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NEUROMARKETING: NAVIGATING NEW PERSPECTIVES IN NEUROSCIENCE AND MARKETING SYNTHESIS

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Abstract

In recent years, the field of neuromarketing has attracted considerable attention from both academics and practitioners. Neuromarketing differs from other fields in terms of both the tools and methods used in market research. Therefore, there is a need for literature reviews that focus on studies conducted in this field to acquire insights into the work carried out. This study aims to fill this gap by evaluating the techniques used in neuromarketing studies within the existing literature and presenting research findings to provide researchers a framework for these investigations. Neuromarketing studies, reviewed under headings such as EEG, fMRI, and others, have been explained in detail in terms of research tools, samples, research topics, and findings. In addition, the research approaches and applications adopted in these pertinent studies have been meticulously addressed. Ultimately, this research aims to provide a more comprehensive approach to the current state of neuromarketing studies, thereby contributing to the development of this interdisciplinary field. Additionally, it highlights future research directions in terms of theory, application, and methodology.

Keywords: Neuromarketing, Consumer Behavior, Literature Review, EEG, fMRI.

Jel Codes: M31, M37.

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NÖROPAZARLAMA: SİNİRBİLİM VE PAZARLAMA SENTEZİNDE YENİ PERSPEKTİFLER

Öz

Nöropazarlama alanı son yıllarda akademisyenlerin ve pazarlama uygulayıcılarının büyük ilgisini çekmektedir. Nöropazarlama, pazar araştırmalarında kullanılan diğer araç ve yöntemlerden farklılık göstermektedir. Dolayısıyla bu alanda yapılacak çalışmalara ilişkin olarak bir görüş elde etmek için çeşitli literatür çalışmalarına ihtiyaç duyulmaktadır. Bu çalışma, nöropazarlama çalışmalarında kullanılan teknikleri mevcut literatür bağlamında değerlendirerek ve araştırmacılara bu araştırmalar için bir çerçeve sağlayacak araştırma bulgularını sunarak bu boşluğu doldurmayı amaçlamaktadır. EEG, fMRI ve diğer yöntemler gibi başlıklar altında incelenen nöropazarlama çalışmaları, araştırma araçları, örneklem, araştırma konuları ve bulguları açısından detaylı bir şekilde açıklanmıştır. Ayrıca ilgili çalışmalarda benimsenen araştırma yaklaşımları ve uygulamaları titizlikle ele alınmıştır. Sonuç olarak bu araştırma, nöropazarlama çalışmalarının mevcut durumuna ilişkin olarak daha kapsamlı bir yaklaşım sunmayı ve böylece bu disiplinler arası alanın gelişimine katkıda bulunmayı amaçlamaktadır. Ayrıca teori, uygulama ve metodoloji açısından gelecekteki araştırma perspektiflerini de vurgulamaktadır.

Anahtar Kelimeler: Nöropazarlama, Tüketici Davranışları, Literatür Taraması, EEG, fMRI.

Jel Kodları: M31, M37.

1. INTRODUCTION

Neuromarketing is a rapidly evolving area in marketing (Genco et al., 2014). This area has attracted the attention of both marketing practitioners and marketing academics, and the number of studies has increased in recent years (Hensel et al., 2017). Since the first neuromarketing study by McClure and colleagues in 2004, the number of studies published with the keyword “neuromarketing” in the Web of Science (WOS) Index has increased to 916 by 2024 (McClure et al., 2004). Neuromarketing offers numerous applications in marketing, enabling more detailed research using varied techniques compared to traditional methods (Fortunato et al., 2014). This approach, applied in various areas from website usefulness to purchase intention, primarily aims to model consumer behavior using predictive methods while measuring participants' responses to marketing stimuli (González-Mena et al., 2022; Santos et al., 2016; Yadava et al., 2017). In addition, approaches such as machine learning classification (Chew et al., 2016), event-related potentials (Q. Ma et al., 2008), event-related oscillations (Vecchiato et al., 2011), and indicators related to cortical activity (Ohme et al., 2010) were used in these studies. Neuromarketing research, which has a wide range of applications and indicators, needs to be handled more comprehensively to be understood more

holistically. There are studies that examine the neuromarketing literature (Aldayel et al., 2020; Alsharif et al., 2021; Oliveira & Giraldi, 2017; Yücel, 2016; Zhu et al., 2022). However, these studies have been shown to be limited in scope and do not provide a holistic perspective on neuromarketing.

