MAKÜ | Journal of Mehmet Akif Ersoy University
Economics and Administrative Sciences Faculty

e-ISSN: 2149-1658
Volume: 11 / Issue: 3
September, 2024
pp.: 980-1010

Comparison of Studies Conducted in the Field of Neuromarketing and Artificial Intelligence Using Bibliometric Method

Abdullah BALLI[1]

Abstract

Neuromarketing research focuses on consumer purchase intention, decision-making processes, purchase behavior, brand awareness, brand loyalty, and repeat purchase behavior. In these studies, consumer behavior has been analyzed using neuroscientific methods and tools. The most commonly used tools include Functional Magnetic Resonance Imaging (fMRI), Eye Tracking, Electroencephalogram (EEG), Positron Emission Tomography (PET), Transcranial Magnetic Stimulation (TMS), Magnetoencephalogram (MEG), Steady State Topography (SST), Implicit Association Test (IAT), Facial Electromyography (fEMG), Automatic Face Coding (AFC), Skin Conductance Response (SCR), and other methods for measuring physiological responses. However, the use of these neuroscientific tools is not always possible due to economic constraints and lack of experimental design. Neuroscientific imaging and measurement methods are not preferred in every study due to their high costs and expertise requirements. However, when neuromarketing studies are examined, it is seen that methods such as Eye Tracking, EEG and fMRI are used more widely. These tools contribute to a deeper understanding of consumer behavior. In order to better analyze consumer behavior, it is of great importance to convey marketing stimuli and messages correctly. In the field of marketing, the effect of stimuli conveyed to consumers using the five senses is one of the focal points of neuromarketing. More than one neuroscientific method should be used together to understand consumer intentions, thoughts and purchasing behaviors. In this way, the obtained data can be analyzed more comprehensively and clearer insights can be provided about neuromarketing. The aim of this study is to present a comprehensive assessment of the use of neuroscientific tools by examining the publications in the field of neuromarketing in the Web of Science database between 2010-2024 with bibliometric analysis. The study will address the limitations of not using more than one neuroscientific tool together in neuromarketing research and the inadequacy of analyses supported by artificial intelligence. A more holistic approach will be proposed to address these shortcomings and a guiding resource for future research will be created.

Keywords: ***Neuromarketing, Neuroscientific Tools, Artificial Intelligence***

1. Doç. Dr., OSTIM Technical University, abdullah.balli@ostimteknik.edu.tr, https://orcid.org/0000-0003-2689-6610

https://doi.org/10.30798/makuiibf.1416687

Article Type	Application Date	Admission Date
Research Article	January 8, 2024	August 23, 2024

To cite this article: Ballı, A. (2024). Comparison of studies conducted in the field of neuromarketing and Artificial Intelligence using bibliometric method. *Journal of Mehmet Akif Ersoy University Economics and Administrative Sciences Faculty, 11*(3), 980-1010. https://doi.org/10.30798/makuiibf.1416687

1. INTRODUCTION

The marketing discipline is changing significantly by expanding concepts, theories, and methods derived from disciplines such as psychology, sociology, anthropology, and neuroscience and adapting to the multidimensional view of consumer preferences. Emotions, biases and values are becoming increasingly important as internal factors for understanding consumers' preferences (Stas et al., 2018). Considering that 95% of purchasing decisions are made through the subconscious, it is an undeniable fact that different tools and methods are needed to better understand the subconscious (Mouline, 2019). In the current era of intense competition, a minor degree of anticipation is pivotal for companies to enhance the efficiency of fresh product launches and promotional messaging. While conventional consumer research methods such as surveys and focus groups play a role, they pose the challenge that consumers may not consistently be capable or inclined to furnish essential information. Consequently, marketing researchers have endeavored to address these limitations by delving into the consumer's subconscious (e.g., via motivational exploration and projective methodologies) and scrutinizing their decision-making processes for extended periods. However, these efforts have been partially successful in helping to understand consumers (Wilson et al., 2008; Conejo et al., 2007). Information is obtained using neuroscientific theories and methods to access the consumer's unconscious information, and this information is obtained through observation of neural processes without directly asking people about their thoughts, feelings, memories, evaluations or decision-making strategies. Neuromarketing paves the way for creating new marketing theories or supporting existing theories in marketing and related disciplines (Bhandari, 2020).

It is a known fact among marketers from the past that consumers' attitudes towards a product, brand or advertisement are shaped not only by rational thoughts but also by emotions. When trying to measure consumer emotions in traditional marketing research methods, data is obtained only from external expressions and evaluations about consumer emotions are made with these data (Galandi et al., 2022). While consumers today are exposed to thousands of marketing messages, this number is rapidly increasing as marketers offer more and more stimuli to reach consumers. Attracting the attention of consumers, whose attention is divided across different channels and multiple tasks with messages, has therefore become more difficult than ever for marketers (Saxon, 2017). What motivates individuals to purchase specific products or services? This inquiry stands at the core of every marketing and advertising professional's considerations, giving rise to the emergence of a burgeoning industry: Market research. Traditionally, market research has leaned on data gathered from consumers through diverse methods like surveys, focus groups, and interviews. Neuromarketing, on the other hand, employs biometrics, brain imaging, and various technologies to measure brain activity, capturing consumers' reactions to marketing stimuli. It involves leveraging neuroscience and physiological research techniques to comprehend consumer behaviors, preferences, decision-making processes, and other facets of human cognition relevant to marketing-related conduct. Thus, it provides access to much more

