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RESEARCH ARTICLE **Open Access**

The Study of Electroencephalography in Neuromarketing Research, Consumer Behavior, and Performance Method: A Systematic Analysis

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Abstract

Neuromarketing and its tools are an emerging and evolving field that bridges the gap between consumer behavior studies and neuroscience. These new technologies are used in the field of neuromarketing and neuroscience to observe the brain areas involved, for example, in seeing, hearing, or smelling the product. For example, functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and event-related potentials (ERP) are used to identify the active points in the consumer's brain when they see, smell, or hear the product or service being tested. How these different techniques and tools work in neuromarketing has always been somewhat confusing to marketers. This study aims to examine the research articles published on the ScienceDirect website by identifying the current state of neuromarketing tools and electroencephalography (EEG) in neuromarketing to identify research gaps and provide recommendations for the application of this technique for experimental research for marketers. Using a two-stage bibliographic methodology, we show that although "neuromarketing" is the focus of research on the ScienceDirect website, there are not many empirical studies examining electroencephalography (EEG) and the combined use of this technology in consumer behavior. However, the use of this tool to screen messages and promotional materials has received the most attention. This study highlights the limitations of a systematic investigation of EEG issues in neuromarketing by examining fMRI, EEG, and ERP technologies. It also focuses on consumer behavior, particularly online shopping decision-making, website design, and consumers' physiological responses to the brand. In addition, future studies are expected to be completed by combining EEG and neuromarketing technologies.

Keywords: *Neuromarketing; Electroencephalography; Bibliometric analysis; Systematic literature review*

Introduction

Consumer neuroscience is an emerging interdisciplinary subject that integrates psychology, neuroscience, and marketing to examine how marketing and advertising tactics affect physiological processes in the brain. (Lee, Broderick, and Chamberlain, 2007; Madan, 2010). Understanding the cognitive, neurological, and emotional factors behind marketing-related behaviors has advanced through the application of neuroscience methods in the study of consumer behavior and the marketing decision process. However, very few neuroscience tools areused in consumer neuroscience research (Alvino et al., 2020). Consumer decision-making and behavior are supported and influenced by neuropsychological mechanisms. Consumer

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neuroscience examines marketing-related problems associated with purchase behavior using two methods from psychology and neuroscience and provides scientific rationales for consumer preferences and behaviors (Lovalos et al., 2012; Russo et al., 2015). Numerous neuroscience methods are used to study consumer behavior and decision-making. Instruments that measure essential physiological processes such as heart rate, respiratory rate, and blood pressure, as well as responses such as gaze fixation, pupil dilation, and facial expression, are widely used among consumer neuroscience products (Global Coordination Group, 2012). These instruments indicate positive and negative outcomes, reactions, and emotional responses to marketing stimuli (Hamlin et al., 2017).

Consumer neuroscience techniques such as functional magnetic resonance imaging (fMRI) and electroencephalograms (EEG) provide real-time evaluation of brain activity (EEG). These devices track consumers' brain activity during consumption-related activities (such as purchasing or evaluating a product)and in the moments before and after such behavior (Plassman et al., 2015, Montazeri Barfroshi et al., 2017). Numerous research papers have examined the benefits of using neuroscience technologies in marketing (Vacciato et al., 2011; Brescia, 2013; Hsu and Yoon, 2015; Ramsway, 2015; Bose et al., 2017; Lee et al., 2017; Alvino, 2019; Song Samu et al., 2019). Although several studies have been conducted in the field of brain activity used in website visual design, its use and function as a typical research technique in marketing studies have not been specified (Kabra et al., 2021; Romano and Shall, 2017). However, not knowing where to start, market analysts are still unsure about these tactics. Market analysts are trying to figure out how to use laboratory techniques in their research. This article focuses on the methodology of research conducted in the field of neuromarketing as a guideline for researchers and marketers. Also, this article only examines scientific articles in recent years that have been done experimentally. At the end of this article, a recipe was designed based on which future generations can conduct their research in the right direction.

In particular, companies and cooperatives do not produce products that suit the needs and tastes of customers due to a lack of knowledge of customer needs, which has reduced their share in the market (Yadegari et al., 2021). The marketers of these companies can expand their marketing research by using such new techniques and methods in social networks (Abesh Loui Aghdam et al., 2023)

This study reviewed articles on the ScienceDirect website from 2013 to 2022 to analyze neuromarketing research gaps in electroencephalography. First, the direction of electroencephalography research on customer behavior in neuromarketing was tracked by analyzing this type of marketing and evaluating its research method. Understanding the implicit stimulus, and recognizing the sense and perception applied to customer behavior, which is an aspect of research in sensory marketing (KohanZahedani et al., 2019), is not included in this research. Regardless of whether they were research papers or reviews and which journals they came from, a total of 355 articles were found. Of the total number of publications found, 222 scientific articles were reviewed. The remaining options on this website, including review articles (28), scientific book chapters (46), encyclopedias, news, etc., were removed to obtain more accurate results. A total of 222 papers were analyzed and the keywords and article density in the field of neuromarketing were examined using a bibliographic search. Finally, the publications that dealt with the use of EEG in neuromarketing were filtered out, their research techniques were analyzed, and then the application of these techniques in marketing was demonstrated to marketers. The gap in neuromarketing research was presented about the neuroscience of consumer behavior. The article is organized as follows. First, a bibliometric analysis of neuromarketing research published to date is presented. The results of the analysis serve as the basis for the subsequent systematic review of the research literature. The three topics of electroencephalography, consumer behavior,

and purchase decision make up the systematic literature review. Finally, the technique of the research examined in this area is highlighted to provide a better understanding of how to conduct laboratory research in marketing.

