experiment, we can see in 8 Hz theta wave that the power at electrode FC6 and F8 are very red, it can be observed from Figure 5 for the first stimuli.

The experiment was repeated for the second time and as depicted in Figure 7, observation were made on the activation of medial frontal electrodes AF3 and AF4 at 6 Hz, which confirms that the in going to subconscious state functions of the medial section of the brain. The last experiment is shown in Figure 9. We could see that the subjects are in total sub consciousness because the brain activity in the medial frontal is only at 1 Hz. 1 Hz delta wave is for the subconscious. There was only active power at AF4 at 1 Hz and the other electrode were not active.

The statistical analysis of the average of all research participants was analyzed using Power Spectral Density. Table 2 shows the statistical average of power spectral density based on eight channels location for each subject during first stimulus. The first stimulus showed the picture of Milo and Vico and subjects need to choose either one of them. Based on the Table 2, 4 subjects have the highest power spectral density which is at FC6. The highest one is subject 4 which is 37.63194 μV. It is at primary motor cortex and premotor cortex. It function as visuospatial and visuomotor attention, long-term memory and movement of finger when to choose the items. Next, the highest power spectral density is at inferior frontal gyrus of frontal lobe which is at F7 and F8. The function is to store memory of shape, smell, taste and feelings that is called non-verbal memory.

It means the memory recall of both images at F7 and F8 (F7 for the right eye and F8 for the left eye). Referring to Table 2, Subjects 2, 3 and 4 consisted of the higher in Milo instead of Vico. The AF3 and AF4 are for the conscience of the mind. The state mind will go to subconscious the frequency was at 4 to 7 Hz. It also control the event and time based prospective memory that trigger the action that is to choose between Milo and Vico within a time limit.

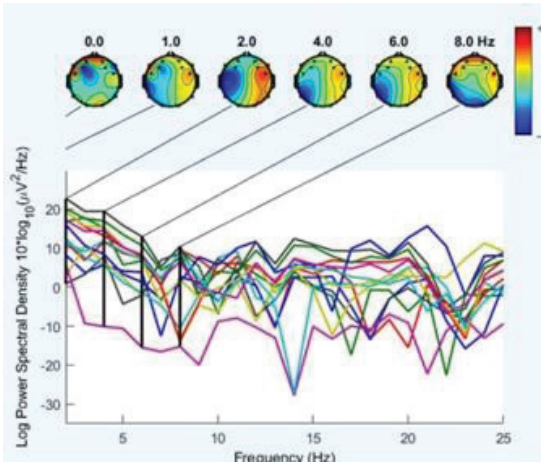


Figure 7: First stimulus in the first experiment

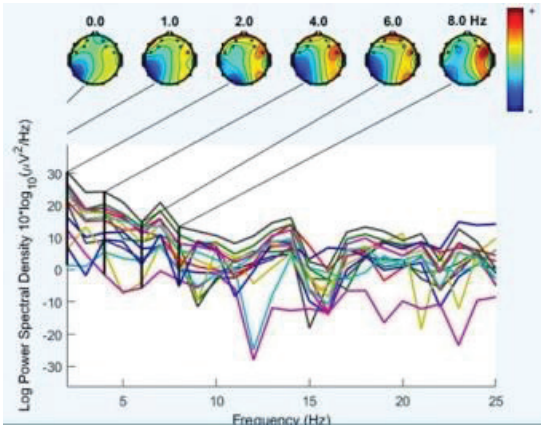


Figure 8: First stimulus in the second experiment

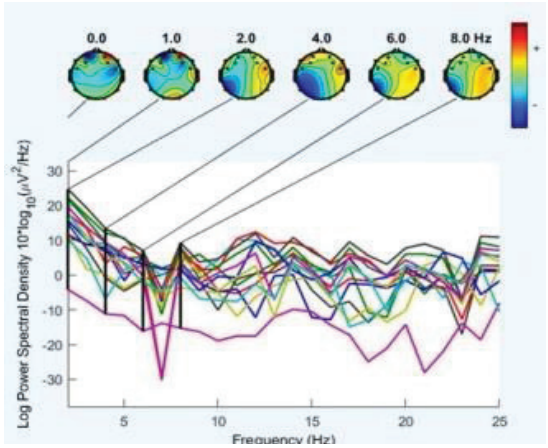


Figure 9: First stimulus in the third experiment

Table 2: Average value of theta wave for every channel of each subject during first stimulus (μV)

Channel	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
AF3	23.79393	21.02185	21.2749	26.49256	22.06689
F7	27.12765	16.93841	22.62476	35.08087	25.09136
F3	20.1111	18.23691	20.9824	22.46559	18.27176
FC5	19.94935	16.83204	18.9612	23.1593	17.38339
FC6	30.93155	21.44828	25.64053	37.63194	28.0296
F4	23.93263	20.59108	21.54705	31.45408	27.37149
F8	26.06353	21.6984	25.57348	28.05283	28.85609
AF4	24.48139	22.89629	22.10427	28.37707	28.86339