real and accurate data that cannot be obtained with traditional marketing methods (Brenninkmeijer et al., 2020; Sebastian, 2014; Stanton et al., 2017). In 2023, on a global scale, the USA and Canada spent 311.1 billion dollars, Asia Pacific Countries 241.5 billion dollars, Western Europe 135.2 billion dollars, Latin America 23.8 billion dollars, the Middle East and Africa 8.9 billion dollars, Central Europe 7.5 billion dollars on advertising expenses (Statista, 2024). According to research conducted in the field of neuromarketing; 3% of objects are perceived by tasting, 3% by touch, 3% by smell, 13% by hearing, 78% by sight, and the consumer makes a significant choice within 9 seconds. People learn 1% of what they learn by experiencing, 2% by touching, 4% by smelling, 10% by hearing, and 83% by observing the events around them (Clifton, 2014). Studies have shown that most advertising expenditures made with large budgets do not create the desired effect on the consumer. Therefore, studies to be conducted in the field of neuromarketing are of great importance for marketing researchers and businesses. However, it is understood that the neuroscientific method tools used in neuromarketing are not used sufficiently. Therefore, in this study, a bibliometric analysis will be conducted by scanning the studies published in the Web of Science database between 2010-2024 in terms of the tools used and artificial intelligence applications on neuromarketing. When the studies in the literature are examined, it is seen that there are deficiencies in the use of tools and methods to adequately understand some consumer behaviors and processes. It is understood that especially in studies conducted in the field of neuromarketing, one or two of some neuroscientific tools (eye tracking, face coding, galvanic skin conductance, heartbeat, electroencephalography, etc.) are used together and this situation leads to deficiencies in understanding and evaluating the reactions of consumer behavior to marketing messages transmitted through the five basic senses. In addition, considering the size of the data obtained in the studies (EEG data, eye tracking data, GSR data, face coding data, heart rhythm data, etc.), it is quite difficult for researchers to reach a healthy conclusion by examining such a large amount of data one by one. The fact that the number of studies conducted in the field of neuromarketing using more than one neuroscientific tool is quite limited and that artificial intelligence, machine learning and deep learning applications are used in a very limited number of studies reveals the importance of the research. The aim of this study is to compare the studies conducted in the field of neuromarketing and the findings obtained with neuroscientific tools. In addition, it is aimed to contribute to the determination of central tendencies with thematic analysis of the techniques used in cumulative information in related studies and to shed light on future research. In addition, it is aimed that the techniques used in cumulative information in relevant studies will contribute to the determination of central tendencies with thematic analysis and shed light on future research. In order to make a comparison within the scope of the research, two data sets were obtained from the most cited studies and those related only to neuromarketing. In this context, in the studies conducted in the Web of Science database, first the data belonging to the studies conducted in the field were obtained (using filters) with the keyword “neuromarketing”. Then, the second data set was obtained using the keywords “neuromarketing”, “neuroscientific tools” and “artificial intelligence”. Both data sets were obtained from 50

(neuromarketing keyword) and 41 studies (neuromarketing, neuroscientific tools and artificial intelligence keywords) conducted between 2010-2024 and analyzed separately with the R program and biblioshiny package program. The study, which explains what needs to be done in the context of understanding the deficiencies in the studies conducted in the literature and developing more holistic solution suggestions, will be a source for future research. In this context, the study will first discuss neuromarketing, neuroscientific tools used in neuromarketing, and the conceptual framework related to artificial intelligence. Then, studies on neuromarketing and artificial intelligence in the literature will be included and the research method will be discussed by referring to the data used. In the fifth section, the analysis of the obtained data and the findings will be discussed. In the last section, the results and limitations of the research are included.

2. CONCEPTUAL FRAMEWORK

Consumer purchase intention, decision making and purchasing behavior processes are shaped by many variables such as the consumer's desires, needs, expectations, past experiences, experiences, emotions, the environment they are in and the stimuli they are exposed to. Therefore, neuroscientific tools and methods used in neuromarketing are used to better understand consumer behavior. In this context, there is a need to explain the concepts of neuromarketing, neuroscientific tools, machine learning, deep learning and artificial intelligence used to analyze the data obtained from research more accurately.

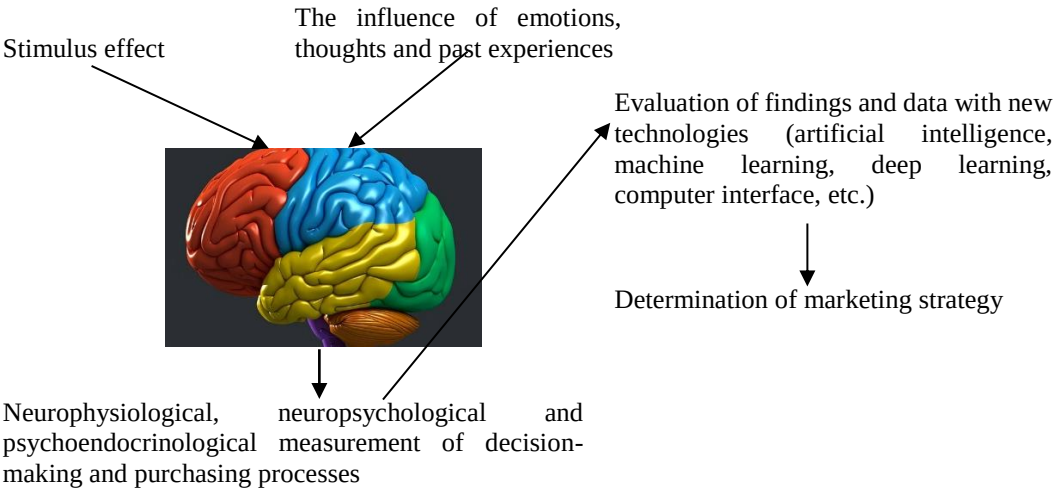
2.1. Neuromarketing

The term neuromarketing was created by combining the concepts of neuroscience and marketing, which are two different fields (Bhandari, 2020). Neuromarketing stands as a youthful domain within marketing, dedicated to unraveling how consumers react to various marketing stimuli. Coined by the amalgamation of neuroscience and marketing, the term "Neuromarketing" denotes the application of neuroscientific principles within the marketing realm (Yasir & Haq, 2022). The concept was first put forward by Ale Smidts. It is based on the principle of using neuroscience to analyze consumer behavior. Neuromarketing, which uses many different branches of science, especially psychology, in experimental research and studies, is considered to be the intersection of different sciences (Cosic, 2016; Burgos-Campero & Vargas-Hernandez, 2013; de Oliveira & Giraldi, 2017; Cárdenas, 2019). Consumer behaviors vary greatly in digital marketing, where classical methods and approaches are inadequate. For this reason, it is very difficult to obtain and evaluate simultaneous information about consumer emotions, thoughts and decision-making processes, which are a dynamic process. Neuroscience provides very useful information at this point (Brenninkmeijer et al., 2020; Sebastian, 2014; Stanton et al., 2017). Obtaining some key information in consumer purchasing behavior and decision-making processes is of vital importance. Classical approaches are sometimes insufficient in obtaining this information. At this point, neuroscientific methods and tools come to the rescue of marketing science. In this way, the neurophysiological and neuropsychological responses of individuals are better understood. This

