

# Benefits and Limitations of Neuromarketing Techniques in Enhancing Marketing Strategies

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**Abstract**— Neuromarketing study is a combination between neuroscience and marketing studies. It is done to get better understanding on consumer behaviors while making purchases. Since the advent of Covid-19 or also known as Coronavirus, eCommerce platforms are widely used by the consumers to purchase goods and services. Various techniques can be used to obtain the brain signals to observe consumers' emotions. There are two types of neuromarketing approaches which are neuroimaging and non-neuroimaging techniques. The neuroimaging techniques are frequently used by the researchers to study neuromarketing as the results obtained are based on the consumers' brainwaves and is not biased to any goods or services such the results from surveys, interviews, or other traditional marketing strategies. So, this describes review on previous research which use the neuroimaging techniques to study neuromarketing, especially using electroencephalogram (EEG).

**Keywords**—neuromarketing techniques, neuroimaging, consumer emotions, electroencephalogram

## I. INTRODUCTION

Neuromarketing is commonly used to promote and sell commercial products and services. Since neuromarketing measures human responses to particular subjects, it can also be used in psychological and theoretical applications [1]. Therefore, there are many advantages of neuromarketing in selling products and services. Brand design, brand development, and excellent advertising may all benefit from neuromarketing. Neuromarketing help to recognize the consumers' shopping experience from the beginning until they leave the store [2]. Not only that, marketers can use neuromarketing to better understand consumer behavior in

order to improve package design, pricing, brand positioning, promotion techniques, and new product development [1].

Functionally, understanding and modelling cognitive reactions to selling messages has long been a methodological difficulty since emotions are major moderators of how consumers receive and process messages [3]. Neuromarketing is used by the majority of successful organizations today because of the competitive advantages it provides [4]. Every company's goal is to address the demands of its consumers. Therefore, neuromarketing is critical in getting to know them better. Emotions are described as a sensation or a perspective that a person has when they are in a certain situation or when they are interacting with others. The emotions formed will correlate to the situations, whether it is positive or negative [5]. Measurable emotions and looking for emotions when purchasing are two things to think about [1]. Meanwhile, the primary objectives of such neuromarketing research are to identify small changes in commercial stimuli that may have significant implications for marketing efficacy. Next, it seeks to explain how changes in the way marketing information is depicted or presented affects the way of the brain reacts in other words, the changes in brain signals [4].

This paper describes a review of techniques that can be used to study neuromarketing. There are two neuromarketing approaches which are neuroimaging and non-neuroimaging. The advantages and disadvantages of each technique are described in the next topic.

## II. NEUROMARKETING TECHNIQUES

Neuromarketing is a relatively new scientific field, basically an interdisciplinary field that aims to link marketing and neuroscience studies [3], [6]. Besides, every different technique has its own advantages and disadvantages. Each of the techniques often used to quantify variables that are compatible for better understanding about marketing issues [6]. The human brain is our body's most complex organ. Synapses shift as a result of learning experience [7].

There are two types of neuromarketing techniques. The two types of neuromarketing techniques are neuroimaging and non-neuroimaging techniques. Neuroimaging techniques are those that involves brain activity and electrical impulses whereas the non-neuroimaging techniques does not involve any neurological activity [8]. The techniques that utilized brain imaging drew the most attention among all of the techniques. The outcomes of these studies had a significant impact in both academia and business [6]. The examples of neuroimaging techniques are fMRI, EEG, PET, and MEG while for non-neuroimaging techniques are eye tracking and GSR. Subtopics below describe the neuromarketing techniques used in many neuromarketing studies.

### A. Electroencephalogram (EEG)

Electrodes that measure the brainwaves associated with various states of stimuli are put on an individual's scalp through bands or helmets in this approach. Fig. 1 and Fig. 2 show the example of EEG helmet and EEG headset. Besides, brain waves can be monitored at small intervals up to 10,000 time per second [3], [6]. The electrical activity of the brain is measured and recorded using this technique [7]. Furthermore, EEG has more validity in the measuring of emotional styles and the diagnosis of psychopathologies. The ability to synchronize with the stimuli is a feature if this technique [6]. The electric currents sent from the brain cell to another are measured by an EEG [8].



Fig. 1 EEG Helmet [9]



Fig.2 EEG Headset [10]

Artifact elimination feature extraction, and classification are included in the standard EEG classification pipeline. An EEG dataset consists of a 2D, which are time and channel, matrix of real values at the most basic level, representing brain-generated potential recorded on the scalp associated with the specific task conditions. The EEG data suitable for machine learning because it is in highly structured form. A significant number of traditional machine learning and pattern recognition algorithms have been used for EEG data [11]. Moreover, it is

possible to distinguish between delta, theta, alpha, beta, and gamma waves as well as spike associated with epilepsy from the brain by electrode placement and operating of the adjacent brain regions [12].

