

Neuromarketing: The popularity of the brain-imaging and physiological tools

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Abstract: In the last two decades, neuromarketing (NM) studies are snowballed because scientists and researchers are looking for understanding the mechanisms of decision-making in the consumer's brain toward marketing stimuli, for example, but not limited to advertising and brands that have not changed overnight. For this purpose, NM research is using state-of-the-art technology to gauge the responses of consumers' minds to marketing stimuli, which is impossible by traditional marketing methods. In this paper, we have concentrated on neuromarketing tools such as functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and eye-tracking (ET). Literature indicates that EEG, fMRI, and ET enable to gauge consumers' neurometrics and biometrics responses; thereby, they provide valuable information about the physiological and mental reactions toward marketing stimuli, which can be used to improve marketing research. Neuromarketing can provide valuable information about consumer behaviour, which is impossible by traditional methods. We hope that this study provides valuable insights into neuromarketing and future directions.

Keywords: neuromarketing; marketing; neuromarketing tools; consumer behaviour;

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1.0 INTRODUCTION

Neuromarketing (NM) is an interdisciplinary field that has derived from neuroscience, psychology, and marketing ([Mansor & Isa, 2020](#)). Undoubtedly, this is a promising field to study how humans made their conscious/unconscious decisions, and so through recording the activity regions in the consumer's brain when the consumer has been exposed to marketing stimuli such as advertisements, brand, sound, and so forth ([Cruz et al., 2016](#)). Traditional marketing methods are often providing not reliable and inaccurate information because it depends on the verbal consumer's choice (self-report) ([Alsharif et al., 2021c](#)). Therefore, traditional methods such as surveys, focus

groups, and interviews are not suitable for measuring unconscious responses ([Colaferro & Crescitelli, 2014](#)).

NM and traditional marketing methods are complementary; the reason turns back to that NM does not use similar techniques as in conventional methods ([Ramsoy, 2015](#)). NM uses state-of-the-art technology such as fMRI, EEG, and ET to study, explore, and analyse consumers' neural and physiological responses toward marketing stimuli to enhance the marketing strategies and the accuracy of the predictions. Hence, the marketers and practitioners have enormously sought to explore what is in the consumers' brains and what they are thinking of and explore the concealed centres in the

brain ([Alsharif et al., 2020b](#)), which lead the consumers to make their decisions, satisfy their needs and desires. Marketing has moved from studying conscious behaviour to study unconscious behaviour by state-of-the-art technology such as fMRI, EEG, and ET ([Fortunato et al., 2014](#); [Stanton et al., 2017](#)).

According to Stanton et al. ([2017](#)), NM has several methods to measure the consumer responses toward marketing stimuli, which have divided into three main categories: i) brain imaging tools such as fMRI and EEG, ii) Physiological tools such as ET, galvanic skin response (GSR), iii) Interventions tools such as transcranial magnetic stimulation (TMS) and neurotransmitters. Undoubtedly, all these methods are using in neuromarketing. However, the fMRI and EEG are still the most popular brain imaging tools among scholars because fMRI and EEG are the most promising tools to perform NM research. These tools are studying, exploring, and analysing the neural responses of consumers toward marketing stimuli such as ads, products, brands, and prices. Meanwhile, ET is considered the popular physiological tool to record eye movements, attention, fixations, saccade, pupil dilation ([Alsharif et al., 2021b](#); [Alsharif et al., 2021d](#)). In this study, the authors concentrate on the fMRI, EEG, and ET because these methods give a more accurate picture of the activity regions in mind timely, cost, temporal resolution, spatial resolution compared with the other methods. Therefore, the key contributions of the current study are summarised, as follows:

- Presents an overview of the NM field and the advantages of this field in marketing research.
- Provides the overview of the fMRI, EEG, and ET techniques used in marketing research.
- Provides new references to other researchers who need insights into enabling the fMRI, EEG, and ET methods in NM.

The organisation of this article is as thus; section 2 presents the advantages of neuromarketing tools in marketing research. Section 3 presents an overview of the fMRI, EEG, and ET techniques used in marketing research. Finally, Section 4 concludes the work and future directions of this field.