facilitates the creation of different and successful strategies. Most importantly, it is measurable, transparent and comparable (Binodl & Jothi 2020; Meckl-Sloan, 2015). This new discipline is a successful result of the collaboration between economics, psychology and neuroscience. Fundamentally, it is possible to better understand human behavior and its underlying causes (Kumar, 2015). The ultimate goal of this method is to obtain results by using multiple tools, equipment, methods and approaches to better understand the results caused by many different parameters. Therefore, it focuses on a wide range of reasons underlying pre- and post-purchase consumer behavior (Nemorin & Gandy Jr., 2017, p. Senior & Lee, 2008; Fortunato et al., 2014). Neuromarketing consists of the fields of social and experimental psychology, econometrics, neuroscience and economics. Neuromarketing can be defined as a subfield of neuroeconomics in which the application of neuroscientific methods to analyze and understand human behavior in relation to markets and market changes is increasing. Neuromarketing is a new branch of marketing that uses neuroscience to determine a consumer's subconscious response to products and brands in order to create effective marketing strategies (Shukla, 2019). Thanks to the opportunities provided by neuroscience to marketing science, it is possible to evaluate consumer behavior from a different and holistic perspective and make correct inferences. It is possible to understand what kind of manipulations are caused in the consumer mind and behavior by messages intended to be conveyed through marketing stimuli (advertisement, sound, music, color, packaging, etc.). Thus, it becomes easier to develop and implement more effective strategies regarding consumer pre-purchase decision-making processes. In studies conducted in the field of neuromarketing, the effects of marketing stimuli (advertisement, brand, packaging, logo, color, etc.) on consumer behavior and preferences have been addressed from neurophysiological and neuropsychological perspectives. The impact of psychoneuroendocrinology on emotions, thoughts and decision-making has been neglected. Psychoneuroendocrinology allows understanding of the impact of hormones and body chemicals on behavior and decision-making processes. Psychoneuroendocrinology encompasses the integral structural and functional relationships between hormonal systems and the Central Nervous System and the behaviors that modulate and derive from both. Hormones have a great impact on human emotions, thoughts, behavior and decision-making processes. Hormones are secreted as a result of stimulation of the brain and have a great impact on behavior. For example, when a consumer buys a product that may be an opportunity for him/her, a perception of reward occurs in the brain and dopamine is secreted intensely. Songur, (2022) states that areas such as the ventral tegmental area, basal nuclei, prefrontal cortex, insular cortex, limbic system (areas such as hippocampus and amygdala), accumbens nucleus, thalamus and hypothalamus have an important place in the reward system. It is known that hormones and brain messenger chemicals (neurotransmitters) are secreted when these reward areas are activated in case of reward perception, gain or loss concern, and economic decisions in consumer decision-making and purchasing processes. Because these are the premises for behavior and decision-making. This is why the neuropsychoendocrinological approach is important in the field of neuromarketing. In this context, neuromarketing is very important to address consumer thought, decision-making and behavior

processes neurophysiologically, neuropsychologically and psychoneuroendocrinologically with neuroscientific methods and tools.

