Biomedical Technology in Studying Consumers' Subconscious Behavior

https://doi.org/10.3991/ijoe.v18i08.31959

Ahmed H. Alsharif[1](✉), Nor Zafir Md Salleh[1],
Wan Amira binti Wan Ahmad[2], Ahmad Khraiwish[3]
[1]Universiti Teknologi Malaysia (UTM), Johor, Malaysia
[2]University Kuala Lumpur (UniKL), Kuala Lumpur, Malaysia
[3]Applied Science Private University (ASU), Amman, Jordan
ahmedalsharif07@gmail.com

Abstract—Despite the technological advancements in neuroimaging and physiological technologies, studies about using this technology to study the neural correlates of consumers' behavior toward external stimuli remain unclear in the academic literature. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework in this article to select relevant articles for this study. We extracted and analyzed fifty-six articles from the Web of Science (WoS) database to answer the research questions. We found eight common methods, as follow: (i) neuroimaging tools such as fMRI, fNIRS, and EEG used to study the neural responses of emotional and cognitive processes, (ii) physiological tools such as ET, EMG, GSR, ECG, and IAT to study eye movements, fixation, pupil dilation, consumers' attitudes, visual attention, heart rate, zygomatic and corrugator facial muscles toward environment stimuli such as machines. We hope this article provides valuable insights into neuroimaging and physiological technology guiding new practitioners and researchers to choose the appropriate tool to conduct the experiment and get high-quality and reliable results.

Keywords—neuromarketing, PRISMA, consumer behavior, neuroimaging tools, physiological tools

1 Introduction

Researchers have resorted to using neuroscience and psychology tools such as electroencephalography (EEG), functional magnetic resonance imaging (fMRI), eye-tracking (ET), and so forth to better understand consumers' behavior. That led to emerging a novel field, so-called "neuromarketing" [1, 2]. Although the term "neuromarketing" was coined in 2002 by Smidts [3], the first study that used neuroscience tools such as functional magnetic resonance imaging (fMRI) in the business field was done in 2000 by [4]. But the first study under the neuromarketing term was conducted by McClure, et al. [5], which was highly contributed to shifting the neuromarketing field from a pure study to a practical study. Neuromarketing is a multidisciplinary field,

measuring the subconscious and unconscious responses of consumers toward advertising, marketing, and branding; thereby enriching us with valuable information about consumers behavior [6, 7].

Even though consumers are exposed to abundant stimuli such as products, brands, ads every day, marketing research is largely relied on self-report methods to measure consumers' responses [8]. At the same time, most consumers' behavior occurs subconsciously or unconscious [4]. Due to the high-competitive environment, many researchers and marketers tried to fill the gap in self-report methods by using neuroscience tools to study consumers' unconscious and subconscious responses toward stimuli such as ads, brands, and products [9]. Consequently, marketers have been adopting neuroscience tools to accomplish marketing excellence (e.g., ads) because advertising is an important channel to communicate with current customers and potential customers [10]. Neuromarketing's main goal/purpose is to better understand consumers' unconscious and subconscious responses that drive their choices [11, 12].

Ramsoy [13] has been divided neuromarketing tools into four categories: (1) Neuroimaging tools such as EEG, fMRI, magnetoencephalography (MEG), and positron emission tomography (PET), steady-state topography (SST), single-photon emission tomography (SPET), and functional near-infrared spectroscopy (fNIRS); (2) Physiological tools such as galvanic skin responses (GSR), ET, electromyography (EMG), and electrocardiogram (ECG); (3) Behavioural tool such as implicit association test (IAT); and (4) Self-report tools such as interviews, surveys, and focus groups. For Instance, neuroimaging tools are used to record the cognitive and emotional responses (e.g., arousal, pleasure, engagement, approach/withdrawal) toward stimuli [14]. Physiological tools can record the physiological responses (e.g., visual fixation, pupil dilation, eye movement, and excitement) at the purchase point; thereby providing reliable and valuable information about preference (e.g., preferred/like or not preferred/dislike) [15]. IAT can measure consumers' attitudes (e.g., approach or withdrawal behavior) toward stimuli [16]. Self-report can measure the consciousness of consumer responses toward stimuli [13].

However, up to date, no investigation has identified the neuroimaging and physiological tools currently used in marketing research to gauge the subconscious and unconscious of consumers' responses toward stimuli. Hence, we present tools currently used to study the consumers' responses toward stimuli such as brands, ads, and products. Accordingly, we conducted the current study to answer the following research questions:

- RQ1. What are the current studies that used neuroimaging tools in the marketing environment from 2004 to 2020?
- RQ2. What are the current studies that used physiological tools used in the marketing environment from 2004 to 2020?
- RQ3. What are the current studies that used self-report methods used in the marketing environment from 2004 to 2020?

In this vein, this study has organized as follows—section 2, methodology and collecting data techniques that have been used in this study. Section 3, presents studies that currently use neuroimaging, physiological, and behavioral techniques to study the consumers' responses toward stimuli. The discussion has addressed in section 4. Finally, section 5, presents the conclusion of the current study.

2 Materials and methods

To answer the current research questions, we have followed the PRISMA framework of Moher, et al. [17] to extract articles that used neuromarketing tools, fill the gap, and understand the consumers' responses toward stimuli. The current research has been designed to extract relevant articles from the WoS database to answer the questions of this research. This process will provide a comprehensive understanding of the neuroimaging, physiological, and behavioral tools currently used in marketing research, thereby developing marketing research. Relevant documents were extracted from the WoS by using the following query applied to the title, abstract, and keywords: ("neuromarketing" OR "consumer neuroscience") AND ("tools" OR "techniques" OR "methods").

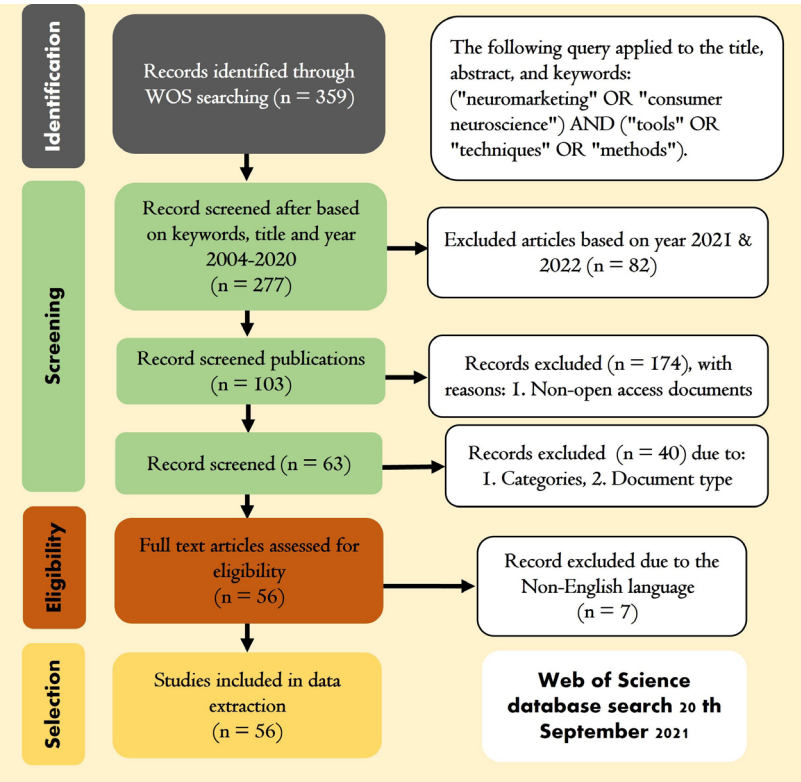

Fig. 1. PRISMA flow chart for selecting articles for this study

The total number of publications was 359 documents from 2004 to 2020. It has been selected a total of 56 articles from the WoS database. Figure 1 shows the followed processes to extract the relevant articles for this study, as follow:

- Articles published in neuromarketing that used neuroimaging, physiological, and behavioral techniques in marketing research from 2004 to 2020 were included.
- Documents published in the non-English language were excluded.
- Documents such as book chapters, books, conferences, and so forth were excluded.

3 Results

3.1 Neuromarketing tools used in studying consumers' behavior to marketing stimuli

The main goal of neuromarketing is to better understand consumers' behavior toward stimuli such as ads, products, and brands, thereby creating more effective advertising, product, and brand, which might reduce the wastage of the budget [18]. After evaluating documents, it was possible to propose a framework of the neuromarketing tools into three categories, as depicted in Figure 2: (i) Neuroimaging tools; (ii) Physiological tools; and (iii) Self-report methods.

Neuroimaging techniques such as fMRI and fNIRS can measure the brain's metabolic activity, while EEG can measure the electrical activity regions in the brain toward stimuli such as ads, products, brands, and so forth. Physiological techniques, for example, ET can measure visual attention such as fixation, pupil dilation, eye movements [19]. GSR and ECG can measure emotional arousal (e.g., high/low) and heart rate [20]. EMG can only measure the unconscious responses of the emotional valence (e.g., pleasure/displeasure, sadness/excitement, and forth) [21]. IAT and consumers' attitudes toward dynamic and static ads [22]. Self-report is important to weigh for various product attributes, which examine consumers' conscious behavior toward marketing stimuli such as products, ads, and so forth. Therefore, it helps researchers and scholars to identify consumers' preferences. Together, these techniques can gauge the neural and physiological responses of consumers' behaviors toward advertising and how to be applied at the purchase point in-store to raise sales. In this study, the authors will focus on neuroimaging and physiological tools.

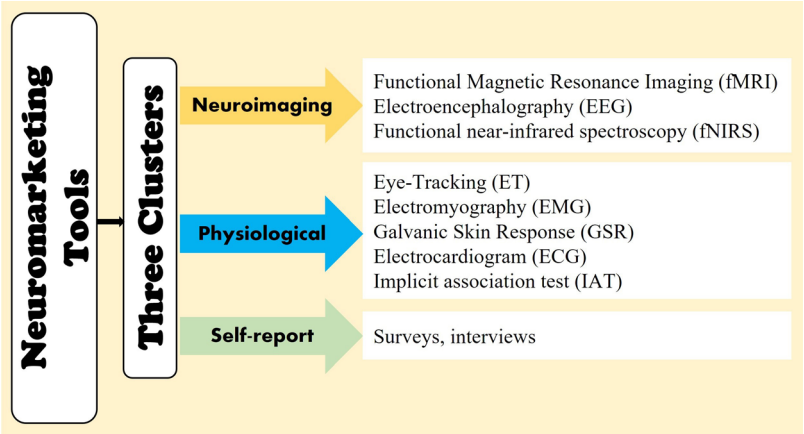

Fig. 2. The proposed neuromarketing tools

Electroencephalography. In the early 1970s, it has been measured the consumers' responses to TV ads campaigns by EEG [15]. EEG is an electrical and non-invasive technique to record the cortical activity in the brain by recording the voltage changes in these regions. It is also not expensive and noisy but can only capture the cortical activity

in the brain; therefore, it is not a proper tool to record the distal regions in the brain [23]. In addition, it has excellent temporal accuracy, which can record the cortical activity regions in milliseconds (Ms). On the opposite side, it has poor spatial accuracy, thereby, unable to record the distal regions in the deep structure of the brain (estimated 1 cm^3 in the cortical areas) [24]. According to the literature, EEG uses a 10-20 system, a globally recognized 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 [25]. In addition, it has five frequency bands (e.g., delta, theta, alpha, beta, and gamma) [26].

EEG has been used to record consumers' subconscious and unconscious responses toward stimuli such as ads, brands, and products [27]. For example, the EEG investigations of Vecchiato, et al. [28] found that the activity in the right and left frontal alpha associated with pleasure and displeasure ads, respectively. Other the EEG studies, the findings of Eijlers, et al. [29] showed that arousal is positively connected to prominent ads in the population and negatively to consumer attitude toward these ads. Cuesta-Cambra, et al. [30] found that the visual activity of men is different from women, wherein the recall relies on the emotional value of ads and simplicity, while complex ads need more visual fixation; thereby, hard to remember. Treleaven-Hassard, et al. [31] found that consumers' engagement with interactive ads linked with more automatic attention.

Ramsoy, et al. [32] found that stronger activity in the prefrontal gamma asymmetry was correlated to willing to pay (WTP) decision. Cartocci, et al. [33], Modica, et al. [34] found that antismoking campaign characterized with a symbolic communication style has gained the highest approach values. At the same time, an image based on the "fear arousing appeal" and a narrative style reported the highest and lowest effort values index, respectively. Pozharliev, et al. [35], Zhang, et al. [36] found that social motivations have a vital role in influencing purchasing luxury products to satisfy social goals (at least one goal). Bosshard, et al. [37] found that preferred brands reflect more motivational aspects and activity signals in the right parietal cortices than unpreferred brands. The findings of Dapkevičius and Melnikas [38] revealed that the experiment suggests that price can affect the quality of the product and decision-making.

Functional magnetic resonance imaging. fMRI is another neuroimaging tool used in marketing research. fMRI is metabolism and non-invasive technique used to measure the blood oxygen level-dependent [39]. The activity regions in the brain will need more oxygenated blood, thereby producing stronger signals than others [23]. FMRI enables recording 1–10 mm^3 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 brain's activity regions [40]. In addition, allowing a three-dimensional view of consumer's brain regions. It is expensive, needs space, noisy, and sensitive to participants' head movement [41]. The fMRI is a revolutionary tool to record, study, explore, and analyse consumers' subconscious and unconscious responses such as emotion, attention, and memory toward marketing stimuli [42]. For example, Shen and Morris [42], Morris, et al. [43] used fMRI to measure consumers' behavior. Their findings revealed that the pleasure and displeasure dimensions have correlated with more activity in the gyri regions (e.g., inferior frontal and middle

temporal gyri). At the same time, low and high arousal have been associated with gyrus regions (e.g., the right superior temporal and right middle frontal gyrus). Falk, et al. [44] found that activity in a prior medial PFC (mPFC) was predicted mainly the success of various advertising campaigns in the real world. A recent fMRI study found that the compatibility between advertising and gender voice (male, female) induces endogenous attention regions [45]. Bakalash and Riemer [46], Seelig, et al. [47] found that a stronger activity in the amygdala (AMY) and frontotemporal regions are associated with memorable and unmemorable ads.