The aim of this research is to evaluate the studies conducted in the field of neuromarketing in the context of the techniques used and to present a framework to the researchers about these studies. This literature review focuses on the studies included on the Web of Science (WOS) Core Collection Database. Studies using Electroencephalography (EEG) and Functional Magnetic Resonance Imaging (fMRI) techniques have been discussed under different headings, as they are the most commonly used techniques in neuromarketing (Alsharif et al., 2021). In addition, studies using eye tracking and facial coding, as well as mixed approaches, are explained under one heading. Neuromarketing studies, which are discussed under three different headings, are described in detail in the context of research tools, samples, research topics and findings. Furthermore, the general focus of these studies is also discussed. As a result, the purpose of this research is to present a more holistic approach to neuromarketing and to contribute to the development of this interdisciplinary field.

The rest of this paper is organized as follows: Section 2 describes the neuromarketing concept, briefly explains neuromarketing methods, and focuses on neuromarketing literature. Section 3 outlines conclusions and offers suggestions for future research.

2. LITERATURE REVIEW

2.1. Neuromarketing Concept

In recent years, neuroscience has begun to provide deeper insights into social practices and intellectual discourses. The growing knowledge has influenced various fields and has gradually paved the way for the emergence of new interdisciplinary studies (such as neuroaesthetics, neurotechnology, and neuropedagogy). Neuromarketing, one of these fields known as neuroculture, has gained popularity by attracting attention (Fischer et al., 2010). The term "neuromarketing" was coined in 2002 by the Bright House company in reference to fMRI studies. Similarly, in the same year, Professor Ale Smitds from Erasmus University in Rotterdam introduced neuromarketing, referring to the application of neuroimaging techniques in marketing research. After that, the neuromarketing study by McClure and colleagues (2004) became a turning point, and the number of studies conducted to date has increased significantly.

Neuromarketing is an interdisciplinary field that integrates neuroscience, psychology and marketing science (Grajdieru, 2017). The interaction of marketing and neuroscience has elucidated the impact of brands, products, advertisements, or purchase decisions on the brain and behavior. Concurrently, the convergence of marketing and psychology has clarified the underlying motives driving purchasing behavior. Consequently, the synergy among these three areas provides a holistic comprehension of consumer behavior (Mansor & Isa, 2020).

Although it is a new discipline, the term "neuromarketing" has numerous definitions. Lee et al. (2007:200) defined it as “the application of neuroscientific methods to analyze and understand human behavior in relation to markets and marketing exchanges”. Morin (2011) described it as “an emerging field that bridges the study of consumer behavior with neuroscience.” In another definition, neuromarketing is described as the area of science investigating the brain and neural responses to stimuli related to market change (Zurawicki, 2010). The themes commonly used in these definitions are “consumer behavior with neuroscience,” “neural responses to stimuli related to market changes,” “application of neuroscience methods”. In short, neuromarketing can be conceptualized as measuring the neural or physiological effects of marketing stimuli with neuroscience methods.

The main purpose of neuromarketing is to evaluate the consumer's cognitive and emotional responses using various marketing techniques. So, the basic idea of neuromarketing is to examine consumer behavior from a cognitive or emotional perspective (Solomon, 2018). In this regard, it offers a wide range of research on how consumer mechanisms related to emotions, memory, attention, and cognitive processes work and which factors are influenced by them (Mansor & Isa, 2020; Sebastian, 2014). Consequently, the neurological context allows for a more comprehensive investigation of consumer reactions to written, visual, or auditory stimuli. Neuromarketing focuses on the neural mechanisms underlying consumer behavior in relation to branding, pricing, advertising, purchasing decisions, and decision-making psychology (Sung et al., 2019).

So far, marketers have gained some insights by applying various traditional approaches. These approaches provided limited information about customer behavior. On the other hand, they provided unreliable information as they relied on consumers' self-reports. Therefore, focus groups, surveys and interviews are not always suitable for measuring the conscious and subconscious processes of customers (Alsharif et al., 2021). Neuromarketing uses neuroscientific methods to overcome the disadvantages of traditional methods, which are judgmental and manipulative (Avinash et al., 2018). Compared to traditional methods,

neuromarketing claims to provide more comprehensive and less biased marketing insights (Fortunato et al., 2014).

Although neuromarketing offers numerous advantages for researchers, it has certain limitations and challenges. Neuromarketing's primary advantages are evaluating customers' unconscious processes, examining cognitive processes, and interpreting emotional processes. (Akan & Atalık, 2024; Boshoff, 2012; Ramsøy et al., 2019). Additionally, one prominent concern is the issue of small sample sizes, typically averaging around 20-30 participants in many studies. (Sung et al., 2019). This raises doubts about the reliability and applicability of the results and highlights the need to expand the scope of research for improved reliability testing (Fortunato et al., 2014). Another challenge in neuromarketing is the concept of reverse inference. Adverse inferences should be used with caution in studies. If a certain brain region is not regularly activated by certain mental processes of interest, a reverse inference becomes problematic (Sung et al., 2019). Costs, on the other hand, are an issue that should not be neglected. The techniques used are often expensive, and costs escalate with an increased number of participants in experiments (Kenning & Linzmajer, 2011). After all, ethics is one of the most important factors in neuromarketing. Despite the fact that there are now numerous neuromarketing research and consulting organizations and a significant number of scientifically published studies, criticism of neuromarketing has not diminished (Stanton et al., 2017). Some of the most common criticisms of neuromarketing include unethical research practices, unethical use of technology, and consumer manipulation. Although there are certain ethical concerns about neuromarketing, it is claimed that these issues can be avoided with certain practices and regulations.