Figure 1. Neuromarketing Process

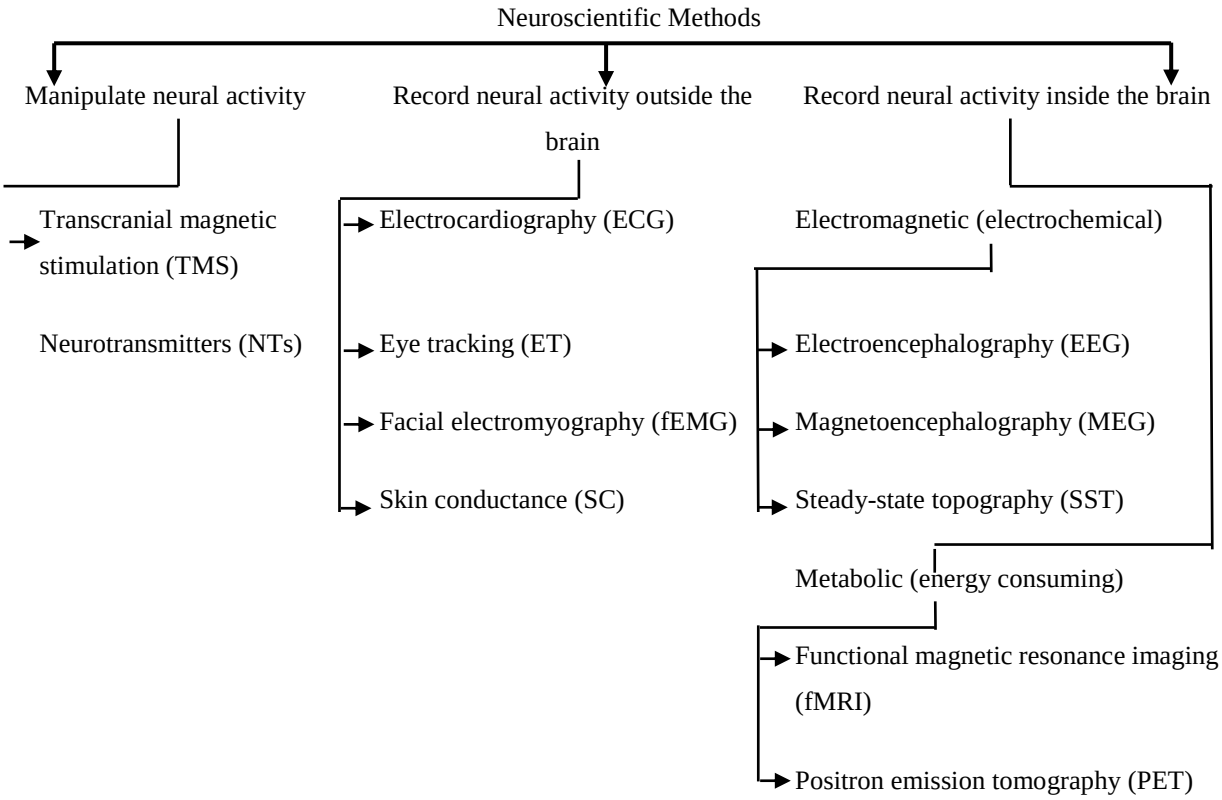


Source: Created by the author

2.2. Neuroscientific Tools Used in Neuromarketing

Neuroscientific investigations hinge on three fundamental components: Location, connectivity, and representation. Location signifies the specific brain areas capable of detecting heightened stimuli, such as the superior colliculus, hypothalamus, or amygdala. Connectivity involves the intricate network of connections between neurons across different brain regions to process information. Representation entails the scrutiny of how information is coded in the brain (Grajdieru, 2017). The arsenal of neuromarketing techniques commonly employed for the analysis of human behavior includes functional magnetic resonance imaging (fMRI), electroencephalography (EEG), eye-tracking glasses, magnetoencephalography (MEG), and positron emission tomography (PET). However, neuromarketing involves more than brain activity and measurements. As an alternative to brain imaging, researchers can measure heart rate, respiration, skin conductance (hand sweat), eye tracking (recording exactly what the eyes are looking at), aspects of environmental physiology, and more, and then relate these measurements to consumers' experiences (Stanton et al., 2017, p. 2). Tools and methods in neuromarketing research are based on three basic principles. Measurements based on the neural metabolic activity of the brain, measurements based on electrical activity, and measurements based on physical activity other than brain activity. It is shown in Figure 2.

Figure 2. Tools and Methods Used in Neuromarketing



Source: (Lim, 2018)

The concept of neuromarketing was first introduced by Professor at Harvard University in the second half of 1990. It came to the fore when Gerry Zaltman announced that he was using the functional magnetic resonance device (fMRI) in marketing research. It was Prof. who expressed these studies with the concept of neuromarketing in 2002. Ale Smidts (Ural, 2008). The tools and methods used in neuromarketing research vary depending on the study. However, the most commonly used tools are Eye Tracking (ET), Electroencephalography (EEG), and Functional magnetic resonance imaging (fMRI).

Table 1. Neuromarketing Tools

Tool or Methods	Working Principle	Features	Shortcomings
Functional magnetic resonance imaging (fMRI)	The neuroimaging approach gauges the quantity of oxygenated hemoglobin correlated with neuronal activity, providing insight into cerebral function through superior temporal and spatial resolution. Detection of the blood oxygenation level-dependent (BOLD) signal is executed utilizing magnetic resonance imaging (MRI) scanning techniques	• Observing cerebral activities with elevated temporal and spatial precision • Precise identification of neural activity associated with alterations in cognitive and emotional states • Being non-invasive • Detailed neuroimaging • High reliability	• High costs • Difficulty in transportation and installation • Difficulty in analyzing data and inability to scale

Electro-encephalogram (EEG)	The technique quantifies alterations in cortical electrical activity, capturing and registering distinct electroencephalographic (EEG) waveforms associated with specific cognitive states such as relaxation (alpha waves), alertness (beta waves), sleep (delta waves), and tranquility (theta waves)	• Being easily portable • High temporal resolution • Being economical • Finding new devices with Wi-Fi technology • Ease of data processing with computer interface programs • Monitoring electrical activity related to neural response • Measuring the effect of emotional stimulation	• Lack of spatial resolution • Inability to monitor differences within deep brain structures • High sound level • Inability to distinguish neural activity occurring in reward centers such as Hippocampus, Amygdala, Hypothalamus, Hippocampus • Erroneous measurements caused by participants
Eye Tracking (ET)	The methodology operates on the foundational principle of acquiring measurements through the generation of thermal maps indicative of physiological activity. This includes the dynamic analysis of pupil dilation and constriction in response to ocular movements, the assessment of gaze fixation frequency, and the identification of multiple points under scrutiny	• Lower costs • No contact with the participant • Ease of measurement • Portability • Ease of data processing with computer interface • programs	• Need for calibration with every measurement • Measurement takes time and participant attention decreases • Cost of ET device
Positron Emission Tomography (PET)	The foundation of this approach lies in the principle of generating visual mappings that delineate regions characterized by heightened blood flow, contingent upon the intensity of metabolic activity associated with glucose consumption. This methodology unveils neuropsychological indices that underlie neural activity	• High spatial resolution • Revealing the neurophysiological background of neurocognitive activity • Deep and detailed analysis with radioactivity • Three-dimensional viewing opportunity	• High costs • Usage restriction due to radiation hazard • Limited temporal resolution
Facial Electro-myography (fEMG)	The methodology is grounded in the principle of quantifying electrical activity emanating from contractions arising from the individual and synergistic movements of diverse muscle groups	• Understanding emotional state • Detection of different muscle activities • High reliability due to muscle movements • Non-invasive ease of use	• Similar muscles move in some emotions • Difficulty distinguishing some emotions
Magneto-encephalography (MEG)	The foundation of this approach relies on the measurement of electromagnetic fields generated by the formation of action potentials	• Being non-invasive • High sensitivity and spatial resolution • Easy to use	• High costs • Difficult to install and move • Measures only based on brain neural activity
Automatic Face Coding (AFC)	The methodology is founded on the principle of recording the fundamental emotional state and moment-to-moment fluctuations, subsequently categorizing them through the utilization of a devised face mapping technique. Emotional states are discerned based on the coordinated or distinct movements of 43 specific muscle groups	• Simple and practical to use • Ability to create mood patterns based on facial movements • Prediction of certain emotions and feelings with high accuracy	• The data obtained are debatable • Requires software • Difficulty processing instant data