McClure, et al. [5] found that the stronger brand logo such as Coca-Cola generated more activity in the hippocampus (HC) and the dorsolateral prefrontal cortex (dlPFC), which connect to memory. Plassmann, et al. [48] found more activity in the medial orbitofrontal cortex (mOFC) when participant thought that he/she was drinking expensive wine, wherein the activity in the mOFC related to the pleasant experience. Fehse, et al. [49] found a stronger activity in the mPFC for popular brands, while a stronger activity in the dorsolateral prefrontal cortex (dlPFC), the lateral and lateral, and mPFC have a vital role in influencing decision-making. Al-Kwifi [41] found a stronger activity in the vmPFC during consumer judgment toward perceived brand usefulness and pleasure.

The fMRI in all studies required participants to remain static and then display advertising such as images videos for 1-5 s; then, participants were required to make a purchase decision within 5s after exposure to advertising [45]. In the last five years, researchers and scholars have used several versions of fMRI machine, for example, 3-T fMRI scanner, 3.0-T Siemens Magnetom Trio system MRI scanner equipped with a 32-channel bridgehead coil [50].

Functional near-infrared spectroscopy. fNIRS is similar to the fMRI technique, and both can be effectively employed to measure metabolic activity in the brain [51]. fNIRS has been used to record and map the oxyhemoglobin and deoxyhemoglobin in the brain during brain activity [52]. Because hemodynamic responses are associated with neuronal activities; thereby, the participants' brains activity regions require more oxyhemoglobin than inactive regions [53]. According to the literature, fNIRS has acceptable temporal accuracy (estimated in seconds) [54], low spatial accuracy (estimated in 4 cm) that can measure the cerebral regions [53]. It is also easy to use, a wireless and portable technique [53]. Generally, the fNIRS technique is more available for economic scholars and practitioners [55].

The fNIRS was applied to measure the cortical processes (approach/avoidance) toward positive/negative picture [56], purchasing decision [55], the effects administration of dietary (e.g., caffeine) components on the cerebral blood flow [57], advertising efficiency and "first choice brand" effect [53]. For example, Ernst, et al. [56] found that the dorsolateral prefrontal cortex (dlPFC) was associated with the approach/avoid the behavior. Plichta, et al. [58] found that emotional stimuli such as pleasant and unpleasant sounds increased activity in the auditory regions in the brain compared to neutral sounds. Cakir, et al. [55] found that positive purchase behavior had increased the neural activity in the frontopolar regions, which are closely linked to the OFC and the vmPFC, wherein can use the neural activation to predict the purchase or withdrawal behavior by 85 percent. Jackson and Kennedy [57] used fNIRS to measure the effects of dietary components (e.g., caffeine, omega-3) on cerebral blood flow. The findings showed that fNIRS is a sensitive measure of change in hemodynamic response during

cognitive tasks in acute and chronic treatment intervention paradigms. Krampe, et al. [53] found that the mobile fNIRS is an appropriate neuroimaging technique for predicting "first-choice-brand".

Eye-tracking. ET is used to record eye movements, saccade, fixation, pupil dilation of consumers toward marketing stimuli such as ads, products, and brands; thereby, it gives valuable insights into the subconscious and unconscious behavior of consumers Cherubino, et al. [15]. It is a helpful tool for experimental psychology and neurological research due to the correlation between visual attention and eye movements [59]. According to Chavaglia, et al. [60], ET is recording where and what individuals are looking at, fixation time, pupil dilation, the degree of focus, and also eye movements to get information about a specific area of interest (AOI) [61]. According to literature, the range of eye fixations lasting between 200 and 350 ms during reading text and watching video scenes, respectively. At the same time, 200 ms indicate the duration of saccadic eye movements [62]. The fixations and saccades are named the scan route and analyze visual perception, cognitive purpose, interest, and relationship [63]. At the same time, pupil dilation with a longer blink period tells us better information processing [2]. The technological advancement in the last decade, the ET has many uses relevant to human-computer interactions, wherein ET can be used in the laboratory and real environments [64]. Thus, the neuro-marketers and researchers can benefit from the information given appropriately by using it professionally to attract the consumer's attention and integrate them into visual activities [65].

Several studies have been used ET to record the consumers' responses (e.g., fixation, pupil dilation, visual attention) toward ads, products, and brands. For example, the ET investigation of Rojas, et al. [66] to study consumers' perceptions toward virtual and real representation of the product (i.e., beer bottle). Their findings revealed that the render quality of products, direction of the product, and presentation method had influenced consumers' perception. Guo, et al. [67] found that disclosures have largely impacted cognitive and emotional responses (e.g., awareness, recognition, attitude) toward brand placement. The findings of Oliveira and Giraldi [68] revealed that the well-known brand has a more substantial impact on visual attention than others. Pileliene and Grigaliunaite [9] used ET to measure the influence of the advertisement's color temperature on consumers' visual attention. The findings showed that the warm color has a more substantial impact on consumers' visual attention than the cool color, thereby, purchase intention.

Electromyography. Faces can provide information about gender, identity, age, ethnicity, physical health, emotional status, personality traits, and so forth [69]. In addition, faces of people are the best communicational method among them; wherein faces can reflect the emotional status of people (e.g., pleasure, sadness, and so forth) [70]. Faces are the initial understanding of unspoken feelings and emotions; thereby, facial expressions are highly important in communicating among people and between people and the marketing environment in daily life. In other words, a smile means we experience happiness; a frown means we experience sadness or anger [71]. That means the facial expressions reflect the emotional status of consumers.

Customers' faces express emotional valence (e.g., pleasure, displeasure, sadness, and so forth) [70]; for example, mouth and eyebrows movements refer to pleasure/displeasure and continuous communication. Therefore, providing feedback on what

other people talk about. EMG is a convenient tool for recording emotional valence, the visible and invisible facial muscles movements such as zygomatic and corrugator muscles [72]. In addition, to record and identify the physiological properties of facial muscles such as voluntary and involuntary responses. Zygomatic muscles indicate positive stimuli; thereby, purchasing decisions Somervuori and Ravaja [73]. In contrast, corrugator muscles refer to negative stimuli [72].