Although neuromarketing has limitations and ethical issues, it is expected that in due course, this field will reach the desired level. This discipline will enable the development of products and services based on actual consumer desires and needs by providing important insights into consumer attitudes and behaviors (Ariely & Berns, 2010). Additionally, it is expected to provide a number of benefits for implementing smarter marketing strategies by increasing the effectiveness of marketing efforts (Agarwal & Dutta, 2015; Mansor & Isa, 2020).

2.2. Neuromarketing Methods

Neuroscience provides insights into the functioning of the nervous system using various neuroimaging tools, and neuromarketing also benefits from these tools (Ariely & Berns, 2010; Fortunato et al., 2014). These tools can be used to measure hormonal and neurotransmitter

changes, skin electrical conductivity through sweating, eye movements, electrical waves from muscle movement, brain metabolism, and functional activity of specific brain regions (Fortunato et al., 2014). These measurements use techniques that assess both brain activity and external activity. Functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS), positron emission tomography (PET), EEG, magnetoencephalography (MEG), transcranial magnetic stimulation (TMS), and stationary topography (SST) are among the techniques used to measure brain activity. Facial electromyography (fEMG), facial coding (FC), eye tracking (ET), electrodermal activity (EDA), and heart rate (HR) are techniques for measuring activity outside the brain (Bercea, 2011; Cherubino et al., 2019; Lim, 2018; Yücel, 2016). To better understand these tools, an overall assessment is required (Kenning & Linzmajer, 2011). The methods referred to in the study as "other methods" are briefly described below.

MEG is sensitive to changes in magnetic fields caused by the brain's electrical activity. This technique is similar to EEG but differs in terms of temporal and spatial resolution (Kenning & Linzmajer, 2011). MEG provides reliable and valid results for cognitive and sensory reactions. It also has high temporal resolution. However, it is rarely preferred due to high installation costs and complex analysis processes (Nyoni & Bonga, 2017).

fNIRS measures changes in neural activity within the brain (Herold et al., 2018). More specifically, fNIRS is a neuroimaging method that measures cortical blood flow (Sung et al., 2019). This technique maps blood oxygenation in brain regions during neural activity (Meyerding & Mehlhose, 2020). Notably, it offers significant advantages in terms of portability, low cost, and high spatial resolution (Herold et al., 2018).

PET is a nuclear medicine imaging technique that measures metabolic activity in the body. Similar to fMRI, this technique requires the injection of a radioactive substance into the body (Singh, 2020). While PET offers reliable measurements of cognitive and emotional responses, ethical concerns arise due to its invasive nature (Klinčeková, 2014).

TMS is a technique that stimulates the brain by sending electromagnetic impulses to the skull and reveals brain activities (Kenning & Linzmajer, 2011). It is preferred in marketing for advertising, new product and package design studies (Nyoni & Bonga, 2017). The fundamental advantage of TMS is that it can identify in which part of the brain a particular cognitive function is taking place (Antoniak, 2020).

SST essentially measures the electrical activities of the human brain (Marcuta et al., 2018).It unveils the steady-state evoked potential via a weak vibration signal positioned at the edge of the visual field in addition to the electrical activities of the brain (Genco et al., 2014). This technique offers high temporal resolution and also has high artifact resistance (Hilderbrand, 2016).

fEMG measures the facial muscles' response to marketing stimuli. This technique provides a very effective measurement method by recording the electrical responses that occur as a result of facial muscle contraction using electrodes placed on the mouth (zygomaticus minor and major), occipitofrontal and orbicularis muscles (Fortunato et al., 2014). Additionally, fEMG measures sensory alterations such as taste and smell, along with emotional changes (Fortunato et al., 2014; Solomon, 2018).

FC operates on the principle of utilizing computer programs to decode facial expressions, yielding specific outcomes (Zurawicki, 2010). Developed with substantial input from Paul Ekman, the facial coding system is capable of identifying emotions like anger, disgust, fear, happiness, sadness, and surprise in consumers (Ekman & Rosenberg, 2005). Images captured by a camera can be analyzed through machine learning techniques to determine the potential emotional responses to relevant marketing stimuli.