### B. Functional Magnetic Resonance Imaging (fMRI)

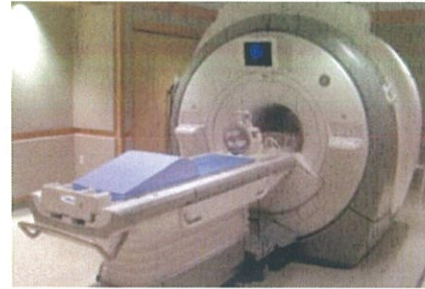


Fig. 3 fMRI Scanner [13]

Fig. 3 shows the example of the fMRI scanner. The amount of deoxygenated hemoglobin in the blood is measured using the fMRI. It is a type of neuroimaging technique. This metric is strongly linked to characteristics of neural activity, allowing fMRI to describe the brain function with high spatial and temporal precision [14]. fMRI is a medical procedure that detects the oxygen level in blood flow to measure brain activity. When a part of the brain is more active, it needs more oxygen [7]. In addition, the oxygen consumed by the thoughts in various parts of the cerebrum responds to changes in brain behavior as a result of the stimulus [8], [15].

### C. Positron Emission Topography (PET)

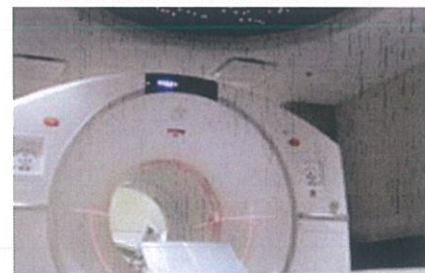


Fig. 4 PET Scanner [16]

Positron Emission Topography (PET) is a symptomatic imaging approach for quantifying the body's metabolic movement. It employs a radioactive medication that can be injected, swallowed, or inhaled to image functioning of tissues and organs as well as diagnose the early stage of infections. When compares to other types of clinical assessments, PET scans can aid in the early detection of certain illnesses [3], [8]. Apart of that, PET is also a technique with equal validity and spatial resolutions as fMRI. However, in order to collect results, radioactive particles or known as positrons must pass

through the person. This makes this approach very intrusive and challenging to utilize in neuromarketing [6].

#### D. Magnetoencephalogram (MEG)

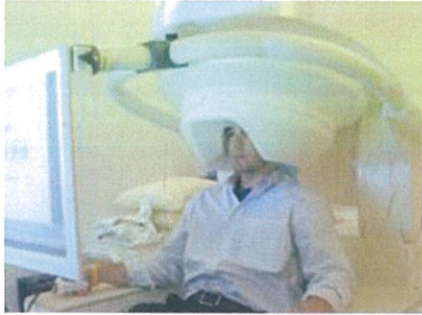


Fig. 5 MEG Scanner [17]

This method is based in the expansion and mapping of magnetic field formed by brain processes as well as electrochemical impulses sent between neurons. Magnetoencephalogram has good temporal resolution which is similar to electroencephalogram. However, its spatial resolution is not optimal for monitoring subcortical areas and deeper parts of the brain is superior to that of EEG [3]. The expenses of acquiring the necessary equipment and attending a magnetoencephalogram session is extremely costly which contributes to EEG popularity over MEG [6]. Besides, it provides information on brain activity using a magnetic field. Unlike functional measures such as fMRI, it is a direct measure of brain activity. It has a high spatial and temporal resolution [7].

#### E. Eye Tracking



Fig. 6 Eye Tracking [18]

Eye tracking is increasingly being utilized in conjunction with the other neuromarketing techniques such as fMRI and EEG [6]. This technique refers to where people stare when they participate in an eye gaze point. The results in heatmaps where people's gaze is fixed [8]. It is a technique that tracks the focus of vision, eye movements, and the size of the pupil in order to measure eye behavior. In addition, this technique also allows for the assessment of pupil size changes which can be used as a reliable indicator of emotional arousal [19]. Not only

that, it enables for the measurement of an individual's brain's numerous processes in response to stimuli, providing useful information on consumer behavior in response to marketing stimuli such as brand and advertising [3], [6]. Hence, eye tracking has become an important neuromarketing tool due to its low cost.

#### F. Galvanic Skin Response



Fig. 7 GSR Device [20]

The objective excitation induced by an emotionally significant stimuli is measured using Galvanic Skin Response (GSR). The central nervous system is linked to the reactions recorded on people's hand and this technology can detect neural responses that precede emotions like fear, anger, disgust, happiness, sadness, and indifference [6]. Furthermore, this technique detects changes in the skin's electrical characteristics as a function of moisture content [7].