Literature Review

Neuromarketing is an emerging field of business marketing communication that applies neuropsychology to marketing research and studies consumers' emotional and cognitive responses to marketing stimuli. (Lee et al., 2007; Volsiani, 2014; Georges, 2014) The term neuromarketing refers to the use of modern brain science and tools to measure the impact of marketing and advertising on consumers (Bhatia, 2014). Neuromarketing is a combination of marketing, psychology, and neuroscience. In this type of marketing, the researchers evaluate and learn the reaction and emotions of the consumers when providing them with products or relevant stimulants. The observations could be associated with the participants' probable emotions and social interactions (Ebner & Fisher et al., 2014). EEG is an electrophysiological monitoring method for recording electrical activities on the head skin which shows the underlying superficial layer of the brain. This type is usually non-invasive, and the electrodes are placed on the head's skin. EEG sometimes includes invasive electrodes placed inside the brain called electrocorticography.

EEG measures the voltage volatilities induced by the ion current in brain neural cells. (Niedermeyer and Silva, 2004) Clinically, EEG records spontaneous brain electrical activity over a period, which is transferred through electrodes on the head skin (Niedermayer and Silva, 2004). Diagnostic programs focus mainly on event-related potentials or spectral content of EEG. The first assesses the probable volatilities of the locked time for an event, such as "initiation of the stimulant" or "button press" .The latter analyzes neural oscillations, commonly called brain waves. Consumer behavior involves "all activities related to the purchase, use, and disposal of goods and services, including emotional-cognitive, mental and behavioral reactions of the consumer that precede or follow these activities." (Kardes et al., 2011). The term consumer can refer to individual consumers as well as organizational consumers, and more specifically, "an end user, and not necessarily a purchaser, in the distribution chain of a good or service" (BusinessDictionary, 2019). Consumer behavior is concerned with (A) Purchasing activities: purchase of goods or services. How consumers access products and services, as well as all activities leading to purchase. including information search, product and service evaluation, and payment methods.

(B) Activities related to consumption: includes time, place and manner of consumption, experience of use, and distribution of goods in consumption units.

(C) Disposal-related activities: related to the way consumers dispose of products and product packaging. It may also include resale activities and secondary markets. (Kardes et al., 2011؛ Sassatelli, 2007)

Bibliometric methods are useful for assessing and tracking dynamic shifts in research areas within a given field (Old, Wang, and Lim, 2019; Wang, Zhao, Villala, and Lim, 2019). They are typically applied to specific publications to capture the prevailing trends that have attracted scholarly attention. Bibliometric methods used in the field of neuromarketing have already been applied in the field of user experience (Zaki and Eslam, 2021) and its tools such as eye tracking (Girai et al., 2022; Kalabi et al., 2021; Yen and Chiang, 2021), ERP (Jing et al., 2022); Liu et al., 2021; Zhao and Wang, 2021), EEG (Yu et al., 2022; Khan and Rasoul, 2022; Wajid et al., 2021), MRI (Yen and Chiang, 2021), and recently in artificial intelligence (Vlašić et al., 2021). A similar study has not yet been conducted on ScienceDirect, a well-known website that disseminates first-rate theoretical, empirical, case-based, and interdisciplinary research. We searched ScienceDirect reviews using the keyword "neuromarketing" and paid particular attention to publications on EEG in marketing and consumer behavior studies and captured the research methodology of applying these methods in marketing and consumer

behavior studies. Since bibliometric approaches are activity-oriented, the focus of this type of study is clearly on the impact or discovery of relationships between topics and titles (Ramos, 2004). Since this study aims to uncover research contributions to research topics (Boccaletti, Latura, Moreno, Chavez, & Huang, 2006; Zopik and Cutter, 2015), the use of bibliographic data is appropriate to identify the primary topics and themes and the relationships between them in a network structure. To conduct the bibliometric analysis, the VOSviewer software was used to achieve the objectives of the study, as it provides a network representation of the clustered topics and their interactions. Binary counting of topics was used to form clusters, which allows theidentification of key terms in the dataset as well as the binary relationships between them. The frequency of topics determines the size of each cluster (i.e., more frequent terms form a larger cluster). The number of clusters is determined by the number of themes discovered and their coherence. To achieve the objectives of the study, the articles indexed in the Web of Science for the last ten years (from 2013 to 2022) were examined.

To achieve this goal, a two-step process is used that includes a bibliometric analysis of research articles published in ScienceDirect. This is followed by a systematic review of the literature designed to address the most relevant papers, examine the research techniques used in these studies, and make recommendations for further research. Although "neuromarketing" is the focus of the ScienceDirect study, the bibliometric analysis shows that this is one of the most understudied areas in the context of consumer behavior. Further searches reveal a dearth of studies on consumer behavior and EEG-based purchase decisions. The focus of studies seems to be on "machine learning" and "neural marketing and advertising technologies," while the importance of EEG in online shopping and purchase decisions, especially in the area of brands, has been overlooked.

Electroencephalography has also not been studied in the field of understanding customer behavior in online purchasing, although it has been studied to some extent in detecting people's emotions. Given the importance of neuromarketing, investigating the influence of consumer behavior in electroencephalography laboratory studies is critical to advancing the current state of marketing research in a laboratory setting.