In marketing environments, facial expressions analysis is a fundamental matter for marketers and researchers to know the emotional status of customers toward marketing stimuli; therefore, creating more effective ads, brands, and products [15]. For example, the EMG, GSR, ET, and EEG investigation of Liaudanskaitė, et al. [74] found that emotional valence and arousal greatly impact advertisements' effectiveness. The EMG, GSR/EDA, and self-report study of Lajante, et al. [1] measure the pleasure/displeasure of the consumer toward ads. Their findings revealed that pleasure and displeasure had been positively influenced the behavior/attitudes of consumers toward ads. Missaglia, et al. [75] used EMG, ECG, GSR, and self-report to identify the predictive percentage of participants toward two different social ads. The findings revealed that 30% of participants prefer non-violent social ads, while 64.3% of participants reported feeling anger while watching a violent social ad. The probability of choosing a social ad that uses a non-violent ad was about 10-fold higher than participants who reported feeling anger. McDuff, et al. [76] used EMG and survey to investigate the accuracy percentage of facial responses toward the effectiveness of ads. They found that the predictive percentage of ad liking accuracy was 85%, while purchase intention was 78%.

Galvanic skin response and electrocardiogram. The GSR and ECG have been used to measure the emotional responses toward marketing stimuli such as dynamic and static ads [77]. The GSR is used to gauge the sweating level and ECG to measure the heart rate/heartbeat [77]. ECG can record the heartbeat activations during exposure to marketing stimuli [20]. Heart rate is considered a good scale of emotional valence, wherein the heartbeat's slowing down in the short term is associated with positive and negative emotions. Still, the positive stimuli increase heart rate long-term, while the reverse is true [78].

GSR is a suitable tool to measure the emotional dimensions (e.g., valence and arousal), sweat glands, and changes in skin conductance [20]. Dawson, et al. [79] defined it as a tentative rise in the skin's electrical conductivity, which leads to increased activity in the sweat glands. As the glands are dense on the palms and the feet' soles, they are measured by GSR, and it is a suitable method for studying consumer decision-making.

Both can measure the autonomic nervous system and evaluate the internal emotional status of consumers [20]. For example, Andrii, et al. [80] found that the atmosphere in the store and the consumers' state influence emotional fatigue. Similarly, Halkin [81] found that waiting in the cashier line indicates an increase in the consumer's fatigue index in the shops and decreases on the road back to home. Overall, it is still higher than at home. The ECG and EDA investigation of Baraybar-Fernández, et al. [77] found that advertisement with sad messages was more effective for participants.

Similarly, Barquero-Pérez, et al. [20] experimented with examining six different advertisements to obtain indices assessing the autonomic nervous system (ANS) using ECG and EDA toward different emotional aspects. Their findings revealed that each advertisement transferred a different emotion (e.g., disgust, anger, and so forth). In

summary, both devices can provide valuable information about the emotional status of consumers toward marketing stimuli.

Implicit association test. The implicit association test (IAT) can measure consumers› attitudes toward brands or advertising [22]. IAT is a suitable tool to measure the reaction time of customers (attitudes). In other words, IAT measures the customers' attitudes toward brands or advertising by tapping on the bottom to choose between positive or negative words, which reflect the emotional valence such as pleasure/displeasure, sadness/excitement [19]. IAT can identify the customers' attitudes toward marketing stimuli such as brands or ads (e.g., like/dislike) by recording the reaction time of customers [71]. In addition, it is an indirect method to record and predict the unconscious customers› behavior (attitudes) toward brands or ads; thereby, overcoming the lack of inner knowledge about customers attitudes, which relied on the survey [74]. Therefore, IAT helps researchers and marketers to compare the customers› attitudes toward two different brands or ads by recording the reaction time of each customer [22]. IAT was founded in 1998 by Greenwald, et al. [82], which was used to measure the individual differences in implicit cognitions such as self-esteem.

Marketing research needs to measure the consumer's reaction time between stimuli display and its response. A shorter latency refers to the vigor association of this brand or advertising in the consumer's mind. Despite the latency between display stimuli and responses in milliseconds, it is significant for identifying the consumers' attitudes (e.g., like/dislike) [63]. For example, Bosshard, et al. [37] used IAT and self-report to measure consumers' behavior (attitudes) toward brands. Their findings revealed that liked brands reflect more motivational aspects and activity signals in the right parietal cortices than disliked brands. Pileliene and Grigaliunaite [9] have used IAT to identify the factors that impact advertising effectiveness, such as gender of spokesperson (celebrity Versus regular person), color temperature, and the content of the ads. Venkatraman, et al. [19] found that the response latency between when each image was paired with a positive or a negative word served as an implicit measure of emotional valence toward each ad. The IAT and survey investigation of Grigaliunaite and Pileliene [16] found that The negative pictures related to smoking cause a negative implicit attitude of customers toward those pictures, then toward smoking behavior, which increases the influence on customers' intention to quit or not start smoking.

4 Discussion

We have followed the PRISMA framework recommended to select the relevant articles for this study [83][84][85] as the neuromarketing tools that are currently used to study the consumers' behavior toward marketing stimuli such as ads, brands, and products. We have found that the EEG is the most used tool currently in neuromarketing research, which measures consumers' behavior toward ads, products, and brands. For example, brands linked with interactive ads have more automatic attention [31], willing to pay (WTP) decisions related to more activity in the prefrontal gamma asymmetry [32], social motivations are highly influenced purchasing luxury products [35], the price can largely affect the quality of products and also decision-making [38].

Several authors have used the fMRI to study and explore the neural correlates of consumers' responses. For example, [46] found that more activity in the AMY and frontotemporal regions were related to memorable and unmemorable ads. At the same time, [44] found that the mPFC was linked to predicting various ads' success. The fMRI study of [5] found that the stronger activity in the dlPFC and the HC were associated with memory. [48] conducted experiment and found the mOFC was connected to the pleasant experiences. Activity in the lateral PFC, mPFC, and dlPFC is associated with decision-making [49], vmPFC is related to consumers' judgment [41]. The fNIRS was applied to measure the cortical processes (approach/avoidance) toward positive/negative picture [56, 58], purchasing decision [55], the effects administration of dietary (e.g., caffeine) components on the cerebral blood flow [57], advertising efficiency and "first choice brand" effect [53].

ET has been used to measure consumers' visual attention toward ads, products, and brands. For example, warm color influences consumers' visual attention more than cool color [9]. EMG is used to measure emotional valence (e.g., pleasure, displeasure, and so forth) toward marketing stimuli. For example, the influence of emotional valence on the effectiveness of ads [74] also consumers' attitudes [1]. GSR and ECG were used to measure consumers' emotional valence and arousal to stimuli. For example, store atmosphere, consumer's status, and waiting in the cashier lines influence the emotional fatigue [80], ads with sad messages were more effective [77], each ad generates a different emotional status [20]. IAT to measure the consumers' attitudes (e.g., like, dislike). For example, liked brands generate more motivational aspects than disliked brands [37], negative pictures related to smoking cause a negative attitude (e.g., quit or not start smoking) [16].