2.0 THE ADVANTAGES OF NEUROMARKETING TOOLS IN MARKETING RESEARCH

NM tools are primarily employed in advertising practices and marketing research. Therefore, NM is used to know how marketing stimuli, for example, but not limited to advertisements impact buying decisions

([Smidts et al., 2014](#); [Venkatraman et al., 2015](#)). For example, identifying the negative elements in advertising cause an individual's aversion to the products and allows to determine visual and audio features and select an appropriate media ([Fugate, 2007](#)). In addition, NM can also identify the real unfulfillment of consumers' needs; in such a way, it helps develop more useful and pleasant products, advertisements, and satiate the actual consumers' needs and desires ([Eser et al., 2011](#)). According to Fortunato et al. ([2014](#)), neuromarketing's contributions often helps in developing branding strategies and positioning a brand in the market. Furthermore, neuromarketing also can adjust its pricing strategy and developing brands and products. Therefore, NM techniques enable to determine the impact of emotion on purchase decisions mechanisms ([Alsharif et al., 2021a](#); [Fugate, 2007](#)). In addition, it also can create more successful social initiatives, such as encouraging the usage of seat belts in cars ([Orzan et al., 2012](#)) and antismoking campaigns ([Cartocci et al., 2018](#); [Rossi et al., 2017](#)). NM techniques can gauge the emotional arousal (e.g., high or low) to an advertising campaign, brands, product, services, besides, select the appropriate stimuli that affect the consumer effectively at the purchase point in-store ([Cherubino et al., 2017](#); [Kühn et al., 2016](#)). Lifestyle nowadays is different from the past and, definitely, it will be different in the future; thereby, the markets relied on the period of time of the consumers' lifestyle to promote their products and brand by using creative ads which are corresponding with consumers lifestyle ([Alsharif et al., 2021b](#)).

Advances in brain-imaging and physiological technology have led to an increase in the number of publications about studying the human brain; thereby, getting accurate images of the human brain, which led to a better understanding of its structure and functions. Accordingly, researchers and scientists from other fields have been interested in applying neuroimaging tools in their research. For example, it has grabbed attention from huge business establishments to use these tools in their research to dive deep into the consumer's brain to know the underlying reasons for consumers' choices to satisfy their actual needs. Notably, by using neuroimaging and physiological tools, companies can only better understand the consumer's behaviour as the mechanisms of making-decision and what processes affect making-decision in the brain ([Alsharif et al., 2021d](#)). Lindstrom ([2009](#)) endorsed the benefits of the NM techniques for both consumers and firms when they discussed that products and advertising campaigns designed on neuromarketing techniques will benefit the

consumer by guiding the consumer to make purchase decisions easier simple. Meanwhile, for firms, techniques will make advertisements and products more effective; thereby, reduce the wastage of firms budget used randomly on advertising campaigns.

3.0 OVERVIEW OF NEUROMARKETING TOOLS

According to the literature, we found techniques to measure brain activity signals such as fMRI and EEG, physiological activity signals such as ET and GSR, and intervention tools like TMS. As well we found studies about other tools such as MEG, PET, and SST are scant. However, it is worthy to mentions that several studies have employed other tools such as observations, interviews, focus groups, questionnaires, and reaction time to measure/record consumers' behaviour. NM techniques are essential for marketing research (Alsharif et al., 2020a). According to Alsharif et al. (2021d); Jordao et al. (2017) the fMRI and EEG are the most brain imaging tools that applied to record the brain activity signal of the consumers toward marketing stimuli such ad advertising campaigns. Meanwhile, according to dos Santos et al. (2015), the ET is the most common physiological tool. Lim (2018) indicates that brain-imaging tools such as fMRI and EEG are the most popular among scholars, followed by physiological tools such as ET.

Overall, we suggest excluding some techniques such as PET and TMS in neuromarketing research. Whether an invasive tool, use an injection of some chemical materials (e.g., fluorodeoxyglucose) in the blood vessels or harmful to use in consumer research. MEG needs a specific environment such as low temperature (estimated zero), too expensive, and limited to recording the cortical regions, making it inappropriate for marketing research. The EEG technique can substitute the SST technique because EEG has more accuracy and reliability, which leads us to infer that EEG and fMRI are convenient tools (Alsharif et al., 2021d; Fortunato et al., 2014; Koc & Boz, 2018). fNIRS is a non-invasive tool, which uses the hemodynamic responses associated with neuronal activities (Krampe et al., 2018). It is employed to record modifications in haemoglobin flow (e.g., oxyhaemoglobin and deoxyhaemoglobin) during brain activity and establish a map of the blood oxygenation in the local brain area (active regions in the brain required more oxyhaemoglobin) (Ernst et al., 2013; Jackson & Kennedy, 2013). According to the literature, it has acceptable temporal accuracy (estimated in seconds) (Alvino et al., 2020) and low spatial accuracy (estimated in 4 cm) (Krampe et al., 2018), which has only the ability

to measure the cerebral regions (Cakir et al., 2018), which lead to infer that this tool is not suitable to measure the deep structure of the brain. Several studies have been used fNIRS technique to study the purchase behaviour and brand (Cakir et al., 2018; Krampe et al., 2018). Therefore, we selected three tools for this review: fMRI, EEG, and ET, employed to record the brain and somatic activity signals of the consumers toward marketing stimuli such as advertisements and brands. **Table 1** shows the pros and cons for each common tools, what does it measure and when does it use?