Methods

Systematic literature review

Based on the results of the bibliometric analysis, the systematic literature review used the approach introduced by Tranfield, Denier, and Smart (2003), which was recently applied by Lowe, Papagiannidis, and Amananos (2018), as well as Marikian, Papagiannidis. . . and Amananos (2019) also used to synthesize research contributions on digital tools. According to Tranfield et al. (2003), a systematic literature review consists of three sequential steps, including (1) planning and review, (2) conducting a review, and (3) reporting and publication. During the first phase, one of the authors of this article formed a review panel and developed a review protocol. In line with the bibliometric analysis, the scope of the review of articles published in Science Direct was limited and focused on EEG-related research contributions published in the last 10 years. We conducted a database search using the advanced search function with the provided limitations to find pertinent articles.

We began by utilizing the broad term "neuromarketing" in this search. The articles that match the terms provided in Table 1 were kept after the results of the bibliographic analysis. All papers that had nothing to do with EEG were eliminated, such as those that discussed "artificial intelligence" or "machine learning." In addition to study publications, some sections based on qualitative and quantitative empirical research were also included. Additionally, news, book chapters, and review pieces were eliminated. 355 articles based on the original database search were found. As shown in Figure 1, the search results using the specified criteria were narrowed down to 222 articles, which had 652 items, 49 clusters, and 2365 links. Then,

according to Lu et al. (2018) and Marikyan et al., a grade was given to each detected article (2019). Each article on neuromarketing received a score of 1.

Articles on neuromarketing technologies that take EEG into account were given a score of 2. EEG-related articles had a score of 3. Table 1 shows the classification of articles according to the assigned score.

Bibliometric analysis

We initially searched the Web of Science and considered every publication that had the term "neuromarketing" in its index. Regardless of article type or publication, our evaluations revealed a total of 355 research papers between 2013 and 2023. The articles collected as bibliometric data were retrieved and used in further research. Only keywords were taken from the titles and abstracts and examined using natural language processing methods to provide an overview of the acquired articles as well as the network interactions between them. Then, a binary count of themes was chosen, with the minimum number of iterations of a phrase set to 10. By eliminating review articles (28), scientific book chapters (46), discussions, editorials, practice guidelines, short communications, encyclopedias, journals, conference abstracts, software publications, and book reviews, we restricted the scope of the research and only studied the indexed scientific research articles. Finally, the present research covered 222 scientific research publications. We analyzed each of the findings independently to closely assess the research void in the area of neuromarketing.

The scientific publications were first entered into the VOSviewer program, and the network diagram's output was then acquired. The terms EEG, FMRI, and Eye-Tracking, which are components of neuromarketing technologies, were noted with high intensity and density in the network of scientific papers (222) with the centrality of neuromarketing (Figure 1).

In a more thorough search, the phrase "EEG" was filtered on the network to display more related research fields, to thoroughly study the research areas that emerged from the word "neuromarketing," and to get us closer to the research objective. As Figure 1 displays, scientific research publications with a focus on neuromarketing were organized into 49 clusters. The term "neuromarketing" with an occurrence of 46 and total link strength of 225 is in the top position in this figure, followed by the word "EEG" with an occurrence of 19 and total link strength of 110.

In that sequence, FMRI Neuroscience, Eye Tracking, and Consumer Neuroscience are mentioned. We are doing a series of investigations focused on papers connected to EEG and electroencephalography since the subject of our research is electroencephalography. The EEG cluster was constructed and its associated words were examined in the next stage. It was noted that the papers in this cluster primarily discuss advertising, advertising design, an alcoholic drink (beer), cognitive neuroscience, EEG, expertise, eye tracking, facial expression analysis, gender classification, gender differences, gender attitudes, retention, and storytelling. The electroencephalography cluster is the subject of the following research. This cluster exists in cluster 14 and consists of 19 items such as affective states, augmented reality, brain-computer interface, classification, data leakage, decision fusion, electroencephalography, evaluation, event-related, graph theory, ground truth, industry, instruments, real-time systems, relevance vector machine, signal smoothing, sleep, stress, and wearable systems. Currently, Table 1 contains all of the scientific research publications that include the terms "neuromarketing," "electroencephalography," (Figure1), and "EEG" (Figure2). The research methods used in these papers will be then analyzed. The publications related to neuromarketing and EEG were separated and the remaining articles were set aside for further review (Refer to Table 1).