### III. BENEFITS AND LIMITATIONS OF NEUROMARKETING TECHNIQUES

Each neuromarketing technique has their own specialties. However, there are pros and cons in every technique. Table I shows the techniques of neuromarketing that are used for marketing studies.

TABLE I. NEUROMARKETING TECHNIQUES

Techniques	Benefits	Limitations
EEG	<ul style="list-style-type: none"> <li>-Portable [6], [8].</li> <li>-Progressively convenient [8].</li> <li>-Less invasive [6].</li> <li>-High temporal resolution [6].</li> </ul>	<ul style="list-style-type: none"> <li>-Only record more superficial electrical signals [6].</li> <li>-Low spatial resolution [6].</li> </ul>
fMRI	<ul style="list-style-type: none"> <li>-Able to measure deeper and smaller structures of brain [6].</li> <li>-High spatial resolution [6], [21].</li> <li>-Excellent temporal accuracy [14].</li> </ul>	<ul style="list-style-type: none"> <li>-Quite expensive [6], [14], [21].</li> <li>-Restrictive environment for subjects [14].</li> <li>-Not portable [14].</li> <li>-Requires delay of 6 to 10 seconds to record processing of neurons [6].</li> <li>-Low temporal resolution [6].</li> </ul>

PET	-Technique with validity and spatial resolution similar to those of fMRI [6].	-Highly invasive [6]. -Difficult to use in neuromarketing as radioactive particles (positrons) must pass through the participant [6].
MEG	-Excellent temporal resolution [3], [6] and high spatial resolution [7].	-Expensive [6]. -Its spatial resolution is not ideal for measuring subcortical areas and deeper areas in the brain [3], [6].
Eye Tracking	-Able to measure the focus of consumers' attention, the pattern of visual behavior of fixations of the gaze, dilation of the pupils, focus, and microfocus [6]. -Portable [6].	-Not possible to understand what emotions are associated with the areas that were the focus of attention [6].
GSR	-Able to identify the neural responses that precede certain emotions [6].	-Measures the changes in the electrical properties of the skin, depending on the level of moisture [7].

There are variety of approaches to assessing physiological responses to advertising but only three non-invasive techniques for monitoring resolution which is in milliseconds compare to fMRI which is in seconds [8], [22]. The temporal resolution is less than 1 millisecond [21]. The attribute is often used by neuroscientists to identify techniques and it is crucial for marketing research since it allows the identification of neurophysiological correlated within a functioning time window. The example of the stimuli are videos and music [22]. It has the ability to record cognitive and motor processes are fast [23]. Second, conventional EEG equipment are non-invasive [8], [22]. It allows person to act normally in the lab while looking at the stimuli or in store which is in the case of field experiments [22]. EEG is easy to operate as the EEG device is portable [21]. The last reason is, as compared to other brain imaging techniques, EEG is substantially less expensive [21] and the equipment needed to conduct studies is widely accessible in neuroscience fields [22].

#### IV. ISSUES ON MARKETING STRATEGIES

After the advent of Covid-19, the usage of online purchase methods has become the new norm in the community. Consumers are increasingly turning to online to buy goods and services, acquire product information, and even browse the product just for fun. This has hastened the adoption of digitization in the commercial sector [24]. Purchasing goods in online platforms will make the consumers feel better as they just make purchases at any time and at any places [25]. Nonetheless, this does not imply that consumers can buy whatever they want. They must also practice to be prudent in spending.

eCommerce strategies, however, may have their own drawbacks. Online contexts are too distinct from offline environments in terms of nature, size, and sensory representation to presume that offline notions and theories are all applicable and sufficient [26]. It is not easy for some people

as they will think wisely and thoroughly before making purchases. Furthermore, making online purchase only uses two senses which are visual sense and auditory sense instead of four. It may be difficult for the consumers as they are purchasing goods virtually. Moreover, individuals have their own preferences and thoughts of goods. Some online products do not meet their desires. Products from the online stores cannot be tasted, touched, smelled, seen directly, and perhaps cannot be heard clearly. For example, consumer cannot touch and feel the types of fabrics, fragrance goods cannot be smelled, can only see the goods virtually, and will be hard to purchase audio device as it cannot be tested by our own ears. To assure goods quality and services at a reasonable price, there must be a guarantee [27]. These factors probably be the drawbacks for consumer decision making to make purchases using the online platforms.

Other than that, it is possible that merchants or marketers will have difficulty selling their goods. It may due to marketing strategies used are ineffective and failed to attract consumers to try the promoted goods. Due to that, merchants must understand what characteristics are most likely to attract consumers to try the manufactured products. Consumers also have their own preferences for product's packaging. Color selection, packaging design, font used in packaging, and other elements are all important considerations. Good advertisements will encourage and convince consumers to make purchase on those products [28].