ET is an eye movement-based system that provides emotional or cognitive cues (Chandrasekharan et al., 2023). This technique reveals where the eye is looking, how the eye moves relative to the head, and how the pupil dilates and contracts in response to a stimulus. When combined with other methods, it usually contributes to more reliable results. Due to its portability, easy data analysis and low cost, ET is one step ahead of the others (Zurawicki, 2010).

EDA, also known as galvanic skin response (GSR) or electrodermal response, measures skin conductivity (Verhulst et al., 2019). EDA is based on the principle of measuring electrical activities that occur as a result of the responses of sweat glands in human skin to various psychological conditions (Sung et al., 2019). Easy to use and relatively inexpensive, EDA is a very popular method for investigating psychophysiological phenomena.

HR is a technique that uses an electrocardiogram to measure the heart's electrical activity through skin electrodes. HR is often used as a measure of arousal. A decrease in heart rate is associated with focus and attention to a stimulus (Sung et al., 2019). As a result, this

technique assesses consumers' responses to sensory stimuli, as well as their attentional state (Boz et al., 2017).

2.3. EEG Method and Studies

EEG, considered the oldest neurophysiological tool, has been used for over a century. This technique measures voltage fluctuations on the scalp and records the electrical potentials generated by neurons through electrodes placed on the scalp. By recording changes in these neuronal potentials, EEG observes the electrical activity resulting from the connections between neurons responsible for cognitive responses. This provides valuable marketing insights (Morin, 2011). EEG is one of the most commercially preferred techniques by academics and marketing practitioners because it is more cost-effective than fMRI and does not require a complex experimental environment like MEG (Alsharif et al., 2020). The greatest advantage of this technique is its high temporal resolution, so it is able to record voltage changes in the brain in milliseconds (Özkara, 2017). Additionally, its non-invasiveness and relative affordability contribute to its popularity. EEG finds applications across various domains, from product and price promotion to brand analysis. It is commonly used to investigate cognitive, emotional, recalling, recognition, attention, arousal, engagement, approach, and withdrawal processes (Nyoni & Bonga, 2017). Table 1 lists some of these studies.

Table 1. Studies with the EEG Method

Authors	Sample	Research Topic	Research Findings
(Q. Ma et al., 2008)	16	Brand extension	The P300 potential can be used as a success metric in a brand extension strategy.
(Handy et al., 2010)	32	Brand logo	The central/parietal/occipital P2 and central N2 components (200-400 msec. time window) have been found to have a significant effect on hedonic evaluation.
(Ohme et al., 2010)	45	Advertising	Different frontal asymmetry measurements have been derived from the emotional and informational parts of the advertisements.
(Vecchiato et al., 2011)	11	Advertising	Liked advertising has increased theta and alpha activity in the left frontal area.
(J.Jones et al., 2012)	39	Purchase behavior	LPC differs in purchasing behavior between individuals with low and high math anxiety.

(Pozharlıev et al., 2015)	40	Purchase behavior	Shopping with others has increased the emotional impact of luxury brands and has created more late-positive potential (LPP).
(Boksem & Smidts, 2015)	29	Customer future choice	Beta and gamma oscillations predict individual choice behaviors.
(Flumeri et al., 2016)	24	Product feature	The scent of mint and rose has been shown to increase consumer's approach motivation.
(Berčík et al., 2016)	67	Store ambiance	The LED lighting and purple color scheme have been found to evoke more positive emotions in participants than the other options.
(Hoefer et al., 2016)	24	Product Perception	Different fabrics, such as jersey, cotton, and custom, have led to varying emotional valence scores.
(Chew et al., 2016)	5	Choice prediction	Using EEG data, consumers' product choices have been predicted with a classification accuracy of close to 80%.
(Jin et al., 2017)	18	Price framing effect	Positive framing has been associated with high LPP potential and a willingness to buy.
(Yadava et al., 2017)	40	Choice prediction	It has been proposed that EEG data can be used to predict product choices.
(Touchette & Lee, 2017)	34	Product attractiveness	Attractive products increase frontal alpha asymmetry. No correlation has been found between the survey and EEG results.
(H. Ma et al., 2018)	33	Price framing effect	Free promotional products increase LPP and enhance consumer motivation.
(Shang et al., 2018)	20	Copycat branding	In copycat branding, the N400 potential can be used for categorization and the late positive component (LPC) potential for recall.
(Cheng & Wang, 2018)	16	Country of origin brand	When the country of origin was compatible with the brand logo, the LPP increased and the N2 potential decreased.
(Q. Ma et al., 2019)	26	Price perception	P2, P300 and LPP can be used to examine the impact of emotions on price value perception.
(Fu et al., 2019)	18	Price deception	Customers with price knowledge receiving fair prices show lower N2 and higher LPP.
(Camarrone & Hulle, 2019)	28	Brand association	When the brand and brand associations were incompatible, the N400 potential increased.
(Alvino et al.,	26	Product choice	Most preferred wines exhibited low beta wave oscillation, while