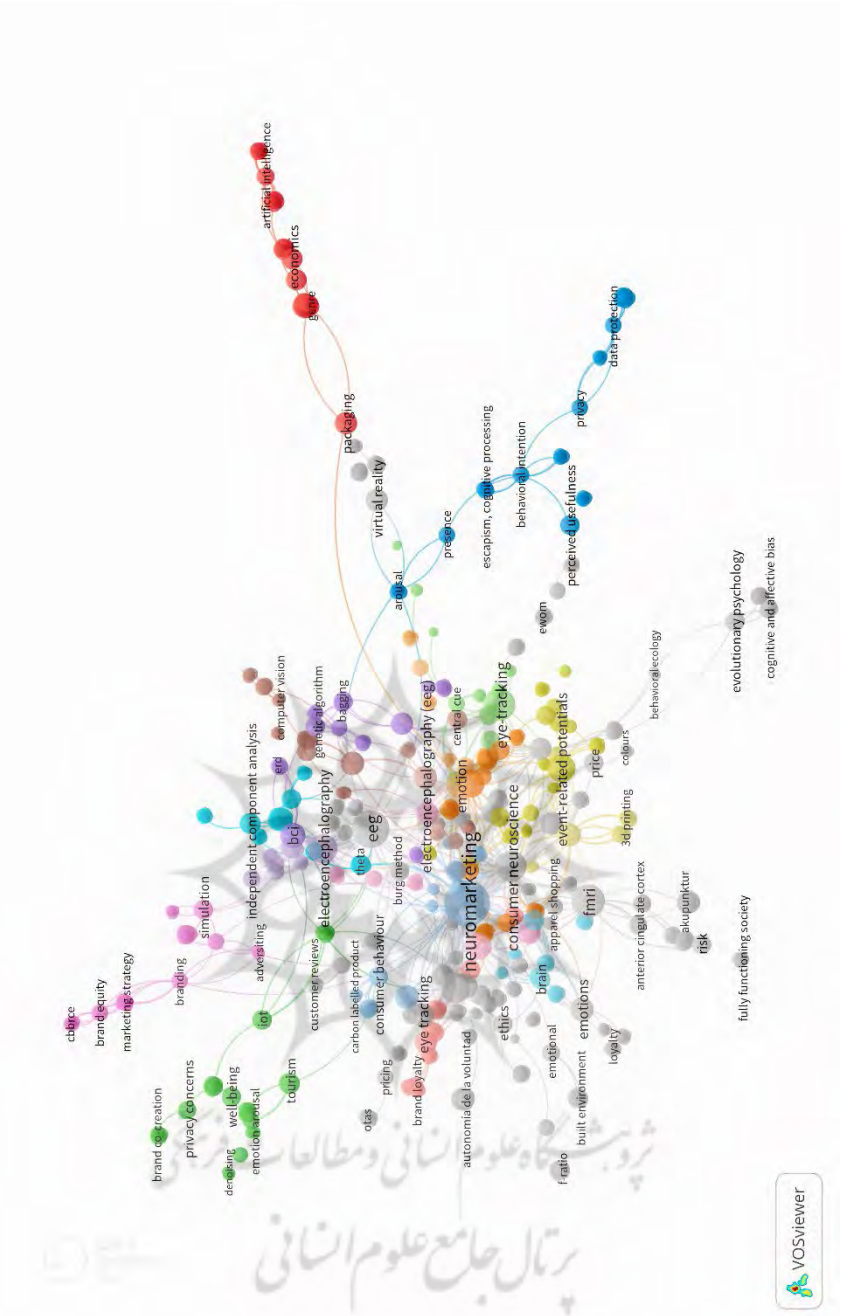

Figure1 .*Network diagram of neuromarketing research articles on the Science Direct site in the VOSviewer software*

Figure 1 represents all articles collected in the field of Neuromarketing. Figure 2 reflects all articles in the field of neural marketing related to EEG. Table 1 shows the articles extracted from the main clusters of VOS Viewer, which include neuromarketing (cluster 12), EEG (cluster 26), and electroencephalography (cluster 14). Also, in this table, the articles were categorized based on the terms and scores to facilitate the review of the articles in the next stages of the research. This table shows the research of the Science Direct website on the main words of the research that have the most relevance.