Malaysia has considered the pandemic as a potential opportunity for digitization in industries such as online shopping, courier services, and food delivery. During the pandemic, majority of Malaysia consumers' purchasing behaviors changes significantly to online shopping [29]. [30] stated that in terms of emotions, positive and negative emotions, both have a significant impact on buying intent. Study done by the authors found that, there is no negative impact of consumer's purchase intentions or in other words, it enhances consumers' positive emotions based on personalize services. However, the study carried by the authors only depending on the self-reported data. There is no experiment done regarding consumers' emotions and behaviors for online purchase in the study.

#### V. APPLICATION OF NEUROMARKETING

There are many studies related to neuromarketing. Most of the researchers used the neuroimaging techniques. The most popular neuroimaging technique is the electroencephalogram (EEG) as it is a portable device [6], [8] and has high temporal resolution [6]. Not only that, EEG technique is one of the most promising and understandable technique for neuromarketing study.

[21] done a study for auditory neuromarketing. The authors chose Indian Instrumental Classic music as the stimuli. They used an EEG device with 32 electrodes as the experiment tool to acquire data from the participants. Furthermore, they stated that theta waves in the frontal midline of the brain can be increased by listening to pleasurable music. From the data obtained, Fast Fourier Transform (FFT) and supervised machine learning algorithms which are K-Nearest Neighbor

(KNN) and Linear Discriminant Analysis (LDA) is used for analysis. The data is analyzed and grouped into two distinct groups which are Appreciator and Non-Appreciator group of the musical stimulus. The authors found that when the participants are in positive emotion, the theta wave on the left region of the brain increased. On the other hand, theta wave increased on the right region when the participants are in negative emotion, such as sad. However, this study only focusing on the theta band power.

Next, a study to improve preferences prediction has been done by [31]. The authors stated that the study used multiple types of measures using the EEG and machine learning algorithms. They said that the predictive potential of combining different types of EEG data may be increased. So, the study combined information on frequency band powers for estimating engagement. The experiment conducted used 8 (wet) electrodes EEG device for data acquisition. Product commercials are selected to be their stimuli. The data are predicted using several machine learning algorithms which are Support Vector Machine (SVM), Logistic Regression, Decision Tree, and K-Nearest Neighbor (KNN). They found that the most predictive EEG metrics were frontal powers in the alpha wave, hemisphere asymmetry in the beta wave, and inter-subject correlation in delta and alpha waves. The drawback of this study is it was a TV-based product commercials which may distract the participant's emotions. This may distract the emotions as it is switching to different state of focus.

Moreover, [32] done research to explore the subconscious mind. The authors focused on the dominant brainwave used in making decision and subconscious mind. The study used an EEG device with 14 electrodes to acquire data. The experiment conducted used images as the stimuli. To obtain the result, participants needed to choose between left or right image from the display by pressing 1 or 2. This experiment needs the participant to recall the image displayed before making decision to press 1 or 2. The data obtained from the experiment is then computed using Fast Fourier Transform (FFT). According to the authors, brain processes can be employed to measure the subconscious mind. They found that the most activated brain area is the right hemisphere. During the experiment, theta wave is the dominating brainwave that is experiencing subconscious mind, and delta wave is the total subconscious mind.

A study on consumer satisfaction using EEG imaging to evaluate neuromarketing technique is one by [33]. This study focused on consumer satisfaction and willingness to pay for product advertised. 16 electrodes of EEG device are used to acquire data and two different product images are used as the marketing stimuli. The authors made price reduction on both products advertised during the experiment. Data obtained from the EEG signals are transformed into Fast Fourier Transform (FFT). From the experiment conducted, they discovered that the frontal lobe and right hemisphere of the brain regions that indicate happiness or satisfied behavior. According to the authors, the presence of large theta wave indicated that the participants are in a deep state of relaxation. They came to the conclusion that participants who were satisfied with their needs recalled the appealing product with intriguing commercial and

excellent product information. The pricing is one of the factors that determined whether someone is willing to buy the offered goods.

[34] has done a study on EEG signals for neuromarketing of non-linear features. The authors stated that there are four categories with five products each are used as the marketing stimuli in the experiment conducted. The main objective of the study is to define the most preferred category and most preferred product in each category. They used video commercials of selected products. Furthermore, the experimental tool used in this study is an EEG device with 32 electrodes. Since the objective of the study is to find the most preferred category and product, the authors focused on two brain signals which are alpha and beta waves. Besides, this study is an analysis on non-linear features of EEG signal. So, Detrended Fluctuation Analysis (DFA) are extracted from the filtered signals. Based on the analysis, the authors managed to determine the most preferred category and product in each category.