Skin Conductance Response (SCR)	The methodology is grounded in the principle of recording data derived from the functioning of sweat glands, reflective of immediate alterations in electrodermal activity	• Measurement of electrodermal activity according to momentary mood change • Ease of mobile use • Lower costs • Participant's ability to move during measurement	• Measurement may be affected by ambient temperature and humidity • Temporal differences between action, reaction and report processes
Implicit Association Test (IAT)	The approach is rooted in comprehending implicit attitudes through the elicitation of specific concepts and expressions related to psychological, social attitudes, and behaviors. It constitutes a psychometric instrument engineered to gauge the robustness of automatic associations between mental representations of objects and concepts The lag in response time signifies a frail connection between the selected term and the group within the participant, while a reduction in reaction time indicates a robust bond. Swiftly associating words with negative connotations with a specific social group implies the existence of implicit bias	• Implicit tests allow assessment of attitude/cognition without requiring people to deliberately consider their responses with insight. • Applicability via mobile devices • A deeper understanding of the participant's stance on a topic	• Difficulty distinguishing different emotions from the object being evaluated • The effectiveness of prejudices
Steady State Topography (SST)	Visual evoked potentials, discerned within the subject's electroencephalogram (EEG) activity when exposed to visual stimuli, particularly in the context of marketing stimuli, gauge variations in Steady State Topography This approach ensures a commendable temporal resolution by persistently monitoring these cerebral activity shifts across prolonged intervals, showcasing a heightened resilience to extraneous interference. However, the applicability of such instruments is confined to visual stimuli, and their deployment may be characterized as somewhat obtrusive to study participants	•High temporal resolution •High data quality •Lower costs •Ease of Use	•Limited coordination of movements between two tasks •Low spatial resolution
Electro-cardiogram (ECG)	The methodology is grounded in the principle of documenting alterations in heart rhythm induced by the autonomic nervous system's involuntary responses orchestrated by the brain. This intricate system, involving both the sympathetic and parasympathetic branches, reacts to diverse stimuli, capturing nuanced physiological reactions	•Lower costs •High data quality •Ease of Use •Portability •Understanding the participant's response to stimuli	•The testing process takes time

Source: Created by the author

2.3. Machine Learning, Deep Learning and Artificial Intelligence

Machine learning has an important place as a sub-branch of artificial intelligence and stands out with its ability to make predictions about the future with data-based learning processes. Studies in this field primarily focus on developing models that can predict future events or situations by learning from past data. Machine learning methods perform the learning process by examining complex relationships between data attributes and extracting meaningful patterns from these relationships. These algorithms usually draw attention with their capacity to extract information by performing in-depth analysis on

multidimensional data sets and without depending on predetermined conditions (Abbott, 2014). Machine learning, which is based on creating mathematical models by associating the most meaningful and appropriate features within existing data within a certain algorithm, aims to reveal the relationships between data correctly (Kelleher, 2019, p. 11). Thanks to the mathematical models produced, complex structures become simple, plain and understandable. It is almost impossible to analyze very large and voluminous data manually by human hands. For this reason, it analyzes relationships based on the learning model using implicit patterns in data sets. Selecting the most appropriate model and optimizing it according to features constitutes the basis of machine learning.

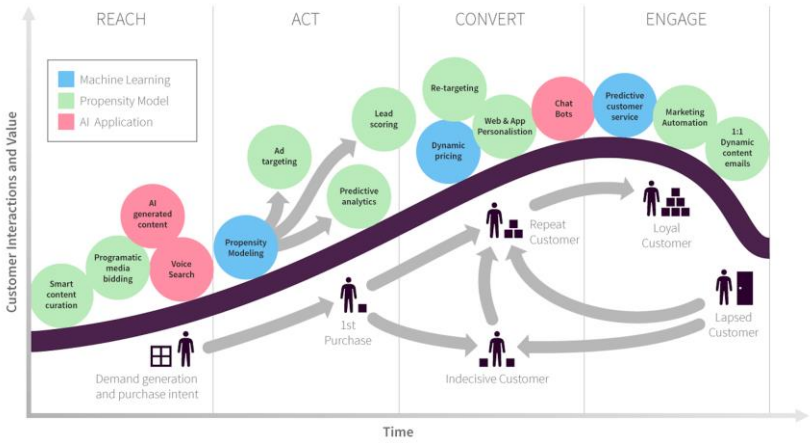
Machine learning is about the ability to generalize data and apply this information to new and unknown data. Algorithms can make predictions about future data points by learning from past experiences and using the information obtained from these experiences. It can reveal even the most complex relationships by making an evaluation from the specific to the general thanks to the mathematical models it has developed by starting from the hidden patterns in the large data set. It has an understanding that works with inductive logic especially in the fields where there is a lot of data and this data needs to be processed and information is obtained (medicine, psychology, economics, social sciences, health, space research etc.). The field, which is constantly developing, is accepted as a branch of artificial intelligence. It has the ability to reveal even the most mysterious relationships and even to prove their accuracy by testing them thanks to artificial neural networks. It is widely used thanks to the multi-layered structures in the data set, complex learning algorithms, and natural language processing feature. It offers important contributions in many different fields thanks to its ability to draw meaningful conclusions from structures called big data (LeCun et al., 2015, p. Schmidhuber, 2015).