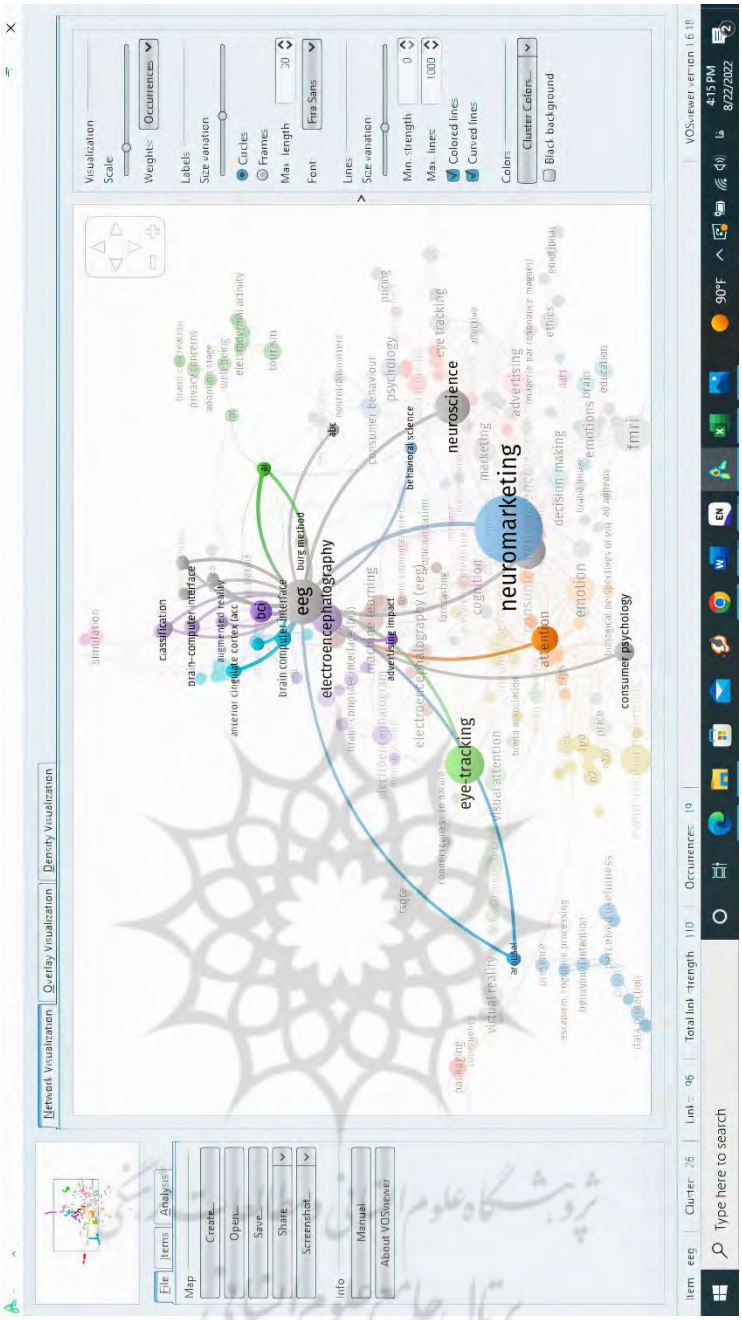

Figure 2. *A cloe-up view of neuromarketing scientific research in the field of EEG*

Table 1.
Themes and their core contributions

Cluster	terms	Target terms	score	Result
Cluster 12	Behavioral science, brain activity, carbon labeled products, carbon labeling, consumer behavior, fNIRS, neuroethics, neuroimaging, neuromarketing, neuromarketing tools, neuroscience, neurotransmitters, non-	**Neuromarketing**	1	(Jing et al, 2022)-(González-Morales, 2020)-(Zhao & Zhong, 2015)-(Benda & Hanová, 2016)-(Meyerding & Mehlhose, 2020)-(Sebastian, 2014)-(Casado-Aranda et al, 2019)-(González-Morales et al, 2020)-(Koc & Boz, 2014)-(Lajante & Ladhari, 2019)-(Boz et al, 2017)

Cluster	terms	Target terms	score	Result
	neuroimaging tech, physiology, psychology, Psychoneurobiochemist research serotonin, system dynamics			
Cluster 14	affective states, augmented reality, brain-computer interface, classification, data leakage, decision fusion, electroencephalography, evaluation, event-related, graph theory, ground truth, industry, instruments, real-time systems, relevance vector machine signal smoothing, ssvep, stress, wearable systems	**Electroencephalography**	2	(Mashrur et al, 2022)-(Hsu, & Chen, 2020)-(Golnar-Nik et al, 2019)-(Artêncio et al, 2022)-(Verhulst et al, 2020)-(González-Morales, 2020)-(Gountas et al, 2019)-(Yen, & Chiang, 2021)-(Gupta et al, 2016)-(Bigne et al, 2021)-(Khan & Rasool, 2022)-(Yılmaz et al, 2014)
Cluster 26	Advertising ، Advertising design ، alcoholic drink (beer), cognitive neuroscience ،EEG ،Expertise ،Eye Tracking،analysis facial expression ، gender classification ، gender diffrences ، gender atitiudes ، retention storytelling	**EEG**	3	(Khushaba et al, 2013)-(Wang, & Hsu, 2014)-(Yılmaz et al,2014)-(Nomura & Mitsukura, 2015)-(Berčík et al, 2016)-(Lee ,2016)-(Gupta et al, 2016)-(Goto et al, 2017)-(Avinash et al, 2018)-(Bastiaansen et al, 2018)-(Folwarczny et al, 2019)-(García-Madariaga et al, 2019)-(Golnar-Nik et al, 2019)-(Gountas et al, 2019)-(Kumar et al, 2019)-(González-Morales, 2020)-(Hsu & Chen, 2020)-(Uhm et al, 2020)-(Mateusz & Kesra, 2020)-(Hakim et al, 2021)-(Niedziela &Ambroze, 2021)-(Wajid et al, 2021)-(Murtazina & Avdeenko, 2021)-(Słupińska et al, 2021)-(Yen & Chiang, 2021)-(Pereira & Oliveira, 2021)-(Artêncio et al, 2022)-(Gorin el, 2022)-(Mashrur et al,2022)

Results

Neuromarketing and its Tools

Researchers understand how consumers process emotional advertising messages, evaluate liking/disliking (approach or avoidance reactions), and measure consumer affect and attitude toward products and services. The study of behavioral changes is covered by the field of neuromarketing, which combines the use of neuroscience and marketing techniques. (Bettiga, Lamberti, & Noci, 2017; Lee, Broderick, & Chamberlain, 2007; Lim, 2018; Jill and Sain, 2022).

Neuroscience techniques are expected to assist elicit relatively more objective information in comparison to conventional research methods like surveys and interviews, which are likely to be relatively more subjective as a result of respondents' reluctance to reveal their preferences and responses to stimuli since the participants are not required to respond actively or consciously using these techniques (Telpaz, Webb and Levy, 2015).

After conducting a systematic review, it found that researchers (like Mashroor et al.,

2022), who introduced an intelligent neural system to predict consumers' future choices from electroencephalography signals, the consumer preferences and predicting his/her behavior in the discussion of neuromarketing were interesting to researchers. FMRI (functional magnetic resonance imaging), EEG (electroencephalography), and ERP (event-related potentials) are only a few of the methodologies and instruments utilized by emerging technologies in the field of neuroscience to examine the brain regions involved in seeing, hearing, or smelling the product. The activity of these regions, such as the nucleus accumbens, insula, and medial prefrontal cortex, provides researchers with a general understanding of how consumers react to different stimuli, allowing them to determine which region of the brain is activated when the test sample sees, hears, or smells the product. A systematic review demonstrated that only a small number of studies have addressed consumer behavior during online shopping and purchase decision-making, particularly in the area of brand exposure.