In another paper, a study on consumer behavior for neuromarketing application is done by [35] using EEG signals. Data used in the study is taken from the previous neuromarketing study. This study is based on a model using data mining and machine learning algorithms for consumer behavior analysis from EEG signals. The authors proposed to use Decision Tree as the classifier to determine and make comparison between the previous study for accuracy of the results obtained while the previous study used Hidden Markov Model (HMM). The study used product images as the stimuli and 14 electrodes EEG device as the experiment tool. The experiment required participants to label the products with like or dislike. As per the authors, Decision Tree outperforms the existing approach in terms of accuracy, sensitivity, and specificity based on the finding obtained.

Other than that, [36] done a study to analyze emotions using emotional stimuli. The emotional states are divided into four, which are happy, scared, calm, and sad. The authors used emotional images as the stimuli to capture the data. 14 electrodes of EEG device are used to obtain signals. The data acquired in this study is analyzed using the Event Related Potential (ERP). There are two different concepts in the ERP analysis stated by the authors which are in the early processing, known as P300, and late processing, known as Late Positive Potential (LPP). They used both of the ERP concepts in the study. The authors found that every region shows both P300 and LPP on emotional stimulus changing. The potential difference was discovered in many places where emotional changes were prevalent.

A study on unconscious like and dislike decisions classification is done by [37]. In the study, the authors used ten different cars images in white and gray scaled as the marketing stimuli. The experimental tool used in this study is an EEG device with 16 electrodes. The authors divided the experiment into five different runs which the first of which was used to familiarize the participants with the visual presentation. The participants must concentrate on the stimuli without further instructions in the second, third, and fourth runs. Finally, on the fifth run, participants were asked to rate the cars. The authors

analyzed the data gathered in the experiment using Event Related Potential (ERP) and classified it into two categories which are like and dislike.

[37]	images. -Use LDA for classification shrinkage.	
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TABLE II. NEUROMARKETING TECHNIQUES

Authors	Method / Approach	Electrodes
Avinash et al. (2018) [21]	-Acquire data using the auditory neuromarketing. -Recognize the appreciator and non-appreciator musical stimuli. -Analyze data using FFT on theta band power.	32 electrodes
Hakim et al. (2021) [31]	-Combine information on frequency band powers for estimating valuation, hemispheric asymmetries for estimating approach/avoidance tendencies correlations and inter-subject for estimating engagement.	8 (wet) electrodes
Shaari et al. (2019) [32]	-Focused on dominant wave used in decision making and subconscious mind. -Brain memory recalls and make decision.	14 electrodes
Mahamad et al. (2019) [33]	-A study on consumer satisfaction and willingness to pay using brain imaging. -Products price reduction during data acquisition.	16 electrodes
Oon et al. (2018) [34]	-Focused on alpha and beta waves to obtained results of the most preferred product category and most preferred product in each category.	32 electrodes
Amin et al. (2020) [35]	-Study on neuromarketing using existing data from previous research with different classification method which is Decision Tree.	14 electrodes
Mehmood & Lee (2015) [36]	-Use ERP to analyze different emotional responses. -Focused on four emotional states which are happy, scared, calm, and sad.	14 electrodes
Wriessnegger et al. (2015)	-Detect like and dislike decisions using ERP analysis on different cars designs	16 electrodes

## VI. DISCUSSION

Previous researchers that used EEG technique in their studies proved that emotions can be estimated and evaluated using the brainwaves acquired from the participants. So, it is possible to determine the emotional states of an individual in the observed environment. There are various EEG devices models with different numbers of electrodes on it. [38] stated that when more electrodes are being used in an experiment, the accuracy and results of the EEG data acquired is high. This means that number of electrodes of the EEG device plays role in data acquisition. For better results of EEG experiments, higher numbers of electrodes are needed as well as the number of participants to be observed.

The EEG technique is the popular technique used in brain imaging because of its capabilities and ease of use. Many researchers chose EEG technique as it is non-invasive equipment and portable which participants can act normally during the experiment is conducted. Furthermore, various analyzing method can be used to transform the raw EEG data into understandable information. For example, using machine learning algorithms such as Decision Tree, Support Vector Machine, and K-Nearest Neighbor. Event Related Potential also can be used to analyzed the raw EEG data in terms of time domain. Different outcomes can be obtained from different methods of analysis. It can be concluded that neuroimaging techniques are the best techniques for monitoring and mapping brain activities.

## VII. SUMMARY

Traditional marketing methods, such as interviews and surveys, can lead to biased or inaccurate results when used to analyzed consumer preferences, needs, and buying intentions. Similarly, expressing preferences orally might result in conscious or unconscious biases. It may be hard for the merchants or marketers to understand consumers' needs. Since the presence of neuromarketing, it benefits both merchants or marketers as well as the consumers. Merchants or marketers can enhance their marketing strategies accordance with consumers' needs. They can improvise their product quality, packaging, advertisement, and other marketing elements.