Machine learning and deep learning have different abilities in terms of certain specific features. While making high-accuracy predictions by processing and generalizing data is the basis of machine learning, structuring complex data sets by analyzing them is the basis of deep learning. This situation makes it possible for large and complex data to become much easier, understandable and analyzable thanks to deep learning. In short, deep learning is a sub-unit of artificial intelligence that tries to obtain the whole from the data by simulating large data sets in the form of structures similar to artificial neural networks. Thanks to this feature, it becomes easier to solve problems that are difficult to solve or require a lot of time in many different fields and disciplines. Deep learning, which produces effective results in various application areas such as speech and visual recognition, has the capacity to perform deeper and more complex data analysis and to derive meaningful results from this data, unlike machine learning. Deep learning has an important place in artificial intelligence research with these aspects and is used in various scientific and industrial fields.

Artificial intelligence is considered a broad concept that mimics human cognitive processes and includes learning and problem-solving abilities (IBM Think Blog, 2017). This technology finds a wide

range of applications, including optimization principles. The first artificial intelligence project proposed by John McCarthy and his team in 1955 (McCarthy et al., 1955) led to theoretical inferences that the use of artificial intelligence in analytical tasks could reduce the need for intuitive and empathic skills (Huang & Rust, 2018, p. 155). Rapid advances in artificial intelligence also offer innovative and exciting opportunities in marketing science. Examining the current knowledge of this field and identifying research gaps are critical to increasing the efficiency of potential studies (Wirtz, 2021, p. 1). Artificial intelligence is used in the field of marketing to examine interactions with market participants and change the definition of these participants. While actors are traditionally defined in sociology and social psychology as individuals who take conscious actions in their own worlds, artificial intelligence in the business world offers a new approach that challenges traditional interaction models (Håkansson et al., 2009). While marketing experts evaluate artificial intelligence as a time-saving tool for achieving strategic goals, they also see it as a threat to the workforce (van Esch & Black, 2021, p. 199). The impact of artificial intelligence technologies on social and relational dynamics from a marketing perspective is striking. In particular, significant gains can be achieved in the field of marketing thanks to the combined use of machine learning or artificial intelligence. For this reason, it is evaluated that both technologies can make significant contributions to almost every stage of marketing activities. The model developed by Smart Insight on this subject is shown in Figure 3.

Figure 3. Artificial Intelligence Applications Used in Marketing



Source: Smart Insights, n.d.

It is important that how artificial intelligence transforms the structure of business networks and that these processes have not been discussed enough (LaPlaca & Lindgreen, 2016). Artificial intelligence is considered the pinnacle of science based on the aim of creating machines with human-like thinking capacity (McCorduck, 1982, p. 242). Artificial intelligence, which has become widespread in many fields by gaining strength in the twenty-first century, has become a trend in various sectors such as science, business and medicine and has also shown itself in marketing (Jarek & Mazurek, 2019, p. 46). In the field of marketing, it offers innovations in many areas such as content creation, customer

acquisition, cost reduction and customer experience management in conceptualization, theory and research processes. Artificial intelligence is used by various brands to fulfill marketing functions from digital advertisements to practical applications (van Esch & Stewart Black, 2021, p. 199). Digital and artificial intelligence technologies are transforming industries based on the idea of creating machines that exhibit superior performance in areas such as speech, understanding and language translation (Elia et al., 2020, p. 1). Marketing science and competition are also affected by this change. When evaluated in terms of business models and marketing, businesses equipped with artificial intelligence technology gain competitive advantage, while those that do not use this technology are at a disadvantage. Therefore, the innovations created by artificial intelligence technologies in the field of marketing offer significant advantages in the global competitive environment (Lee et al., 2019, p. 1). The rapid spread of artificial intelligence-based applications and marketing innovations in business life and industrial marketing requires the evaluation of existing research with qualitative and quantitative approaches (Kumar et al., 2020, p. 126; Han et al., 2021, p. 2467). It is expected that artificial intelligence will continue to be used in marketing functions (Mustak et al., 2021, p. 390). This holistic perspective can increase the power of marketing (Haenlein & Kaplan, 2019, p. 5).

3. LITERATURE REVIEW

Recent neuroscientific developments regarding the structure and functioning of the brain have also revealed new ways to understand the consumer and neuromarketing. This new field of knowledge is gradually becoming an essential complement to marketing research (Duque-Hurtado et al., 2020). Today, the widespread use of neuromarketing techniques to evaluate customer preferences and decision-making processes is advantageous for customers and marketers. Considering that more than 90% of information is processed subconsciously in the human brain, the reality of neuromarketing research reveals better results than traditional analysis methods based on surveys and interviews (Singh, 2020). Neuromarketing attempts to understand consumer attitudes and behaviors and the reasons behind them in a way that is aimed at measuring them. In the meantime, it is aimed to reach a generalization by measuring the reactions of the consumer to stimuli with neuroscientific tools. In this way, it is possible to create the most accurate and realistic marketing strategies and approaches possible (Rawnaque et al., 2020). According to Thomas et al., (2017), neuromarketing guides marketing managers by examining the reactions of people to events and situations. In this way, it is possible to make healthy inferences about the attitudes and approaches that consumers will adopt in the face of various situations (marketing stimuli effect) in the future (Lee et al., 2007). Researchers who want to turn this situation into an opportunity obtain much more realistic results by processing neuroscientific tools and the data they obtain from them with artificial intelligence-based applications. In this context, the studies conducted in the field and the findings obtained are given in Table 2.

Table 2. Studies and Findings in The Field of Neuromarketing and Artificial Intelligence