Effective product presentations in online clothing purchase decisions and brain activity via it were shown in studies examined in the field of FMRI by Jai et al (2021). The use of neuromarketing techniques for reward perception and information value (RIV) has advanced to the point that it is now possible to pinpoint the consumer's brain regions responsible for these two behaviors—engagement, recommendation, and sharing—in social media marketing. Using fMRI, Zhang and Li (2021) found that when consumers are exposed to aesthetically appealing and attractive (vs. unattractive) goods in social media advertising, the first substrate in the brain (i.e., the nucleus accumbens reward-value region) is activated. The informational value region of the prefrontal cortex, which is located in the second substratum of the brain, is stimulated when customers are presented with new (as opposed to used) items via social media advertising. Multiple mental processes have been employed to demonstrate brand equity-related mental processes by investigating the brain areas with FMRI and the BrandMap module.

The strategies used in environmental awareness communications can affect research into the psychological mechanisms that predict behavior. Gomez et al. (2022) discovered the brain areas that are activated during the processing of positive advertisements. Additionally, it examines the processing of elevating commercials in people with high (vs. low) environmental anxiety. Moreover, among those with significant environmental worries, brain activity elicited in reaction to positive advertising corresponds with more critical advertising views. Because fNIRS is portable and enables tests to be conducted outside of the laboratory, it considerably widens the range of applications for neuroimaging techniques and potentially lowers their costs. However, according to Merding and Mehlhus (2020), when it comes to brand exposure, marketers must develop strategic plans to incorporate a variety of consumer mental processes while building brand equity to analyze the role that these mental processes play in building brand equity (Wanatuki and Akama, 2022).

The study of decision-making processes, including attention, attitudes, emotions, and memory, is made possible by advances in neuroscience (Bettiga et al., 2017; Lim, 2018; Plassman, Venkatraman, Hotel, & Yoon, 2015). A similar strategy can be employed for neuromarketing in social networks and user behavior change (reference: Facebook). Neuroscience could potentially offer a way to make intervention techniques more effective. For instance, EEG investigations can track the brain's activity second-by-second in response to message content that causes positive activation and is valuable enough to be captured on video. However, certain parts of the video can be modified or eliminated if the message's substance causes adverse reactions (avoidant brain activity) or inattention. EEG research can thus be used to improve the signals that are used to trigger

long-term memory and the development of a positive attitude (Gordon & Ciorciari, 2017; Gordon, Ciorciari, & van Laer, 2018; Harris, Ciorciari, & Gountas, 2018a, 2018b; Vecchiato, Cherubino, Trettel, & Babiloni, 2013).

Consumers' EEG measurements when deciding between brands or making purchases, particularly when making purchases online or utilizing services, might reveal trends and forecast their behavior. It enables brand placement as well as more targeted product placement on shelves and online for marketers. Our surveys made it quite obvious that this sort of study was both necessary and deficient. Studies in the aforementioned subject can be more thorough and give usability in a variety of sectors, such as website design, brand comparison, leveraging the Internet of Things in marketing, etc. The examination of content and advertising messages is restricted to one sequence. Khan and Sol (2022) employed machine learning algorithms to identify certain personality traits and to express distinct emotions in response to video game stimuli based on data collected from recorded electroencephalography (EEG). Indeed, this method has advanced to the point where it can depict user and customer emotions in video games.

Unique brainwave signals that combine the P3 and the late positive potential (LPP) signal gain intensity with repeated exposures using a novel neuroscience study technique called event-related potentials (ERP). Bilateral temporal areas of the brain show these distinct brain wave patterns within 300 ms in response to involvement with online material. Marketers may soon be able to forecast customers' internet clicking activities using microsecond brain processes that occur nearly concurrently with content exposure thanks to emerging neuromarketing techniques (Zhang et al., 2021). Event-related potentials, or ERPs, are brain reactions that have been employed in a variety of neuromarketing studies as neurological indicators of brand associations. Studying brand-product association traits and their function in brand expansion was made possible by the use of ERPs' N400 component. Finally, in contrast to simply semantic connections, more research employing multichannel EEG or magnetic brain imaging is required to clarify the cerebral roots of brand and marketing associations (Gurin et al., 2022). Studies like those by Ma et al. demonstrate how brand name and categorization familiarity impacts consumers' cognitive processes concerning brand name expansion (2021). This technique has become so ingrained in marketing that it is now influencing how well electronic services are provided in electronic commerce, particularly when neuroscience and service engineering are used in the creation of digital product-service systems (Zhao, 2022). The dynamic character of emotion (such as arousal) during the customer experience may be revealed by neurophysiological measurements like the galvanic skin response, and valence evaluated by neurophysiological techniques (using electroencephalography) is more consistent with the impact seen for satisfaction (Verhulst et al. 2020).

When the study areas were examined, it was discovered that this research had gotten into the field of green marketing, where measurements had been made of how advertisements were formatted and how customers decided whether to purchase green items (Zubair et al., 2020; Jing et al., 2022). From an underlying neuroscience standpoint, Zubair et al (2020) offered stronger proof of how attentional and affective brain responses may affect how a message is framed in the context of green marketing.