3.1 Functional magnetic resonance imaging

fMRI is a metabolism and non-invasive technique. fMRI is used to measure the level of oxygen in the blood vessels wherein the activity regions in the brain need more oxygenated blood than inactive regions; thereby, the activity regions in the brain will produce stronger signals than others (Morin, 2011; Murray & Antonakis, 2019). The participant have to lay into the fMRI tube, wherein the participant's head is surrounded by a huge magnet to measure the activity regions in the brain. In addition, the participant should not move throughout the experiment because the magnetic is too sensitive toward any movement of participants (Alsharif et al., 2020b; Pradeep, 2010). Marketing stimuli (e.g., picture, videos, product, logo, brand) will be displayed on the participants, the activity regions in the brain will need more oxygenated blood than inactive regions. The blood vessels in the activity regions will dilate to receive a great amount of oxygenated blood and glucose which active regions need it. As a result of that the activity regions produce a stronger magnetic field than the inactive ones, which is leading to changes in the magnetic field (Gani et al., 2015; Zurawicki, 2010). Therefore, fMRI records the signals of the active regions and displays the activity regions of the brain in three-dimensions view on the computer screen, which appears in grey colour named blood oxygen level-dependent (Boksem & Smidts, 2015; Cabre et al., 2019). fMRI tool enables the record of 1-10 mm³ in the deep structure of the brain because it has an excellent spatial resolution. Meanwhile, it has acceptable temporal accuracy, estimated 1-6 seconds (s) to start recording the activity regions in the brain. Therefore, fMRI is deemed as one of the best techniques in marketing research to measure the neural responses of consumers such as emotion (e.g., valence, appeal, engagement, and arousal) toward brands (e.g., recall, recognition, preference, and liking) and advertising campaign (e.g., effectiveness) (Alsharif et al., 2021d; Casado-Aranda et al., 2018; Chen & Morris, 2016; Venkatraman et al., 2015).

Table 1: The most common popular tools applied in marketing research.

Tool	Reference	What does it measure?	When does it use?	Pros	Cons
fMRI	Morris et al. (2009); Shi et al. (2017); Chen & Morris (2016); Langleben et al. (2009); Wang et al. (2015); Hsu & Cheng (2018); Casado-Aranda et al. (2018)	Memory, dimension of emotion (i.e., valence and arousal) perception, attention, engagement, reward.	Testing new products, ads, brands, design of the package, prices, reposition and quality of a product, predicting consumers' purchase decisions.	High spatial resolution, trustable for measuring the neural correlates of cognitive and emotional processes.	Low temporal resolution, expensive, non-portable, uncomfortable, data analysis is quite complex, need a wide place.
EEG	Wang et al. (2016); Cartocci et al. (2017); Wei et al. (2018); Harris et al. (2019); García-Madariaga et al. (2020); Eijlers et al. (2020)	Cognitive and emotional processes, engagement, and excitement.	Testing ads (e.g., print, images, online, videos), products (e.g., label, brand, price, design), websites (e.g., design, brightness, usability).	High temporal resolution, quite inexpensive, Wearable, non-invasive, data analysis is quite straightforward, trustable for measuring cognitive information processing, enables comparisons between cortical hemispheres (e.g., left and right).	Low spatial resolution, findings prone to influence through artefacts, unable to record emotional arousal.
ET	Pileliene & Grigaliunaite (2017); Ananos (2015); Cuesta-Cambra et al. (2017); Christoforou et al. (2015); García-Madariaga et al. (2020); Boscolo et al. (2020)	Attention, visual stimuli, fixation, pupil dilation, eye movements, saccade, excitement.	Testing ads (e.g., picture, videos, colour, brightness), product (e.g., brand, label, position in-store), design (e.g., product, website, package, the usability of the website).	Portable, low cost, and non-invasive tool	Not work very well with glasses, eyelashes, and lenses