Writer(s)	Findings
Bowen, (2009)	The effectiveness of artificial intelligence in the process of document analysis, examination, evaluation and collection of certain data from existing documents in printed and electronic media
Ohme, Reykowska, Wiener & Choromanska, (2010)	Electrodermal activity data is proficient in discerning both approach and withdrawal reactions with effectiveness
Ariely & Berns, (2010)	Neuromarketing holds the potential to be more cost-effective than conventional methods and can unveil valuable insights throughout the product design phase
Maxwell, Jeffrey, & Lévesque, (2011)	Artificial intelligence and machine learning algorithms have enabled efficient data processing that allows formulating the right decision
Lajante, Droulers, Dondaine & Amarantini, (2012)	The fundamental emotional processes experienced by consumers, such as the evaluation of stimuli, can be precisely quantified through the recording and processing of electrodermal activity data
Khushaba, Greenacre, Kodagoda, Louviere, Burke & Dissanayake, (2012)	Integration of eye tracking and electroencephalography (EEG) data facilitates the discrimination of crucial factors during the product selection process
Gangadharbatla, Bradley & Wise, (2013)	The analysis of electrocardiogram (ECG) and electrodermal activity data implies that in-game advertisements could be indirectly retained in memory and exert an influence on subsequent decision-making processes
Somervuori & Ravaja, (2013)	Examination of electromyography (EMG) and electrodermal activity data revealed that lower prices and brand-name products elicited a 25% increase in positive emotional responses, accompanied by heightened purchase intent, in comparison to higher prices and private-label products
Maxian Bradley, Wise & Toulouse, (2013)	Electromyography (EMG) responses have demonstrated greater amplitude and positivity in reaction to well-liked brands, contrasting with increased amplitude and negativity observed in response to less favored brands
Fortunato, Giraldi & Oliveira, (2014)	Neuromarketing proves instrumental in unraveling intricate purchasing behaviors, offering insights into the degree of rationality entwined within consumer decision-making processes
Venkatraman, Dimoka, Pavlou, Vo, Hampton, Bollinger & Winer (2015)	Functional Magnetic Resonance Imaging (fMRI) holds a heightened capacity to predict distinctions in sales responses to advertising when juxtaposed with data derived from consumers' self-reported responses
Gupta & Falk, (2016)	Broadly speaking, our investigation indicates that graph-theoretic features derived from electroencephalogram (EEG) data are more adept at emotion classification compared to conventionally employed EEG features like spectral power features (SPF) and asymmetry index (AI) features
Lopes, De Aguiar, De Souza, & Oliveira-Santos, (2017)	Although automatic face coding systems (AFC) can make predictions to a certain extent, thanks to the new model developed (computer interface), they were able to detect it with 96% accuracy compared to previous measurements
Kietzman, Paschen & Treen, (2018)	The accumulation of this data generated by consumers is constantly increasing
Cannella, (2018)	The content created by many users in the digital environment is analyzed with the help of artificial intelligence tools and the marketing process for businesses is ensured to be carried out in a healthy way
Halkin, (2018)	The study expanded neuromarketing theory by incorporating the actual environmental component with a method to process and evaluate the emotional state of the consumer in purchasing items using galvanic skin response (GSR) and heart beat (HB) devices
Nguyen & Sidorova, (2018)	Customer experience is improved through AI-powered chatbot with Natural Language Processing (NLP)
Perakakis, Mastorakis, & Kopanakis, (2019)	Artificial intelligence is an innovative system that automatically analyzes data generated by consumers for marketers and produces healthier results for businesses, without the need for human intervention to analyze it
Golnar-Nik, Farashi, & Safari, (2019)	The electroencephalogram (EEG) study exhibited a robust predictive capacity for consumer decision-making frequency, achieving a noteworthy accuracy exceeding 87%. Discrimination between "Like" and "Dislike" preferences was similarly demonstrated with an accuracy surpassing 63%. Notably, the most discriminative channels for forecasting decision-making frequency and differentiating preferences were localized to frontal and centro-parietal areas, specifically at Fp1, Cp3, and Cpz
Chatterjee, Ghosh, Chaudhuri, & Nguyen, (2019)	Artificial Intelligence (AI) application is required to analyze customer habits, purchases, likes, and dislikes
Seranmadevi & Kumar, (2019)	Customer Relationship Management (CRM) functions are enhanced through Artificial Intelligence User Interface (AIUI)

Sha & Rajeswari, (2019)	Advanced AI-enabled machine can monitor five human senses and advanced e-commerce business
Tjepkema, (2019)	With artificial intelligence applications, marketers can access most of the information they want about their consumers
Aldayel, Ykhlef, & Al-Nafjan, (2020).	With the deep learning approach to detect consumer preferences using EEG signals, consumer behavior can be predicted with higher accuracy, precision and recall
Huang & Rust, (2021)	Strategic marketing planning can be used to organize existing AI marketing efforts and identify research gaps in AI marketing
Aldayel, Ykhlef, & Al-Nafjan, (2021)	Deep neural network (DNN) created using discrete wavelet transform (DWT) and power spectral density (PSD) used to measure EEG-based preference indices has shown higher accuracy, sensitivity and performance in determining consumer preferences
Jai, Fang, Bao, James III, Chen, & Cai, (2021)	In the study, where 24 participants were asked to make purchasing decisions for 60 garments, consumer preferences were determined with 95% accuracy thanks to machine learning using functional magnetic resonance imaging (fMRI) and visual stimulus effects in 3 categories
Hilken, Chylinski, de Ruyter, Heller, & Keeling, (2022)	It has been claimed that augmented reality (AR) and virtual reality (VR) technologies can make significant contributions to controlling digital content through thought and revealing brain reactions based on digital content
Haleem, Javaid, Qadri, Singh, & Suman, (2022)	AI tools analyze the performance of a competitor's campaigns It can also be used to identify and reveal customers' expectations
Oikonomou, Georgiadis, Kalaganis, Nikolopoulos, & Kompatsiaris, (2023)	In an investigation utilizing a publicly accessible neuromarketing EEG dataset, the devised classification scheme for emotional state recognition and cognitive state recognition demonstrated superior performance, achieving an enhanced classification accuracy exceeding 8% when compared to both baseline and state-of-the-art methodologies
Villegas, (2023)	Artificial intelligence in the context of customer experience, businesses, chat robots, virtual assistants, a wide range of artificial intelligence, such as sentiment analysis and predictive modeling benefits from supported solutions

Source: Created by the author

When the frequently cited studies conducted in the last 14 years in the literature are examined, it is understood that certain neuroscientific methods and tools have been used and, especially as of 2020, more successful results have been achieved by taking advantage of new technological opportunities such as artificial intelligence, machine learning and computer interface.