Neuroimaging tools can measure and record the neural responses of consumers toward stimuli. In contrast, physiological tools such as ET, GSR, ECG, IAT, and EMG provide valuable information about emotional valence and arousal, eye movements, fixation, pupil dilations, consumers' attitudes, facial expressions, heart rate, and visual attention. Self-report provides consumers' conscious responses toward stimuli. These tools/techniques complement each other, providing valuable information about consumers' conscious, subconscious, and unconscious responses toward marketing stimuli such as ads, brands, and products. Therefore, providing valuable information to better understand consumers' behaviors toward the marketing environment can help marketers, researchers, and practitioners increase the ad effectiveness and quality of products by maintaining affordable pricing and understanding how consumers perceive the value of brands.

5 Conclusions

Neuromarketing is a revolutionary field promising to better understand consumers' behaviors toward marketing stimuli such as brands, products, and ads, thereby solving marketing issues such as advertising effectiveness, quality of products, and perceived brand value. For example, creating more attractive and effective advertising enhance high-quality products to satisfy consumers' needs by maintaining affordable pricing and improving brands. In today's hyper-competitive environments, each company seeks to

find beneficial methods to beat competitors and prioritize consumers' priorities. We found nine common neuromarketing tools used in marketing research, as follow: (i) neuroimaging tools such as fMRI, fNIRS, and EEG used to study the neural responses of emotional and cognitive processes, (ii) physiological tools such as ET, EMG, GSR, ECG, and IAT to study eye movements, fixation, pupil dilation, consumers' attitudes, visual attention, heart rate, zygomatic and corrugator facial muscles toward stimuli; and (iii) self-report to measure the consumers' conscious responses toward stimuli. Hence, advertisers and marketers have been used neuroimaging, physiological, and self-report techniques to study, explore, and analysis the neural and physiological responses of consumers' conscious and unconscious responses toward stimuli.

The findings suggested that neuroimaging, physiological, and self-report are complementary and highly significant to capture/record consumers' brain and physiological responses toward marketing stimuli. For example, neuroimaging tools enable measuring and recording the activity signals of the consumer's brain. Physiological tools can record bodily responses such as eye movements, sweating levels, and fixation. Self-report can measure consumers' conscious responses toward stimuli. We believe that this study provides a comprehensive overview of the current and main neuromarketing methods used in marketing research. We hope that this study will help researchers identify the proper mental processes for their research to get accurate and high-quality results.

6 Acknowledgment

The authors would like to thank Universiti Teknologi Malaysia (UTM), University Kuala Lumpur (UniKL), and Applied Science Private University (ASU) for supporting this study.

7 References

[1] M. Lajante, O. Droulers, C. Derbaix, and I. Poncin, "Looking at aesthetic emotions in advertising research through a psychophysiological perspective," *Frontiers in Psychology,* vol. 11, p. 2544, 2020. https://doi.org/10.3389/fpsyg.2020.553100

[2] A. H. Alsharif, N. Z. M. Salleh, and R. Baharun, "Neuromarketing: The popularity of the brain-imaging and physiological tools," *Neuroscience Research Notes,* vol. 3, no. 5, pp. 13–22, 2021. https://doi.org/10.31117/neuroscirn.v3i5.80

[3] A. Smidts, *Kijken in het brein: Over de mogelijkheden van neuromarketing*. Netherland: Erasmus Research Institute of Management, 2002.

[4] G. Zaltman, "Consumer researchers: Take a hike!" *Journal of Consumer Research,* vol. 26, no. 4, pp. 423–428, 2000. https://doi.org/10.1086/209573

[5] S. M. McClure, J. Li, D. Tomlin, K. S. Cypert, L. M. Montague, and P. R. Montague, "Neural correlates of behavioral preference for culturally familiar drinks," *Neuron,* vol. 44, no. 2, pp. 379–387, 2004. https://doi.org/10.1016/j.neuron.2004.09.019

[6] S. Kühn, E. Strelow, and J. Gallinat, "Multiple "buy buttons" in the brain: Forecasting chocolate sales at point-of-sale based on functional brain activation using fMRI," *NeuroImage,* vol. 136, pp. 122–128, 2016. https://doi.org/10.1016/j.neuroimage.2016.05.021

[7] A. H. Alsharif, N. Z. M. Salleh, R. Baharun, and R. H. E. Alharthi, "Neuromarketing research in the last five years: A bibliometric analysis," *Cogent Business & Management,* vol. 8, no. 1, p. 1978620, 2021. https://doi.org/10.1080/23311975.2021.1978620

[8] A. H. Alsharif, N. Z. M. Salleh, and R. Baharun, "Neuromarketing: Marketing research in the new millennium," *Neuroscience Research Notes,* vol. 4, no. 3, pp. 27–35, 2021. https://doi.org/10.31117/neuroscirn.v4i3.79

[9] L. Pileliene and V. Grigaliunaite, "Relationship between spokesperson's gender and advertising color temperature in a framework of advertising effectiveness," *Scientific Annals of Economics and Business,* vol. 64, no. 2, pp. 1–13, Dec 2017. https://doi.org/10.1515/saeb-2017-0036

[10] M. T. Bendixen, "Advertising effects and effectiveness," *European Journal of Marketing,* vol. 27, no. 10, pp. 19–32, 1993. https://doi.org/10.1108/03090569310045861

[11] S. Songsamoe, R. Saengwong-ngam, P. Koomhin, and N. Matan, "Understanding consumer physiological and emotional responses to food products using Electroencephalography (EEG)," *Trends in Food Science & Technology,* vol. 93, no. 2019, pp. 167–173, 2019. https://doi.org/10.1016/j.tifs.2019.09.018

[12] A. H. Alsharif, N. Z. M. Salleh, R. Baharun, H. Abuhassna, and A. R. E. Hashem, "A global research trends of neuromarketing: 2015–2020," *Revista de Comunicación,* vol. 21, no. 1, pp. 15–32, 2022. https://doi.org/10.26441/RC21.1-2022-A1

[13] T. Z. Ramsoy, *Introduction to neuromarketing & consumer neuroscience*. Rørvig, Denmark: Neurons Inc., 2015.