Various techniques can be used to study neuromarketing either using neuroimaging or non-neuroimaging techniques. Every technique has their own specialties and drawbacks. However, the neuroimaging techniques have been proven by the researchers to get better results with high accuracy of consumers behaviors. Lastly, neuroimaging or brain imaging technologies are widely used to study individual's behaviors and emotions.

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## REFERENCES

- [1] M. Išoraitė, "NEUROMARKETING FEATURES," *Ecoforum Journal*, vol. 10, no. 1, 2021.
- [2] P. R. Solomon, "Neuromarketing: Applications, Challenges and Promises," *Biomedical Journal of Scientific & Technical Research*, vol. 12, no. 2, Dec. 2018, doi: 10.26717/bjstr.2018.12.002230.
- [3] C. Morin, "Neuromarketing: The New Science of Consumer Behavior," *Society*, vol. 48, no. 2, pp. 131–135, Mar. 2011, doi: 10.1007/s12115-010-9408-1.
- [4] T. Nyoni and W. G. Bonga, "Neuromarketing: No brain, no gain!," *Dynamic Research Journals' Journal of Economics and Finance (DRJ-JEF)*, vol. 2, no. 2, pp. 17–29, 2017.
- [5] V. S. Mohan, M. F. M. Amran, Y. H. Yahaya, N. M. M. Yusop, T. M. T. Sembok, and M. A. A. Zainuddin, "Emotion classifications in electroencephalogram (Eeg) signals," *International Journal of Recent Technology and Engineering*, vol. 8, no. 3, pp. 2736–2740, Sep. 2019, doi: 10.35940/ijrte.B2650.098319.
- [6] V. C. R. Fortunato, J. D. M. E. Giraldi, and J. H. C. de Oliveira, "A Review of Studies on Neuromarketing: Practical Results, Techniques, Contributions and Limitations," *Journal of Management Research*, vol. 6, no. 2, p. 201, Apr. 2014, doi: 10.5296/jmr.v6i2.5446.
- [7] Orzan G, Z. Ia, and P. VI, "Neuromarketing techniques in pharmaceutical drugs advertising. A discussion and agenda for future research," *Journal of Medicine and Life*, vol. 5, pp. 428–432, 2012, [Online]. Available: [www.esomar.org](http://www.esomar.org)
- [8] R. Gill and J. Singh, "A study of neuromarketing techniques for proposing cost effective information driven framework for decision making," Nov. 2020, doi: 10.1016/j.matpr.2020.08.730.
- [9] David Ibañez, "EEG/tES closed Loop stimulation - Neuroelectrics Blog - Latest news about EEG & Brain Stimulation Neuroelectrics," *Neuroelectrics*, Oct. 24, 2019, <https://www.neuroelectrics.com/blog/2019/10/24/eeg-tes-closed-loop-stimulation/> (accessed Nov. 19, 2021).
- [10] Muse, "Why Choose the Muse Meditation Headband & App," Muse, 2021. <https://choosemuse.com/why-muse/> (accessed Nov. 01, 2021).
- [11] A. Craik, Y. He, and J. L. Contreras-Vidal, "Deep learning for electroencephalogram (EEG) classification tasks: A review," *Journal of Neural Engineering*, vol. 16, no. 3, 2019, doi: 10.1088/1741-2552/ab0ab5.
- [12] A. Virendra et al., "Electroencephalogram (EEG) and its interpretation in dogs," ~ 1627 ~ *Journal of Entomology and Zoology Studies*, vol. 8, no. 4, pp. 1627–1631, 2020, [Online]. Available: <http://www.entomoljournal.com>
- [13] Megan Tung, "What is an fMRI scan and how does it work?," *Jameco Electronics*, 2021. <https://www.jameco.com/Jameco/workshop/HowItWorks/what-is-an-fmri-scan-and-how-does-it-work.html> (accessed Nov. 19, 2021).
- [14] S. J. Stanton, W. Sinnott-Armstrong, and S. A. Huettel, "Neuromarketing: Ethical Implications of its Use and Potential Misuse," *Journal of Business Ethics*, vol. 144, no. 4, pp. 799–811, Sep. 2017, doi: 10.1007/s10551-016-3059-0.
- [15] M. Nilashi et al., "Neuromarketing: A Review of Research and Implications for Marketing," *Journal of Soft Computing and Decision Support Systems*, 2020, [Online]. Available: <http://www.jsdcss.com>
- [16] Mayo Clinic, "Positron emission tomography scan - Mayo Clinic," Mayo Clinic, Aug. 10, 2021. <https://www.mayoclinic.org/tests-procedures/pet-scan/about/pac-20385078> (accessed Nov. 19, 2021).
- [17] Spiers Lab, "Magnetoencephalography (MEG) | SpiersLab," Spiers Lab Spatial Cognition, 2021. <https://spierslab.com/magnetoencephalography-meg/> (accessed Nov. 19, 2021).