Source: Adopted by Alsharif et al. (2021d)

fMRI is used to know how different marketing stimuli impact buying decisions, including exposure to a certain advertisement (Morin, 2011; Smidts et al., 2014). For high-quality information, fMRI and PET techniques can be combined because the PET technique can record what is happening in the brain moment-by-moment, while fMRI is more appropriate to identify the activity regions in the brain accurately. But using the PET technique in marketing research is limited due to the PET technique uses chemical material which is injecting into the blood-vessel to record the activity regions in the brain, which is not convenient for participants (Fortunato et al., 2014; Sebastian, 2014). However, these tools are huge and require big places; thereby, it

is impossible to use them in realistic circumstances, and last but not least, costly (Cherubino et al., 2019). A number of studies have used fMRI to measure the neural responses of consumers behaviour toward marketing stimuli (Al-Kwafi, 2016; Fehse et al., 2017). For example, Fehse et al. (2017) conducted an experiment to investigate the neural correlates of the perceptions toward two types of brands (organic and popular brands). The findings illustrated that a stronger activity in the medial prefrontal cortex (mPFC) for popular brands, while a stronger activity in the dorsolateral prefrontal cortex (dlPFC), wherein the lateral and medial PFC have vital role in influencing decision-making. Chen and Morris (2016) investigated the

activity regions in the brain that are relevant to the emotional dimensions (e.g., arousal, pleasure) evoked by TV ads. Their findings revealed that the pleasure and displeasure dimensions are correlated with more activity in the gyri regions (e.g., inferior frontal and middle temporal gyri), while the low and high arousal is associated with gyrus regions (e.g., the right superior temporal and right middle frontal gyrus).

3.2 Electroencephalography

EEG is the most technology used in marketing practices before the release of the fMRI technique because of its less expensive and excellent temporal resolution ([Alsharif et al., 2021d](#); [Cruz et al., 2016](#); [Lee et al., 2017](#); [Telpaz et al., 2015](#)). EEG is a non-invasive electrical technique, which is using electrodes placed on the consumer's scalp to measure the voltage changes of frequencies at scalp toward marketing stimuli in milliseconds ([Cherubino et al., 2019](#); [Davis, 2019](#); [Eijlers et al., 2020](#); [Kumar, 2015](#)). According to the literature, EEG has five frequency bands such as delta (less than 4 hertz (Hz)), theta (4-7 Hz), alpha (8-15 Hz), beta (16-31 Hz), and gamma (larger than 32 Hz) ([Wei et al., 2018](#)). EEG has an excellent temporal resolution (estimated in milliseconds) ([Ohme et al., 2011](#); [Telpaz et al., 2015](#)), but it has a poor spatial resolution because it enables only to record the cortical activity regions of the brain (estimated in 1 cm) ([Telpaz et al., 2015](#); [Zurawicki, 2010](#)). In addition, EEG uses a 10-20 system, which is a globally recognised method. This system is used to express the locations of electrodes on the scalp of the participants such as prefrontal (Fp), frontal (F), occipital (O), parietal (P), temporal (T), and central (C). EEG uses an equal number of electrodes on the right and left parts of the head ([Rawnaque et al., 2020](#); [Silverman, 1965](#)). It also uses to understand how a consumer is reacting to an advertisement or to understand what is happening in a consumer's brain when interacting with a salesperson ([Telpaz et al., 2015](#)). Increasing the number of electrodes enables the record of the extremely low frequency of the active signals ([Calvert & Thesen, 2004](#); [Du Plessis, 2011](#); [Pradeep, 2010](#); [Samsuri et al., 2016b](#)).

A number of studies have used EEG/ event-related potential (ERP) to measure the consumers' behaviour toward marketing stimuli such as ads, products ([Ciorciari et al., 2019](#); [Eijlers et al., 2020](#); [Samsuri et al., 2016a](#); [Samsuri et al., 2016b](#)). For example, the ERP and ET investigation to measure the attention level, pupil dilation, and fixation toward the display design of car advertisements. The findings revealed that the higher amplitudes of the ERP component (N100 refers to

perception and P300 refers to attention and memory) were found during the right lateral grouped view of cars. Therefore, the right lateral grouped view of the car has higher interest than the left lateral grouped view of the car. Heat maps showed that the red colour of the car has a common interest in both views of car ([Samsuri et al., 2016b](#)). Similarly, [Samsuri et al. \(2016a\)](#) found that the higher amplitudes and shorter latencies of the ERP component were found during the left lateral singular view, therefore, the left lateral singular has higher visual attention and perception than the right lateral singular view of cars. In addition, heat maps showed that the black car's left lateral singular view has a higher interest, while the red car view has a higher interest in the right lateral singular. Consequently, both experiments can help automotive firms better understand visual attention, thoughts, and perceptions of consumers toward automotive display, improving marketing strategies such as promotion. In other EEG studies, [Eijlers et al. \(2020\)](#) investigated the arousal evoked in response to advertisements. The findings showed that arousal is positively connected to prominent ads in the population and negatively to consumer attitude toward these ads. [Harris et al. \(2019\)](#) examined the effectiveness of emotion-based ads on the public health sector. The findings revealed that emotion-based ads are more effective in decision-making than rational-based ads.