Electroencephalography (EEG)

The electrophysiological monitoring technique of electroencephalography (EEG) is used to capture the electrical activity of the brain. Large populations of cortical neurons create meso- and macroscopic neural dynamics, which are reflected in EEG data (Cohen, 2014). Researchers can examine how electrical activity produced by populations of neurons supports or carries out a variety of

cognitive tasks, including emotion, memory, perception, behavioral monitoring/control, and others, using this way of monitoring cognitive electrophysiology. Electrodes are positioned on the scalp as part of this non-invasive monitoring technique. Ionic currents within brain neurons create voltage variations, often known as brain waves, that are measured by EEG. Our brain communicates information and organizes actions in its numerous anatomical areas through electrical impulses. The variations in electrical activity that were observed can be used to detect changes in cognitive functioning. Modern EEG equipment has the maximum temporal resolution of any neuroimaging tool, taking a picture of the brain's electrical activity every 1 to 3 milliseconds. Therefore, EEG is the best approach for examining quick brain events, such as those that take place while watching a television advertisement (Kalaganis et al., 2021). According to the systematic evaluation of the chosen publications, EEG neuromarketing technologies are primarily utilized in the same industry—advertising on various media platforms like television or social media (Yen and Chiang, 2021; Wajid et al., 2021; Gonzalez et al., 2020; Guntas et al., 2019; Glanarnik et al., 2019; Nimura and Mitsukura, 2015).

Since EEG is one of the most popular technologies for neuromarketing studies because it enables scientists to capture brain activity at a pace of cognition that is inextricably connected to certain limits. EEG is not a straightforward technique, despite claims made by several commercials to the contrary. EEG-based measurements may be more difficult to interpret or comprehend than direct behavioral measures like those that track the movements of the eyes or the face. For instance, a hybrid strategy was employed to complete the dimensions of the research in the studies by Yen and Chiang, 2021; Wu et al., 2021; Slopinska et al., 2021; Pereira and Oliveira, 2021; Salehzadeh et al., 2020; Garcia-Madariaga et al., 2019; Fulunsheni et al., 2019; Berchik et al., 2016; Khoshaba et al., 2013. Finally, it should be mentioned that EEG is an appropriate neuroimaging technique for detecting brain activity that comes from deep inside the brain, such as the emotions and memory centers. However, major efforts are being made in this direction by the neuroscience community, particularly in the area of EEG-based emotion identification (Alarcao and Fonseca, 2017). In consumer research, Pereira and Oliveira (2021) discovered that this approach is very practical and helpful for measuring objectives (value and significance), as well as for customer segmentation (cognition-based clustering). Although EEG research alone is insufficient and has several limitations in the realm of neuromarketing, little study has been done on consumer behavior and online buying decision-making. Due to the strength of EEG or electroencephalography word density employed in the investigations, our expectations in this field were greater than simple observations.

Performance Method

In the previous parts, the results of the systematic literature review about the two words Neuromarketing and EEG, as well as the research gap, were stated. After examining these two areas, the EEG research method in neuromarketing was modified and a general guideline about the performance of articles was specified. The performance method of the reviewed articles was standardized according to Table 1. That is, most of the articles followed standard methods in their research method. For example, Electrodes can be either placed directly on the scalp or a cap can be used instead. The international system 10-20 is used to position the electrodes. One electrode to hundreds of sensors may be used to measure brain activity. The voltage of electrical potentials and the frequency (Hz) of oscillations in brain activity are measured using electrodes. The main frequency bands that make up an EEG generally include Δ (0.5–4 Hz), θ (5-7 Hz), α (8–14 Hz), β (15–30 Hz), and γ (30–50 Hz), each of which exhibits a substantially distinct behavioral mode (Ehlert et al., 2006; Sanei and

Chambers, 2007; Banich and Compton, 2011). The frequency bands employed in several studies are listed in Table 2. Contrarily, since it incorporates the spatial and temporal aspects of low-amplitude electrical impulses, the interpretation of electroencephalographic data is extremely difficult, especially when compared to behavioral data. EEG signals can be impacted by both internal (like eye movements) and external (like ambient noise) variables. As a result, they are typically employed with specialized computer software to amplify, filter, and divide into several components. Power spectrum analysis is used in many investigations. Each channel's (electrode's) signal is split into several frequency bands (Table 2). Gamma and delta bands are also included in a thorough examination, in addition to the standard α, β, and θ frequency bands. Therefore, because this type of research must be conducted in a laboratory setting, it necessitates the design of a specific research protocol. These changes in waves and their differences become important in marketing research because they reveal characteristics such as arousal, pleasure, etc. for marketers. As a result, marketers in this field must first develop their procedures for customers who wish to watch a promotional video or make a website purchase. They should then present their procedure to specialists in neuroscience to standardize it. Following these actions, experts design the experiment-related task using the specified procedure.