[14] A. H. Alsharif *et al.*, "Neuroimaging techniques in advertising research: Main applications, development, and brain regions and processes," *Sustainability,* vol. 13, no. 11, p. 6488, 2021. https://doi.org/10.3390/su13116488

[15] P. Cherubino *et al.*, "Consumer behaviour through the eyes of neurophysiological measures: State of the art and future trends," *Computational Intelligence and Neuroscience,* vol. 3, no. 2, pp. 1–41, 2019. https://doi.org/10.1155/2019/1976847

[16] V. Grigaliunaite and L. Pileliene, "Attitude toward smoking: the effect of negative smoking-related pictures," *Oeconomia Copernicana,* vol. 8, no. 2, pp. 317–328, 2017. https://doi.org/10.24136/oc.v8i2.20

[17] D. Moher *et al.*, "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement," *Systematic Reviews,* vol. 4, no. 1, pp. 1–9, 2015. https://doi.org/10.1186/2046-4053-4-1

[18] E. Gurgu, I. A. Gurgu, and R. B. M. Tonis, "Neuromarketing for a better understanding of consumer needs and emotions," *Independent Journal of Management & Production,* vol. 11, no. 1, pp. 208–235, 2020. https://doi.org/10.14807/ijmp.v11i1.993

[19] V. Venkatraman *et al.*, "Predicting advertising success beyond traditional measures: New insights from neurophysiological methods and market response modeling," *Journal of Marketing Research,* vol. 52, no. 4, pp. 436–452, 2015. https://doi.org/10.1509/jmr.13.0593

[20] Ó. Barquero-Pérez, M. A. Cámara-Vázquez, A. Vadillo-Valderrama, and R. Goya-Esteban, "Autonomic nervous system and recall modeling in audiovisual emotion-mediated advertising using partial least squares-path modeling," *Frontiers in Psychology,* vol. 11, no. 3, pp. 576771–576781, 2020. https://doi.org/10.3389/fpsyg.2020.576771

[21] A. Hadinejad, B. Moyle, N. Scott, and A. Kralj, "Emotional responses to tourism advertisements: The application of facereader," *Tourism Recreation Research,* vol. 44, no. 1, pp. 131–135, 2019. https://doi.org/10.1080/02508281.2018.1505228

[22] D. Maison and A. P. Gregg, "Capturing the consumer's unconcious: Applying the implicit association test in consumer research," in *Routledge International Handbook of Consumer Psychology*, 2017, pp. 143–164.

[23] C. Morin, "Neuromarketing: The new science of consumer behavior," *Society,* vol. 48, no. 2, pp. 131–135, 2011. https://doi.org/10.1007/s12115-010-9408-1

[24] 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, pp. 1–16, Dec 2020, Art. no. 594566. https://doi.org/10.3389/fnins.2020.594566

[25] F. Rawnaque *et al.*, "Technological advancements and opportunities in Neuromarketing: A systematic review," *Brain Informatics,* vol. 7, no. 1, pp. 1–19, 2020. https://doi.org/10.1186/s40708-020-00109-x

[26] Z. Wei, C. Wu, X. Y. Wang, A. Supratak, P. Wang, and Y. K. Guo, "Using support vector machine on EEG for advertisement impact assessment," *Frontiers in Neuroscience,* vol. 12, p. 12, Mar 2018, Art. no. 76. https://doi.org/10.3389/fnins.2018.00076

[27] G. Di Flumeri *et al.*, "EEG frontal asymmetry related to pleasantness of olfactory stimuli in young subjects," in *Selected Issues in Experimental Economics*, Springer, 2016, pp. 373–381. https://doi.org/10.1007/978-3-319-28419-4_23

[28] G. Vecchiato *et al.*, "Changes in brain activity during the observation of TV commercials by using EEG, GSR and HR measurements," *Brain Topography,* vol. 23, no. 2, pp. 165–179, 2010. https://doi.org/10.1007/s10548-009-0127-0

[29] E. Eijlers, M. A. S. Boksem, and A. Smidts, "Measuring neural arousal for advertisements and its relationship with advertising success," *Frontiers in Neuroscience,* vol. 14, no. 4, pp. 736–748, Jul 2020, Art. no. 736. https://doi.org/10.3389/fnins.2020.00736

[30] U. Cuesta-Cambra, J.-I. Niño-González, and J. Rodríguez-Terceño, "The cognitive processing of an educational app with EEG and eye tracking," *Media Education Research Journal,* vol. 25, no. 52, pp. 41–50, 2017. https://doi.org/10.3916/C52-2017-04

[31] S. Treleaven-Hassard *et al.*, "Using the P3a to gauge automatic attention to interactive television advertising," *Journal of Economic Psychology,* vol. 31, no. 5, pp. 777–784, Oct 2010. https://doi.org/10.1016/j.joep.2010.03.007

[32] T. Z. Ramsoy, M. Skov, M. K. Christensen, and C. Stahlhut, "Frontal brain asymmetry and willingness to pay," *Frontiers in Neuroscience,* vol. 12, no. 3, pp. 138–150, 2018. https://doi.org/10.3389/fnins.2018.00138

[33] G. Cartocci *et al.*, "Electroencephalographic, heart rate, and galvanic skin response assessment for an advertising perception study: Application to antismoking public service announcements," *Journal of Visualized Experiments,* vol. 3, no. 126, pp. 55872–55881, 2017. https://doi.org/10.3791/55872

[34] E. Modica *et al.*, "Neurophysiological profile of antismoking campaigns," *Computational Intelligence and Neuroscience,* vol. 5, no. 3, pp. 1–11, 2018. https://doi.org/10.1155/2018/9721561

[35] R. Pozharliev, W. J. Verbeke, J. W. Van Strien, and R. P. Bagozzi, "Merely being with you increases my attention to luxury products: Using EEG to understand consumers' emotional experience with luxury branded products," *Journal of Marketing Research,* vol. 52, no. 4, pp. 546–558, 2015. https://doi.org/10.1509/jmr.13.0560

[36] W. K. Zhang, J. Jin, A. L. Wang, Q. G. Ma, and H. H. Yu, "Consumers' implicit motivation of purchasing luxury brands: An EEG study," *Psychology Research and Behavior Management,* vol. 12, pp. 913–929, 2019. https://doi.org/10.2147/PRBM.S215751

[37] S. S. Bosshard, J. D. Bourke, S. Kunaharan, M. Koller, and P. Walla, "Established liked versus disliked brands: Brain activity, implicit associations and explicit responses," *Cogent Psychology,* vol. 3, no. 1, pp. 1–16, 2016, Art. no. Unsp 1176691. https://doi.org/10.1080/23311908.2016.1176691

[38] A. Dapkevičius and B. Melnikas, "Influence of price and quality to customer satisfaction: Neuromarketing approach," *Science–Future of Lithuania,* vol. 1, no. 3, pp. 17–20, 2011. https://doi.org/10.3846/144

[39] J. J. Cabre *et al.*, "Feasibility and effectiveness of electrochemical dermal conductance measurement for the screening of diabetic neuropathy in primary care. decoding study," *Journal of Clinical Medicine,* vol. 8, no. 5, p. 13, May 2019, Art. no. 598. https://doi.org/10.3390/jcm8050598

[40] B. Burle, L. Spieser, C. Roger, L. Casini, T. Hasbroucq, and F. Vidal, "Spatial and temporal resolutions of EEG: Is it really black and white? A scalp current density view," *International Journal of Psychophysiology,* vol. 97, no. 3, pp. 210–220, 2015. https://doi.org/10.1016/j.ijpsycho.2015.05.004

[41] S. O. Al-Kwifi, "The role of fMRI in detecting attitude toward brand switching: An exploratory study using high technology products," *Journal of Product & Brand Management,* vol. 25, no. 2, pp. 208–218, 2016. https://doi.org/10.1108/JPBM-12-2014-0774