3.3 Eye-Tracking

Eye-tracking (ET) is employed to record eye movement or saccades (fast eye movement), fixation (look at a specific point), and pupil dilation (pupil size). It allows measuring the various processes of the individual's brain toward stimuli such as emotional responses ([Guo et al., 2018](#); [Wang et al., 2010](#)). Accordingly, it is an effective tool for experimental psychology and neurological research because of the relationship between visual attention and eye movements ([Hoffman, 1998](#)). ET is a convenient tool to record where eyes are looking at and what eyes are looking for, for example, it records the fixation time (i.e., spent time that the consumer keeps his/her eyes on a specific thing), saccade (i.e., time that the consumer's eyes jump from one to another fixation point); therefore, collect information about interest area ([Alsharif et al., 2020b](#); [Cherubino et al., 2019](#)). The eye fixation time during reading text was estimated at 200 milliseconds (ms). Meanwhile, watching the video scene was estimated at 350 ms. Saccade eye is estimated at 200 ms ([Rayner, 2009](#)). According to literature, fixation and saccades are called scan and analyse visual stimuli, interest area ([Fortunato et al., 2014](#)).

ET has been widely employed in neuromarketing research to investigate visual and engagement behaviour (Zamani et al., 2016), many scholars use ET in both environments (i.e., lab and the factual world) (King et al., 2019). In marketing research, the ET technique has been largely used to evaluate the visual behaviour of consumers toward marketing stimuli, for example, but not limited to the design of packaging and products. Many scholars and practitioners have used the ET and EEG techniques together to collect more accurate information about consumers' emotional and cognitive reactions toward stimuli (Alsharif et al., 2021c; Guixeres et al., 2017). For example, it has investigated the influence of color temperature of ad and the gender of spokesperson on the advertising effectiveness. Their findings suggested that the warm color temperature attracts more visual attention to the advertisement, generating a positive implicit attitude to the advertisement and inducing the buying intentions of the advertised products compared with cool color temperature advertisements whether the spokesperson's female or male celebrity (Pileliene & Grigaliunaite, 2017). Therefore, the color temperature impacts the effectiveness of the advertising spokesperson and advertising effectiveness.

4.0 CONCLUSION AND FUTURE DIRECTIONS

Marketing research still largely relies on traditional methods to study consumers' behaviour wherein consumers consciously report on their experiences and thoughts. While unconscious behaviour is largely unmeasured by conventional methods. Therefore, the NM give marketers, researchers, and practitioners an unrivalled opportunity to better understand unconscious consumers' behaviour and pre-purchase and post-purchase behaviour toward marketing stimuli (e.g., brands, products) by using neuroimaging and physiological tools such as fMRI, EEG, and ET. This is expected to increase the effectiveness of marketing stimuli, such as product and brand preference

(likes/dislikes), the perceived value of product, and brand and promotion. For example, fMRI is a non-invasive and metabolic technique to measure the activity regions of the consumer's brain by measuring the oxygenated and deoxygenated blood, wherein the active regions of the brain need more oxygenated blood than inactive regions. EEG is a non-invasive and electrical technique to measure the changes in voltage at the scalp regions, wherein use electrodes at the scalp within 10-20 standard system. ET is a physiological tool to measure eye movements, fixation, saccade, pupil dilation toward visual stimuli. These techniques can identify the weaknesses and address them, meanwhile, identify strengths and enhance them.

Although NM faces many ethical issues (e.g., autonomy, privacy) and challenges (e.g., cost, need experts, lack to access to resources), it is a novel method to analyse the consumer's behaviour. It provides valuable information for marketing research. For example, it gives proactive steps to marketers, researchers, and practitioners to better understand consumer behaviour and decision-making processes toward various stimuli such as brands. This paper is providing an overview of NM domain and techniques such as the fMRI, EEG, and ET. To end, scholars have to use NM for the sake of improving people's lives, not for their own goals.

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