2019)			the least preferred wines showed high beta wave oscillation
(Hsu & Chen, 2020a)	40	Product tasting	Alpha, beta and gamma waves can be used to measure the impact of music on product tasting.
(Hsu & Chen, 2020b)	16	Advertising	Subliminal messages increased theta band activity while decreasing beta band activity.
(Wang et al., 2022)	95	Price	Mobile payment usage induces the "pleasure of paying," which, along with the "pain of paying," mediates increased purchase intention.
(Mashrur et al., 2022)	15	Customer future choice	The frontal cortex and Fz channel have provided the best accuracy for categorizing positive and negative affective attitudes.
(Q. Ma et al., 2022)	38	Purchase behavior	Pain interferes with early stage reward feedback valence detection and reduces motivation salience in the late stage.
(Oikonomou et al., 2023)	33	Choice prediction	The algorithm demonstrates an improvement of over 8% in classification accuracy compared to existing methods for emotional and cognitive state recognition tasks
(Hakim et al., 2023)	213	Willingness to pay	The DLN model achieved an accuracy rate of 75.09%, surpassing other models in predicting high and low WTP
(Hassani et al., 2023)	20	Choice prediction	Significant improvements in classification accuracy were observed for different genders through the use of specific frequency bands, while differences in decision-making times during visual assessments based on gender were evident.

There are numerous EEG-based neuromarketing studies in the literature. These studies focus on purchase behavior, predictions, products, prices, brands and advertising topics. Studies on purchase behavior examine the effects of differentiating consumer personality traits and product characteristics (Flumeri et al., 2016; Q. Ma et al., 2022). Furthermore, changes in late potentials at the time of purchase were also assessed (J.Jones et al., 2012; Pozharlıev et al., 2015). Predictive studies primarily aim at estimating consumer preferences and suggest the use of beta and gamma oscillations for product prediction (Boksem & Smidts, 2015). Product selection is predicted with over 80% accuracy (Chew et al., 2016; Hassani et al., 2023; Oikonomou et al., 2023). Oscillations and asymmetry metrics have been used in product studies to explain the effects of scent (Flumeri et al., 2016), music (Hsu & Chen, 2020a), and product characteristics (Hoefer et al., 2016) on consumer behavior. Alpha, beta and gamma oscillations, as well as frontal alpha asymmetry, were prominent in these studies. The effect of

price changes is observed in price studies. These studies mainly focus on the potential of N2, P200, P300 and LPP[3] (Fu et al., 2019; Jin et al., 2017; H. Ma et al., 2018; Q. Ma et al., 2019). Brand studies cover a range of topics, from country of origin to brand extension. In these studies, the effectiveness and success of brand strategies were evaluated based on their various potentials. In general, P200, P300, N400 and LPP have been used to guide brand studies (Camarrone & Hulle, 2019; Cheng & Wang, 2018; Q. Ma et al., 2008). Advertising studies examined the effects of advertising qualities on brain activities. In this direction, the effects of subliminal messages on brain waves (Hsu & Chen, 2020b), the frontal changes caused by popular advertising (Vecchiato et al., 2011), and the effects of advertising qualities on approach motivation (Ohme et al., 2010) were discussed.

2.4. fMRI Method and Studies

fMRI, like the EEG technique, is widely used in neuromarketing studies (Alvino, 2020). fMRI measures blood flow in the consumer's brain using a powerful magnetic field and radio waves (Alsharif et al., 2020). This technique allows the visualization of blood flow in the brain in three dimensions (Ariely & Berns, 2010). In this way, the regions in the brain activated by stimuli such as advertising, sounds and brands can be determined with high-resolution images (Alsharif et al., 2020) (Table 2). Its primary advantage is its high spatial resolution, which allows for measuring changes in the deepest areas of the brain (Ariely & Berns, 2010). Therefore, it offers highly precise measurements of cognitive and emotional processes. However, the fMRI technique has significant disadvantages, including high setup costs per participant. Additionally, its complex data processing and the requirement for skilled technicians have limited its widespread application (Nyoni & Bonga, 2017; Sebastian, 2014).