[42] F. Shen and J. D. Morris, "Decoding neural responses to emotion in television commercials," *Journal of Advertising Research,* vol. 56, no. 2, pp. 11–28, 2016. https://doi.org/10.2501/JAR-2016-016

[43] J. D. Morris *et al.*, "Mapping a multidimensional emotion in response to television commercials," *Human Brain Mapping,* vol. 30, no. 3, pp. 789–796, Mar 2009. https://doi.org/10.1002/hbm.20544

[44] E. B. Falk, E. T. Berkman, and M. D. Lieberman, "From neural responses to population behavior: Neural focus group predicts population-level media effects," *Psychological Science,* vol. 23, no. 5, pp. 439–445, May 2012. https://doi.org/10.1177/0956797611434964

[45] L. A. Casado-Aranda, L. N. Van der Laan, and J. Sánchez-Fernández, "Neural correlates of gender congruence in audiovisual commercials for gender-targeted products: An fMRI study," *Human Brain Mapping,* vol. 39, no. 11, pp. 4360–4372, 2018. https://doi.org/10.1002/hbm.24276

[46] T. Bakalash and H. Riemer, "Exploring ad-elicited emotional arousal and memory for the ad using fMRI," *Journal of Advertising,* vol. 42, no. 4, pp. 275–291, 2013. https://doi.org/10.1080/00913367.2013.768065

[47] D. Seelig *et al.*, "Low message sensation health promotion videos are better remembered and activate areas of the brain associated with memory encoding," *PloS One,* vol. 9, no. 11, p. e113256, 2014. https://doi.org/10.1371/journal.pone.0113256

[48] H. Plassmann, J. O'Doherty, B. Shiv, and A. Rangel, "Marketing actions can modulate neural representations of experienced pleasantness," *Proceedings of the National Academy of Sciences,* vol. 105, no. 3, pp. 1050–1054, 2008. https://doi.org/10.1073/pnas.0706929105

[49] K. Fehse, F. Simmank, E. Gutyrchik, and A. Sztrokay-Gaul, "Organic or popular brands-food perception engages distinct functional pathways: An fMRI study," *Cogent Psychology,* vol. 4, p. 11, 2017, Art. no. 1284392. https://doi.org/10.1080/23311908.2017.1284392

[50] M. Hubert, M. Hubert, M. Linzmajer, R. Riedl, and P. Kenning, "Trust me if you can – neurophysiological insights on the influence of consumer impulsiveness on trustworthiness evaluations in online settings," *European Journal of Marketing,* vol. 52, no. 1–2, pp. 118–146, 2018. https://doi.org/10.1108/EJM-12-2016-0870

[51] S. E. Kober *et al.*, "Near-infrared spectroscopy based neurofeedback training increases specific motor imagery related cortical activation compared to sham feedback," *Biological Psychology,* vol. 95, pp. 21–30, 2014. https://doi.org/10.1016/j.biopsycho.2013.05.005

[52] I. M. Kopton and P. Kenning, "Near-infrared spectroscopy (NIRS) as a new tool for neuroeconomic research," *Frontiers in Human Neuroscience,* vol. 8, no. 2, pp. 549–562, 2014. https://doi.org/10.3389/fnhum.2014.00549

[53] C. Krampe, N. R. Gier, and P. Kenning, "The application of mobile fNIRS in marketing research – detecting the "first-choice-brand" effect," *Frontiers in Human Neuroscience,* vol. 12, no. 4, pp. 433–444, Nov 2018, Art. no. 433. https://doi.org/10.3389/fnhum.2018.00433

[54] R. Sitaram, A. Caria, and N. Birbaumer, "Hemodynamic brain–computer interfaces for communication and rehabilitation," *Neural Networks,* vol. 22, no. 9, pp. 1320–1328, 2009. https://doi.org/10.1016/j.neunet.2009.05.009

[55] M. P. Cakir, T. Çakar, Y. Girisken, and D. Yurdakul, "An investigation of the neural correlates of purchase behavior through fNIRS," *European Journal of Marketing,* 2018. https://doi.org/10.1108/EJM-12-2016-0864

[56] L. H. Ernst *et al.*, "Prefrontal activation patterns of automatic and regulated approach–avoidance reactions–A functional near-infrared spectroscopy (fNIRS) study," *Cortex,* vol. 49, no. 1, pp. 131–142, 2013. https://doi.org/10.1016/j.cortex.2011.09.013

[57] P. A. Jackson and D. O. Kennedy, "The application of near infrared spectroscopy in nutritional intervention studies," *Frontiers in Human Neuroscience,* vol. 7, p. 473, 2013. https://doi.org/10.3389/fnhum.2013.00473

[58] M. M. Plichta *et al.*, "Auditory cortex activation is modulated by emotion: A functional near-infrared spectroscopy (fNIRS) study," *Neuroimage,* vol. 55, no. 3, pp. 1200–1207, 2011. https://doi.org/10.1016/j.neuroimage.2011.01.011

[59] J. Hoffman, "Visual attention and eye movements," *Attention,* vol. 31, no. 2, pp. 119–153, 1998.

[60] J. N. Chavaglia, J. A. Filipe, and B. Ramalheiro, "Neuromarketing: Consumers and the anchoring effect," *International Journal of Latest Trends in Finance and Economics Sciences,* vol. 1, no. 4, pp. 183–189, 2011.

[61] C. Christoforou, S. Christou-Champi, F. Constantinidou, and M. Theodorou, "From the eyes and the heart: A novel eye-gaze metric that predicts video preferences of a large auidence," *Frontiers in Psychology,* vol. 6, no. 2, pp. 579–590, May 2015, Art. no. 579. https://doi.org/10.3389/fpsyg.2015.00579

[62] K. Rayner, "Eye movements and attention in reading, scene perception, and visual search," *Quarterly Journal of Experimental Psychology,* vol. 62, no. 8, pp. 1457–1506, 2009. https://doi.org/10.1080/17470210902816461

[63] L. Zurawicki, *Neuromarketing: Exploring the brain of the consumer*. Boston, USA: Springer Science & Business Media, 2010. https://doi.org/10.1007/978-3-540-77829-5_1

[64] A. King, N. Bol, R. Cummins, and K. John, "Improving visual behavior research in communication science: An overview, review, and reporting recommendations for using eye-tracking methods," *Communication Methods and Measures,* vol. 13, no. 3, pp. 149–177, 2019. https://doi.org/10.1080/19312458.2018.1558194

[65] B. Piqueras-Fiszman, C. Velasco, A. Salgado-Montejo, and C. Spence, "Using combined eye tracking and word association in order to assess novel packaging solutions: A case study involving jam jars," *Food Quality and Preference,* vol. 28, no. 1, pp. 328–338, 2013. https://doi.org/10.1016/j.foodqual.2012.10.006