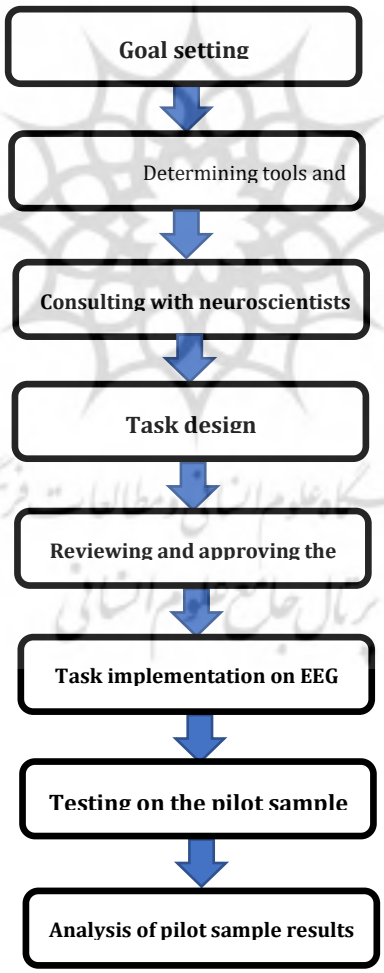

Figure 3. *The steps of the electroencephalography study method*

The inclusion of neuroscience professionals in neuromarketing research is crucial since they have the specific knowledge required for protocol design and data analysis. A neuroscience specialist is required because he possesses the essential knowledge for

calculating the frequency of the EEG device, the range of wave numbers, the duration of passing each task, mounting the EEG cap, and evaluating it. As a result, the protocol design and involvement of neuroscience specialists may be seen as the foundation of neuromarketing research. Due to the possibility of numerous types of brain wave recording devices, it is unclear what frequency each research employs and what number the device's power is set to. The information required to perform this study has been given in the table below from the studies we have evaluated so that marketers may better comprehend it.

The processes of these laboratory procedures often vary depending on the sort of experiment that will be conducted, but by reviewing all of the publications found throughout the systematic review, an overall opinion can be reached (Figure 3). For each created protocol, these procedures could be modified or made more specific, but neuromarketing researchers can still use them as a starting point for their study. Any investigation should start by determining its goal before looking at message content, a retail website, or an online service. The test tool and the specialist laboratory should be chosen after the aim has been established. Usually, this may be accomplished through making use of academic and research institutions. The papers about the subject should be identified to complete the details of your approach once the goal, instruments, and lab type are decided. After choosing the laboratory, specialists, neurologists, and technicians from that facility should be approached to get their input on the proposed experiment's design and the chosen instrument. The task's design for the research is then completed by professionals. The work should be carried out by the technician on the appropriate device following the marketer's observation and permission, and a test sample should then be run to discover any gaps or flaws. However, these tests are not just for this stage; it is also extremely crucial to analyze the outcomes. We recommend that the Payolt sample test findings be studied and reviewed before moving on to the research's main stage and enlisting additional participants. Diagram 1 clearly illustrates the main phases and processes.

Table 2.
Frequencies

	Frequency bands	reference
1	Δ (0.5–4 Hz), θ (5-7 Hz), α (8–14 Hz), β (15–30 Hz), and γ (30–50 Hz),	Ehlert et al., 2006; Sanei and Chambers, 2007; Banich and Compton, 2011
2	Δ (1–4 Hz), θ (4-8 Hz), α (8–12 Hz), β (12–30 Hz), and γ (30< Hz),	Kalaganis et al., 2021

Conclusion and suggestions

The primary subjects and the relationships between them in a journal may be determined with the use of bibliometric tools. As a "basic academic endeavor" (Mulrow, 1994), accompanying thorough literature reviews may appraise major research contributions, identify research gaps, and recommend future research paths (Marikian et al., 2019; Tranfield et al., 2003). The bibliometric technique demonstrates that while electroencephalography is at the core of neuromarketing research interests, little focus has been placed on these topics yet, including website design, consumer physiological responses to brands, and online buying decision-making. There are a few publications that examine customer behavior across numerous websites, including brand exposure and online purchase decisions. It is important to research customers' physiological responses to products and brands, as well as their decision-making processes. These contributions, which focus on EEG applications and examine 26 cluster topics, are reviewed in Section 3.1. Themes from other clusters as well as other technologies, such as neuromarketing tools and EEG technologies, and their roles in analyzing customer behavior, should be examined. It appears that the Internet of Things, advertising, and sporadic consumer behavior study topics are the only ones being explored by researchers in the field of EEG.

Marketing professionals may plan and progress their research in the aforementioned

sectors by looking to brain mapping facilities in academic institutions and talking with specialists in neuroscience and medical engineering. Future studies should investigate the role of EEG in various neuromarketing activities, such as branding, consumer decision-making orientation, and their response, all of which are highlighted in section 4 of the article. These activities involve users in e-marketplaces across international borders. Finally, since the EEG tool is less susceptible to coronavirus than other neuromarketing techniques, marketers' focus on this area is less apparent. These tools are now sold in a variety of brands and models, which has simplified their usage during testing. The lack of consumer behavior research in non-medical disciplines, particularly neuromarketing, is fairly obvious. It is also apparent that little study has been done on customers' physiological responses to products, websites, and applications. Although our focus was on neuromarketing tools, particularly EEG, the combined use of these tools expands the potential for predicting consumer behavior and allows the results of the studies to be applied to a wider range of topics, including website design, product placement, the reasons behind why people make purchases online, and the provision of online services.

Researchers are recommended to use a variety of strategies to accomplish their goals and gain a deeper understanding of consumer behavior in the context of commercial realities.

Also, at the end of the research, a recipe was presented about the EEG performance method in neuromarketing based on the research reviewed so that researchers and marketers can use it as a guide in their research.

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