Table 2. Studies with the fMRI Method

Authors	Sample	Research Topic	Research Result
(McClure et al., 2004)	67	Brand perception	The vmPFC has a crucial role in behavioral preferences.
(Knutson et al., 2005)	14	Negative price effect	It has been suggested that the nucleus accumbens is associated with product preferences, the insula region with

[3] The related signs express the potentials of the measurements of the stimuli in milliseconds as positive or negative (Özkara, 2017). These potentials are electrical potentials associated with specific events (De Pascalis, 2004).

			excessive prices, and the mPFC with discounted prices.
(Deppe et al., 2005)	22	Brand perception	Favorite brands increase activity in the dlPFC, posterior parietal cortex, occipital cortex, and vmPFC.
(Schaefer et al., 2006)	13	Brand perception	Culturally familiar brands activate the mPFC more than unfamiliar brands.
(Yoon et al., 2006)	20	Brand personality	Personality characteristics are processed in the mPFC, while brand personality is processed in the lower left prefrontal cortex.
(Plassmann, O'Doherty, et al., 2007)	19	Willingness to pay	Activities in the mOFC and dlPFC are associated with willingness to pay.
(Plassmann, Kenning, et al., 2007)	22	Brand loyalty	Through activation of the vmPFC, loyal customers more intensely integrate their emotions into the decision-making process, and favorite brands stimulate their reward system.
(Erk et al., 2007)	12	Product perception	Artificial cultural objects associated with wealth and social dominance activate reward-related brain areas.
(Plassmann et al., 2008)	20	Price perception	Increasing wine prices increases subjective reports of flavor pleasantness and also blood-oxygen-level-dependent activity in the medial orbitofrontal cortex (mOFC), which is widely thought to encode for experienced pleasantness.
(Kenning et al., 2009)	22	Advertising effectiveness	Attractive advertisements have been shown to activate brain areas associated with emotion integration (ventromedial prefrontal cortex (vmPFC) and reward perception (ventral striatum/nucleus accumbens).
(Reimann et al., 2010)	16	Packaging design	Aesthetics of product packaging have been found to activate the reward center.
(Reimann et al., 2012)	17	Brand perception	The choice of novel brands is preceded by greater activity of both the cingulate gyrus and the vmPFC (as compared to the choice of familiar brands).
(Falk et al., 2012)	31	Advertising	The effectiveness of public service announcements was predicted by neural activity in the mPFC.
(Berns & Moore, 2012)	32	Sales forecasting	It has been suggested that activity in the ventral striatum can be used to predict product sales.
(Hubert et al., 2013)	22	Packaging design	Attractive packages activate reward-related areas, whereas unattractive packages activate negative emotion-related

			regions.
(Hillenbrand et al., 2013)	25	Brand perception	Brand names hint at the key benefits of the underlying product, influencing customer choice positively.
(Bruce, Crespi, et al., 2014)	50	Price perception	When too much information about the product is presented, an activity is observed in the dorsolateral prefrontal cortex (dlPFC) region, which is associated with uncertainty.
(Jai et al., 2014)	12	Online shopping	Zooming in on an online product display increases visual perception throughout the product evaluation phase, whereas rotating pictures create pleasure and reward expectations.
(Bruce, Bruce, et al., 2014)	17	Brand perception	Brands with familiar logos activate the orbitofrontal and inferior prefrontal cortex, whereas brands without logos activate the posterior cingulate cortex (PCC).
(Santos et al., 2016)	25	Brand perception	Purchase intention is higher for higher-priced national brands and lower-priced own brands.
(Al-Kwifi, 2016)	13	Brand perception	Images reflecting the perceived usefulness of the brand have more vmPFC activity.
(Fehse et al., 2017)	18	Brand perception	Organic brands activate the dlPFC while popular brands activate the mPFC.
(Karmarkar et al., 2019)	24	Price perception	Early price exposure, or "price primacy," alters the valuation process, as seen by altered patterns of activity in the medial prefrontal cortex (mPFC) just before making a purchase decision.
(Medina et al., 2020)	18	Price perception	When evaluating price information, non-prosocial (compared to prosocial) consumers exhibit greater activation in brain areas involved with reward, valuation, and choice.
(Gómez-Carmona et al., 2022)	50	Advertising	In environmental advertisements, positive appeals increase vmPFC activity in concerned subjects, and the insula is more active in highly concerned subjects.

Numerous studies in the literature use the fMRI technique and focus particularly on packaging design, price perception, advertising and branding issues. Brand studies often revolve around measuring brand perceptions and identifying the activated brain regions associated with brands of different qualities. For instance, studies have indicated that favorite brands activate regions like the dorsolateral prefrontal, posterior parietal, occipital, and ventromedial

prefrontal cortex (Deppe et al., 2005; Plassmann, Kenning, et al., 2007). Conversely, familiar brands tend to activate the medial prefrontal, orbitofrontal, and inferior prefrontal cortex[4] (Reimann et al., 2012; Schaefer et al., 2006). Additionally, organic brands have been found to activate the dorsolateral prefrontal cortex (Fehse et al., 2017). Furthermore, specific issues such as brand personality are handled (Yoon et al., 2006). Research on package design indicates that packages described as aesthetically pleasing and attractive activate the pleasure-related reward center (Hubert et al., 2013). In advertising studies, advertisements that are considered attractive have increased vmPFC activity (Gómez-Carmona et al., 2022). It has been argued that the medial prefrontal region is an important reference area in determining advertising effectiveness (Falk et al., 2012). Studies on pricing have demonstrated that changes in price or context affect brain activity and have significant managerial implications. The mOFC and dıPFC are associated with willingness to pay (Bruce, Crespi, et al., 2014; Plassmann, O'Doherty, et al., 2007), while the insula region has been associated with the perception of excessive pricing (Knutson et al., 2005).