- [18] Tobii Pro, "Your eye tracking research partner | Tobii Pro Singapore," Tobii Pro, 2021. [https://go.tobiipro.com/top\\_page?creative=516016081178&keyword=to%20pro%20eye&matchtype=p&network=g&device=c&gelid=Cj0KCQiAkNiMBhCxARIsAIDDKNX-Rk1Eae8bKcgHeD7w1mNrEyowu9y89MOMGfQh-469Obaf\\_eTWpMcaAgTIEALw\\_wcB](https://go.tobiipro.com/top_page?creative=516016081178&keyword=to%20pro%20eye&matchtype=p&network=g&device=c&gelid=Cj0KCQiAkNiMBhCxARIsAIDDKNX-Rk1Eae8bKcgHeD7w1mNrEyowu9y89MOMGfQh-469Obaf_eTWpMcaAgTIEALw_wcB) (accessed Nov. 19, 2021).
- [19] M. Antoniak, "Benefits and threats of neuromarketing: theoretical background and practical use," *Scientific Papers of Silesian University of Technology – Organization and Management Series*, vol. 2020, no. 148, pp. 9–25, 2020, doi: 10.29119/1641-3466.2020.148.1.
- [20] Explorer Research, "GSR Market Research Overview - Explorer Research," Explorer Research, 2021. <https://explorerresearch.com/gsr-market-research/> (accessed Nov. 19, 2021).
- [21] T. Avinash, L. Dikshant, and S. Seema, "Methods of Neuromarketing and Implication of the Frontal Theta Asymmetry induced due to musical stimulus as choice modeling," in *Procedia Computer Science*, 2018, vol. 132, pp. 55–67, doi: 10.1016/j.procs.2018.05.059.
- [22] A. Bazzani, S. Ravaioli, L. Trieste, U. Faraguna, and G. Turchetti, "Is EEG Suitable for Marketing Research? A Systematic Review," *Frontiers in Neuroscience*, vol. 14, Dec. 2020, doi: 10.3389/fnins.2020.594566.
- [23] S. H. Lim, H. Nisar, K. W. Thee, and V. V. Yap, "A novel method for tracking and analysis of EEG activation across brain lobes," *Biomedical Signal Processing and Control*, vol. 40, pp. 488–504, Feb. 2018, doi: 10.1016/j.bspc.2017.06.017.
- [24] Z. Zatul Iffah, "Covid-19 lonjak jual beli dalam talian," *myMetro*, Mar. 29, 2021. <https://www.hmetro.com.my/mutakhir/2021/03/689274/covid-19-lonjak-jual-beli-dalam-talian> (accessed Oct. 28, 2021).
- [25] A. H. Nurul Nabila, "Pembelian secara dalam talian pilihan terbaik semasa PKP," *Sinar Harian*, May 12, 2021. <https://www.sinarharian.com.my/article/138248/LAPORAN-KHAS/Pembelian-secara-dalam-talian-pilihan-terbaik-semasa-PPK> (accessed Nov. 09, 2021).
- [26] C. Demangeot and A. J. Broderick, "Conceptualising consumer behaviour in online shopping environments," *International Journal of Retail and Distribution Management*, vol. 35, no. 11, pp. 878–894, 2007, doi: 10.1108/09590550710828218.
- [27] FOMCA, "Hak-hak Pengguna," FOMCA, Feb. 16, 2017. <https://www.fomca.org.my/v1/index.php/tentang-kami/hak-hak-pengguna> (accessed Nov. 09, 2021).
- [28] M. H. A. Bakar, M. A. M. Desa, and M. Mustafa, "Attributes for Image Content that Attract Consumers' Attention to Advertisements," in *Procedia - Social and Behavioral Sciences*, Jul. 2015, vol. 195, pp. 309–314, doi: 10.1016/j.sbspro.2015.06.349.
- [29] R. Naszariah et al., "Issues And Challenges Of Online Shoppingactivities On The Impact Of Corona Pandemic:A Study On Malaysia Retail Industry," *Turkish Journal of Computer and Mathematics Education*, vol. 12, no. 10, pp. 7682–7686, 2021, [Online]. Available: [https://www.abeam.com/my/en/topics/insights/covid19\\_retail](https://www.abeam.com/my/en/topics/insights/covid19_retail)
- [30] I. O. Pappas, P. E. Kourouthanassis, M. N. Giannakos, and V. Chrissikopoulos, "Shiny happy people buying: the role of emotions on personalized e-shopping," *Electronic Markets*, vol. 24, no. 3, pp. 193–206, Sep. 2014, doi: 10.1007/s12525-014-0153-y.
- [31] A. Hakim, S. Klorfeld, T. Sela, D. Friedman, M. Shabat-Simon, and D. J. Levy, "Machines learn neuromarketing: Improving preference prediction from self-reports using multiple EEG measures and machine learning," *International Journal of Research in Marketing*, vol. 38, no. 3, pp. 770–791, Sep. 2021, doi: 10.1016/j.ijresmar.2020.10.005.
- [32] N. A. S. Shaari, M. M. J. Syafiq, M. K. M. Amin, and O. Mikami, "Electroencephalography (EEG) Application in Neuromarketing- Exploring the Subconscious Mind," *Journal of Advanced Manufacturing Technology (JAMT)*, 2019.
- [33] N. A. Mahamad, M. K. M. Amin, and O. Mikami, "Evaluating Neuromarketing Technique on Consumer Satisfaction Using EEG Imaging," *Journal of Advanced Manufacturing Technology (JAMT)*, 2019.
- [34] H. N. Oon, A. Saidatul, and Z. Ibrahim, "Analysis on Non-Linear Features of Electroencephalogram (EEG) Signal for Neuromarketing Application," in *2018 International Conference on Computational*