[66] J. C. Rojas, M. Contero, N. Bartomeu, and J. Guixeres, "Using combined bipolar semantic scales and eye-tracking metrics to compare consumer perception of real and virtual bottles," *Packaging Technology and Science,* vol. 28, no. 12, pp. 1047–1056, 2015. https://doi.org/10.1002/pts.2178

[67] F. Guo, G. Ye, V. G. Duffy, M. Li, and Y. Ding, "Applying eye tracking and electroencephalography to evaluate the effects of placement disclosures on brand responses," *Journal of Consumer Behaviour,* vol. 17, no. 6, pp. 519–531, 2018. https://doi.org/10.1002/cb.1736

[68] J. H. C. d. Oliveira and J. d. M. E. Giraldi, "Neuromarketing and its implications for operations management: An experiment with two brands of beer," *Gestão & Produção,* vol. 26, no. 3, pp. 1–12, 2019. https://doi.org/10.1590/0104-530x3512-19

[69] R. Jack and P. Schyns, "The human face as a dynamic tool for social communication," *Current Biology,* vol. 25, no. 14, pp. 621–634, 2015. https://doi.org/10.1016/j.cub.2015.05.052

[70] P. Ekman, "Darwin, deception, and facial expression," *Annals of the New York Academy of Sciences,* vol. 1000, no. 1, pp. 205–221, 2004. https://doi.org/10.1196/annals.1280.010

[71] A. H. Alsharif, N. Z. M. Salleh, R. Baharun, and S. Mehdi, "Neuromarketing approach: An overview and future research directions," *Journal of Theoretical and Applied Information Technology,* vol. 98, no. 7, pp. 991–1001, 2020.

[72] J. T. Larsen, C. J. Norris, and J. T. Cacioppo, "Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii," *Psychophysiology,* vol. 40, no. 5, pp. 776–785, 2003. https://doi.org/10.1111/1469-8986.00078

[73] O. Somervuori and N. Ravaja, "Purchase behavior and psychophysiological responses to different price levels," *Psychology & Marketing,* vol. 30, no. 6, pp. 479–489, 2013. https://doi.org/10.1002/mar.20621

[74] G. Liaudanskaitė, G. Saulytė, J. Jakutavičius, E. Vaičiukynaitė, L. Zailskaitė-Jakštė, and R. Damaševičius, "Analysis of affective and gender factors in image comprehension of visual advertisement," in *Computer Science On-line Conference*, 2018, pp. 1–11: Springer. https://doi.org/10.1007/978-3-319-91189-2_1

[75] A. L. Missaglia, A. Oppo, M. Mauri, B. Ghiringhelli, A. Ciceri, and V. Russo, "The impact of emotions on recall: An empirical study on social ads," *Journal of Consumer Behaviour,* vol. 16, no. 5, pp. 424–433, 2017. https://doi.org/10.1002/cb.1642

[76] D. McDuff, R. El Kaliouby, J. Cohn, and R. G. Picard, "Predicting ad liking and purchase intent: Large-scale analysis of facial responses to ads," *IEEE Transactions on Affective Computing,* vol. 6, no. 3, pp. 223–235, 2014. https://doi.org/10.1109/TAFFC.2014.2384198

[77] A. Baraybar-Fernández, M. Baños-González, Ó. Barquero-Pérez, R. Goya-Esteban, and A. De-la-Morena-Gómez, "Evaluation of emotional responses to television advertising through neuromarketing," *Comunicar,* vol. 25, no. 52, pp. 19–28, 2017. https://doi.org/10.3916/C52-2017-02

[78] S. Genco, A. Pohlmann, and P. Steidl, *Neuromarketing for dummies*. USA: John Wiley & Sons, 2013.

[79] M. Dawson, A. Schell, and D. Filion, "The electrodermal system. Handbook of psychophysiology 2 ed," 2007, pp. 200–223.

[80] G. Andrii *et al.*, "Attractiveness modeling of retail on emotional fatigue of consumers," *South East European Journal of Economics and Business,* vol. 14, no. 2, pp. 106–116, 2019. https://doi.org/10.2478/jeb-2019-0017

[81] A. Halkin, "Emotional state of consumer in the urban purchase: Processing data," *Foundations of Management,* vol. 10, no. 1, pp. 99–112, 2018. https://doi.org/10.2478/fman-2018-0009

[82] A. Greenwald, D. McGhee, and J. Schwartz, "Measuring individual differences in implicit cognition: The implicit association test," *Journal of Personality and Social Psychology,* vol. 74, no. 6, pp. 1464–1480, 1998. https://doi.org/10.1037/0022-3514.74.6.1464

[83] H. Sikandar, Y. Vaicondam, N. Khan, M. I. Qureshi, and A. Ullah, "Scientific mapping of industry 4.0 research: A bibliometric analysis," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 15, no. 18, p. 129, 2021. https://doi.org/10.3991/ijim.v15i18.25535

[84] H. Sikandar, Y. Vaicondam, S. Parveen, N. Khan, and M. I. Qureshi, "Bibliometric Analysis of Telemedicine and E-Health Literature," *International Journal of Online and Biomedical Engineering (iJOE)*, vol. 17, no. 12, pp. 52–69, 2021. https://doi.org/10.3991/ijoe.v17i12.25483

[85] M. I. Qureshi, N. Khan, H. Raza, A. Imran, and F. Ismail, "Digital technologies in education 4.0. Does it enhance the effectiveness of learning? A systematic literature review," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 15, no. 4, pp. 31–47, 2021. https://doi.org/10.3991/ijim.v15i04.20291

8 Authors

Ahmed H. Alsharif is a PhD student of Azman Hashim International Business School (AHIBS)v at Universiti Teknologi Malaysia (UTM), Malaysia. His main research interests include Neuromarketing, Consumer Behavior, Marketing, Emotional Processes, Cognitive Processes, advertising. ahmedalsharif07@gmail.com, https://orcid.org/0000-0002-1364-3545

Nor Zafir Md Salleh is a senior lecturer of marketing at AHIBS, Universiti Teknologi Malaysia. Her research interests include Culture and Heritage, Service Innovation, Islamic Tourism, and Marketing. zafir@utm.my, https://orcid.org/0000-0001-7230-8766

Wan Amira Wan Ahmad is a Senior Lecturer of Marketing at University Kuala Lumpur (UniKL) holding a position as a Program Coordinator for the Marketing Program. Her research interests include Marketing. wanamira@unikl.edu.my

Ahmad Khraiwish is an Assistant Professor in the department of Marketing at the Applied Science Private University (ASU) and a part-time lecturer at the German Jordanian University (GJU). His current research interests include but not limited to; Digital Marketing, Mobile Marketing, Social Media Marketing (SMM), in addition to the research that is focused on the development of Digital Marketing within the Small to Medium sized Enterprises (SMEs) and E-Tailing. A.khraiwish@asu.edu.jo

Article submitted 2022-03-17. Resubmitted 2022-05-12. Final acceptance 2022-05-16. Final version published as submitted by the authors.