2.5. Other Methods

Although fMRI and EEG techniques are commonly used in neuromarketing studies, other techniques are also preferred. Both neuronal and physiological activities were measured using these techniques (Table 3). These techniques have been used in neuromarketing studies both alone and in combination with other neuromarketing techniques. Among these techniques, the ET technique was observed to be prominent. Although ET is a physiological measurement technique used alone in many studies, it is most commonly used in combination with the EEG technique. Furthermore, it has been observed to be used in combination with FC, GSR, fMRI, and EDA techniques. Besides ET, FC, fEMG, HR, and fNIRS techniques are rarely used alone. They are often used in combination with other techniques to improve the accuracy of results.

Table 3. Study with Other Methods

Authors	Techniques	Sample	Research Findings
(Vecchiato et al., 2010)	HR, GSR, EEG	15	There was increased theta band activity in the left frontal region and increased HR activity while watching ads that

[4] The different regions of the brain are responsible for various cognitive and emotional functions such as executive functions, spatial awareness and visual processing.

			were remembered later.
(Khushaba et al., 2013)	ET-EEG	18	Cortical activity changes depending on the product's shape, flavor, and topping, and the flavor and topping forms have an impact on consumers' purchasing decisions.
(Somervuori & Ravaja, 2013)	fEMG	33	Compared with high prices and private-label products, low prices and national-brand products evoke more positive emotions.
(Hernández-Méndez & Muñoz-Leiva, 2015)	ET	30	It has been observed that the first focus on websites is static ads, while they are more focused on text ads.
(Venkatraman et al., 2015)	ET, fMRI, EEG	186	It has been emphasized that the fMRI technique is the most accurate way to predict the success of advertisements, and activities in the ventral striatum are associated with advertising success.
(Cherubino et al., 2016)	EEG,GSR, HR	24	It has been proposed that age and gender differences in advertising perception can be measured using cerebral and emotional indices developed using EEG, GSR, and HR techniques.
(Boz et al., 2017)	ET	-	Consumers are much more interested in the discount rate than in price reductions. Discount and reduced price labels should be placed at the center of the visual promotion.
(Hamelin et al., 2017)	FC	60	Emotions influence cognitive processes, and emotional advertisements have a significant impact on advertising effectiveness.
(Muñoz-Leiva et al., 2019)	ET	60	The use of celebrities in banner ads attracts the attention of website visitors.
(García-Madariaga et al., 2019)	EEG- ET	40	It has been observed that visual elements on the packaging increase the participants' attention levels, while color changes have no significant impact.
(Qing et al., 2020)	fNIRS	8	Short (15-30 sec.) and non-linear advertisements are more persuasive than other types of advertisements.
(Garczarek et al., 2021)	EEG, ET, EDA	24	EDA has been identified as a parameter that can be used to predict purchasing behavior.
(Rúa-Hidalgo et al., 2021)	ET, FC, GSR	30	In social media, the explicit measure of emotional valence is higher and more positive than the implicit measure.

(Zamith et al., 2021)	ET, GSR	60	In-feed native advertising attracts more attention than content recommendation advertisements.
(Levrini & Santos, 2021)	FC-ET	80	New variables influence the unconscious choices and purchasing decisions of consumers.
(Flores et al., 2022)	ET	--	The placement of certain elements in advertisements is strategic, and brands must be simple, communicative, legible, and capture users' attention
(Pelau et al., 2022)	ET	24	In a food advertisement, celebrities have drawn more attention than the brand logo and product.
(Herrando et al., 2022)	HR	10	Flow experience, which influences purchase intention, is associated with pleasure and concentration, whereas a low level is associated with boredom.
(Chiang et al., 2022)	ET, EEG, FC	80	The differences in working memory capacity, processing speed, and visual processing between the elderly and the young influence purchasing behavior.
(Šola et al., 2022)	ET, FC	168	The BIO label is an important part of the BIO packaging and should be visually highlighted on the packaging, reflecting earthy-color tones.
(González-Mena et al., 2022)	ET, FC	39	The new dynamic website increases the following emotions: joy, anger, surprise, disgust, fear, and neutral.
(Savelli et al., 2022)	EEG, ET	60	People's visual attention and cognitive engagement are more influenced by social and emotional factors.
(Mas et al., 2023)	EEG, EDA, CAS	30	Latin American cultures have exhibited a significantly higher emotional response to fear communication compared to those from European cultures
(Mancini et al., 2023)	ET, FC	175	The presence of non-ad elements within YouTube's advertising format resulted in lower performance in measures such as facial disgust, self-reported disgust, ad irritation, and ad attitude.
(Šola et al., 2023)	ET, FC	529	Analyzed participant behavior on the homepage revealed stronger negative emotions during scrolling, while viewing regions with subdued colors in photos or brighter colors emphasizing essential text increased the pleasant mood moderately.