- Approach in Smart Systems Design and Applications (ICASSDA), 2018, pp. 1–8. doi: 10.1109/ICASSDA.2018.8477618.
- [35] C. R. Amin et al., "Consumer Behavior Analysis using EEG Signals for Neuromarketing Application," in 2020 IEEE Symposium Series on Computational Intelligence, SSCI 2020, Dec. 2020, pp. 2061–2066. doi: 10.1109/SSCI47803.2020.9308358.
- [36] R. M. Mehmood and H. J. Lee, "ERP analysis of emotional stimuli from brain EEG signal Deep Learning-Based Action Recognition View project Applied Scene Description and Action Recognition in IoT View project ERP analysis of emotional stimuli from brain EEG signal," 2015. [Online]. Available: <https://www.researchgate.net/publication/309428313>
- [37] S. C. Wriessnegger, D. Hackhofer, and G. R. Muller-Putz, "Classification of unconscious like/dislike decisions: First results towards a novel application for BCI technology," in Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, Nov. 2015, vol. 2015-November, pp. 2331–2334. doi: 10.1109/EMBC.2015.7318860.
- [38] T. M. Lau, J. T. Gwin, and D. P. Ferris, "How Many Electrodes Are Really Needed for EEG-Based Mobile Brain Imaging?," *Journal of Behavioral and Brain Science*, vol. 02, no. 03, pp. 387–393, 2012. doi: 10.4236/jbbs.2012.23044.

**Parallel Session 9 (11:00 am – 1:00 pm Kuala Lumpur GMT+8)**

**2 November 2022**

Track: Information Technology & Computer Systems

Microsoft Teams link <https://bit.ly/3CQmk7L>

Session Chair: Ts. Dr. Farahwahida Mohd @ Abu Bakar

Co Chair: Dr. Nur Hazwani Dzulkefly

<b>Time</b>	<b>Paper Title</b>	<b>Authors</b>
11:00am – 11:20 am	Timber Harvesting Decision-Making for Sustainable Forest Management: Elimination Process of Potential Tree To Be Harvested On Promoting Forest Regrowth and Minimize Damages	Hana Munira Muhd Mukhtar; Yasmin Yahya; Azizah Rahmat; Roslan Ismail
11:20am – 11:40 am	Benefits and Limitations of Neuromarketing Techniques in Enhancing Marketing Strategies	Mohd Fahmi Mohamad Amran; Nurhafizah Moziyana Mohd Yusop; Yuhanim Hani Yahaya; Siti Rohaidah Ahmad; Mat Razali Noor Afiza; Nurul Natasha Awinda Mohammad Nizam
11:40am – 12:00 pm	Factor Effecting Cloud-VLE Implementation in HEIs	Rahimah Kassim; Adnan Bakri; Fauziah Abdul Rahman
12:00pm – 12:20 pm	Low-cost Modular Smart Home Controlling System for Minimising Energy Consumption - A Conceptual Study	Zaid Mujaiyid Putra Ahmad Baidowi; Muhammad Danial Hakim Nazrin actionIzuan Gerard; Ruwaida Ramly
12:20pm – 12:40 pm	A Room Light Controlling System Based on Curtain and Occupants' Motion - A Conceptual Study	Zaid Mujaiyid Putra Ahmad Baidowi; Adli Zahin Muhammad Ruslee; Norzaidah Md Noh