4.0 CONCLUSION

This study essentially affirmed its objective as the decision making made by the respondents were mainly based on experience. As such, it can be concluded that the subconscious mind can be quantified from brain activities. This finding confirmed to the experiment result when 3 of the participant chose the common Milo brand. Even though the other two participants chose Vico brand, it may be because this product is known to these two participants. This is shown from the brain activity behavior when their subconscious mind initialized it in the later experiment. The Theta wave, the wave that should be initializing the subconscious mind had displayed great power in spectrum density on topographic map, which are very red at the medial frontal for the first experiment at 8 Hz. Then, it reduced to 6 Hz for the second experiment. Lastly, it reduced further still until the delta wave which is total subconscious at 1 Hz. providing marketers with such neuro data may replace the traditional and conventional marketing strategy to win customers. Huge surveys may become obsolete as very few respondents are adequate to value marketing products. However, the neuromarketing field is still in its infancy as many parameters need to be explored such as huge 10 billion neural activities of EEG recording and its big data characteristic may present further insight of engineering contribution to the society. Therefore, many factors on the brainwaves investigation like different stimuli to observe the gamma wave frequency band due to the alphatheta zone can be considered in the long run research activities.

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REFERENCES

[1] M. Yadava, P. Kumar, R. Saini, P.P. Roy and D.P. Dogra, "Analysis of EEG signals and its application to Neuromarketing", *International Journal of Multimedia Tools and Applications*, vol. 76, no. 18, pp. 19087-19111, 2017.

[2] V.A. Roth, "The potential of neuromarketing as a marketing tool," Bachelor thesis, University of Twente, Enschede, Netherlands, 2013.

[3] H. Plassmann, V. Venkatraman, S. Huettel, and C. Yoon, "Consumer neuroscience: applications, challenges, and possible solutions", *Journal of Marketing Research*, vol. 52, no. 4, pp. 427-435, 2015.

[4] R.N. Khushaba , C. Wise, S. Kodagoda, J. Louviere, B.E. Kahn and C. Townsend, "Consumer neuroscience: Assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking", *Expert Systems with Applications*, vol. 40, no. 9, pp. 3803-3812, 2013.

[5] J. Guixeres, E. Bigné, J.M. Ausín Azofra, M. Alcañiz Raya, A. Colomer Granero, F. Fuentes Hurtado and V. Naranjo Ornedo, "Consumer neuroscience-based metrics predict recall, liking and viewing rates in online advertising", *Frontiers in Psychology*, vol. 8, no. 1808, pp. 1-14, 2017.

[6] N. Fauzan, T.P. Broto, M. Sophian and N. Muhammad, "Neuromarketing: physiological response of human brain using quantitative electroencephalogram (QEEG) in consumers decision making", *International Journal of Trend in Research and Development*, vol. 4, no. 3, pp. 116-118, 2017.

[7] G.R. Vijayaragavan, R.L. Raghav, K.P. Phani and V. Vaidyanathan, "EEG monitored mind de-stressing smart phone application using yoga and music therapy", in International Conference on Green Computing and Internet of Things, Greater Noida, India, 2015, pp. 412-415.

[8] M. Choubisa and P. Trivedi, "Analysing EEG signals for detection of mind awake stage and sleep deprivation stage", in International Conference on Green Computing and Internet of Things, Greater Noida, India, 2015, pp. 1209-1211.

[9] M. Rezaee and M. Farahian, "Subconscious vs. unconscious learning: A short review of the terms", *American Journal of Psychology and Behavioral Sciences*, vol. 2, no. 3, pp. 98-100, 2015.

[10] Journal Psyche. (2018). *Freud's Model of the Human Mind* [Online] Available: http://journalpsyche.org/understanding-the-human mind/ #more-169

[11] P. Kamble. (2014). *What is subconscious mind? How does it impact our actions and relations?* [Online] Available: http://www.academia.edu/ 30691124/What_is_Subconscious_Mind_How_Does_it_Impact_Our_A ctions

[12] P.D. Nussbaum. (2019). *Get to know your brain* [Online] Available: http://www.paulnussbaum.com/gettoknow.html

[13] N. Jalaudin and M.K.M. Amin, "EEG analysis on human reflection towards relaxation of mind", *Malaysian Journal of Fundamental and Applied Sciences*, vol. 15, no. 2, pp. 185-189, 2019.

[14] L.V. Marcuse, M.C. Fields and J.J. Yoo, *Rowan's primer of EEG*. Amsterdam, Netherland: Elsevier Health Sciences, 2016.

[15] EMOTIV. (2019). *EMOTIV EPOC+* [Online]. Available: https://www. emotiv.com/epoc/?utm_expid=1213327400.3HahreoeQam14gOQLeD D5Q.0&utm_referrer=https%3A%2F%2Fwww.google.com%2F

[16] TechSmith. (2017). *Screen recording and video editing software* [Online] Available at: https://www.techsmith.com/camtasia.html

[17] A. Alshbata, P. Vial, P. Premaratne and L. Tran, "EEG-based brain-computer interface for automating home appliances", *Journal of Computers*, vol. 9, no. 9, pp. 2159-2166, 2014.

[18] N. Behboodian, M. Amin, K. Natsume and T. Kitajima, "Frequency Analysis of Brain Signals for Biometric Application", *International Journal of Pure and Applied Mathematics*, vol. 118, no. 24, pp. 1-14, 2018.

[19] C. Brunner, A. Delorme, and S. Makeig. (2013). *Eeglab – an open source Matlab toolbox for electrophysiological research* [Online]. Available: https://www.ncbi.nlm.nih.gov/pubmed/24042816