ET is a major neuromarketing technique that researchers favor, although not as much as EEG and fMRI. ET has been used in various contexts, from advertising to pricing. Studies have shown that the inclusion of celebrities in advertising enhances its effectiveness (Muñoz-Leiva et al., 2019; Pelau et al., 2022). Moreover, static and straightforward ads tend to garner more attention compared to other advertising formats (Flores et al., 2022; Hernández-Méndez & Muñoz-Leiva, 2015). Additionally, ET is considered pivotal in guiding ad placement strategies (Flores et al., 2022). ET also complements other methods and provides valuable insights, particularly regarding attention (García-Madariaga et al., 2019; Savelli et al., 2022) and visual processing (Chiang et al., 2022). Therefore, it is frequently used in conjunction with techniques such as EEG, FC, and fMRI.

HR, FC, and fEMG techniques have rarely been used alone in neuromarketing studies. FC, HR and fEMG studies have focused on emotional processes rather than cognitive processes (Hamelin et al., 2017; Herrando et al., 2022; Somervuori & Ravaja, 2013). They were preferred to better explain the emotional processing processes.

3. CONCLUSION

This study examined neuromarketing articles indexed in WOS. A total of 79 research articles were assessed, categorized under three main headings: EEG, fMRI and other techniques. This study aims to provide researchers with a new perspective on neuromarketing studies and presents useful research results by stating the research topics. Additionally, the study identified fundamental themes within the studies conducted using the respective techniques, outlining the broader potential of neuromarketing methodologies. The study is intended to serve as a guide for researchers conducting marketing research and to provide new perspectives. The literature review presents significant implications beneficial for researchers.

Firstly, while EEG and fMRI techniques are generally preferred in studies, there is an observed tendency to combine them with other techniques. Combining different methods is crucial for a more comprehensive understanding and prediction of consumer behavior. According to Zhu et al. (2022), the use of multiple neuroscience tools and methods is expected to be a future trend in neuromarketing. Additionally, they suggest that hybrid approaches, incorporating traditional methods, will play a prominent role in upcoming neuromarketing studies.

Secondly, although the studies covered a wide range of marketing topics, certain issues stood out prominently: product, brand, price, and advertisement. Significantly, these studies

produced remarkable research results. Within these investigations, neural connections associated with value perceptions induced by marketing stimuli were identified. Additionally, the studies examined the effects of different environments, such as stores or websites (Berčík et al., 2016; González-Mena et al., 2022; Hernández-Méndez & Muñoz-Leiva, 2015). Moreover, they revealed the cognitive and emotional processing mechanisms triggered by marketing stimuli (Pozharlıev et al., 2015; Savelli et al., 2022). On another note, researchers also examined neural or physiological differences resulting from variations in product or consumer properties (Fu et al., 2019; Hoefer et al., 2016; Yoon et al., 2006). Furthermore, there was a specific focus on predicting consumer behavior (Mashrur et al., 2022; Oikonomou et al., 2023).

Thirdly, various neuromarketing techniques have guided the exploration of the elusive 'secrets' embedded within the human brain. In this regard, neuromarketing has provided valuable insights into topics that cannot be measured using traditional methods. Various applications have emerged, ranging from the effect of subliminal messages to the monitoring of subconscious potential (Hsu & Chen, 2020b). Neuromarketing has also been shown to produce effective results in this area.

Fourthly, the frontal cortex of the brain is the most important area for understanding consumer behavior. Both EEG and fMRI studies have generally explained consumer behavior with activities in this area (Karmarkar et al., 2019; Kenning & Linzmajer, 2011; Vecchiato et al., 2011). Cognitive, emotional and subconscious processing processes are explained by the changes that occur in this area. Besides the frontal cortex, important organs such as the face and eyes also provide important information about consumer behavior.

There are several suggestions for future studies. First, there are few studies on distribution, which is one of the important elements of the 4Ps. Studies that focus on distribution can provide valuable insights. Secondly, there is a need to categorize neuromarketing studies into a systematic classification scheme. Such a categorization would serve as a helpful reference for researchers studying or interested in neuromarketing. Third, there are concerns about the generalizability and scalability of the neuromarketing results. This requires further studies in the field of neuromarketing. Consequently, the researcher hopes that these suggestions will prove beneficial for future research endeavors.

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