4. METHOD

In the research, data were obtained according to the studies conducted in the field of neuromarketing, the variety of neuroscientific tools, and whether artificial intelligence applications were used or not. The obtained data were examined with bibliometric analysis. Bibliometric analysis works on the principle of statistical and numerical examination of scientific studies according to certain metrics (Al et al., 2019). In terms of methodology, the studies in the literature are classified and evaluated (Zupic and Čater, 2015). In short, it aims to measure the effectiveness of researchers, groups, institutions and organizations and journals that have conducted studies in the field qualitatively and quantitatively (Krauskopf, 2018). It also has a functional aspect such as guiding future studies by identifying the authors and studies that are active in the literature (Zupic and Čater, 2015). The impact analysis of existing studies is performed by classifying different types of studies conducted in a certain field within a certain period of time (Al et al., 2019). Thanks to the methods and analyses used, it makes it possible to evaluate the findings obtained in the research comprehensively. It is especially important to better understand the quantity and quality of the scientific studies, to determine the power of impact and to determine the direction of general trends.

The articles in the international literature on neuromarketing were examined in the study. Both data sets to be examined within the scope of the study were obtained from the Web of Science (WoS) database. Due to the widespread presence of neuromarketing studies in the literature, a search restriction was imposed on the relevant citation indexes between the years 2010-2024. In addition, studies conducted with artificial intelligence, machine learning and deep learning tools, which are frequently used in neuromarketing research, were taken into account. Another limitation is that the studies in the literature were only scanned through Web of Science (WoS) and other international databases such as Scopus, PubMed, Elsevier ScienceDirect, SpringerLink, Taylor & Francis were excluded from the scope. The main reason for this situation is that very few publications were reached in the literature search. In addition, the language of the studies was English and only articles (excluding articles, book chapters, abstracts, etc.) were included in the analysis, which constitutes another limitation of the study.

This section of the study includes bibliometric analyses of concepts related to the keywords "neuromarketing", "neuromarketing and neuroscientific tools" and "artificial intelligence", "machine learning", "deep learning", which are frequently used tools in neuromarketing research.

4.1. Purpose of the research

Within the scope of the research; as a result of quantitative data and numerical measurement indicators, the concepts of EEG, ET, fMRI, ECG, SCR, AFC, MEG, which are the most frequently used in studies on neuromarketing, neuroscientific tools used in neuromarketing and artificial intelligence, machine learning and deep learning, were included. As a result of the bibliometric analysis, it was aimed to present the studies on the concepts to the attention of researchers from a holistic perspective and to make suggestions on what should be done in future studies.

4.2. Data and analysis

Various bibliometric analysis tools are used in scientific literature. In this study, the R program and the biblioshiny package program were preferred due to their strong functional aspects. This program is considered as an important program that provides convenience to researchers who want to discover evolutions, relationships and new concepts in the literature. The program's visualization, mapping and multidimensional analysis capabilities allow for in-depth examination of data sets. Thanks to these features, researchers can understand developments in scientific fields in more detail and visually analyze relationships in the literature. The use of the Biblioshiny package program provides researchers with an effective tool for understanding and interpreting large data sets. Therefore, the selection of Biblioshiny within the scope of the study was evaluated as an important strategy in terms of providing analytical depth and discovering developments in the literature.

While a great number of studies were found when only neuromarketing-related studies were investigated in the data acquisition process, a limited number of publications were reached in the data acquisition process conducted with neuroscientific tools, artificial intelligence, machine learning and

deep learning concepts. This situation has been interpreted as an indication that artificial intelligence, machine learning, deep learning and more than one neuroscientific tool and method are not used together sufficiently in the field of neuromarketing.

It was created based on bibliometric data of different types of studies scanned in the Web of Science (WoS) database on 02.01.2024 and published between 2010-2024. It was determined that there were 867 studies on "neuromarketing" in the WOS database regarding the concepts specified in the purpose section of the research. However, only 49 studies were reached in the examination conducted with the keywords "neuroscientific tools", "artificial intelligence", "machine learning", "deep learning" used in these studies. The "bibliometrix" package and biblioshiny application developed by Aria and Cuccurullo (2017, p. 959) for the R program were used in the analysis of the obtained data. The R program allows the detailed examination of studies on the subject and the developments to be seen.

5. FINDINGS AND COMMENTS

The findings obtained from bibliometric analyses are presented under this heading. Bibliometric analyses of studies published between 2010-2024 are included. Within the scope of the research, studies indexed in the WOS database were analyzed separately according to the database features they belong to. The results of this evaluation were included in the research through graphs and tables.

In Table 3, the data on the left side belong to the dataset related to "neuromarketing", while the data on the right side belong to the keywords "neuromarketing", "neuroscientific tools" and "artificial intelligence". As can be seen in Table 3, although neuromarketing and artificial intelligence research is 25% less (50 publications and 41 publications), it is seen that the average annual publication is 12% more, the number of authors is higher (184 authors and 194 authors) and the co-authorship per document is higher (3.92 and 5.37) in neuromarketing and artificial intelligence research. This shows that the interest in neuromarketing and artificial intelligence research is increasing.

Table 3. General Information on Data Sets

Description	**Results**	**Description**	**Results**
MAIN INFORMATION ABOUT DATA		MAIN INFORMATION ABOUT DATA	
Timespan	2010:2024	Timespan	2010:2024
Sources (Journals)	30	Sources (Journals)	32
Documents	50	Documents	41
Annual Growth Rate %	0	Annual Growth Rate %	12,25
Document Average Age	5,38	Document Average Age	3,8
Average citations per doc	21,56	Average citations per doc	21,32
References	2725	References	1602

DOCUMENT CONTENTS		DOCUMENT CONTENTS	
Keywords Plus (ID)	206	Keywords Plus (ID)	87
Author's Keywords (DE)	155	Author's Keywords (DE)	167
AUTHORS		AUTHORS	
Authors	184	Authors	194
Authors of single-authored docs	5	Authors of single-authored docs	3
AUTHORS COLLABORATION		AUTHORS COLLABORATION	
Single-authored docs	5	Single-authored docs	3
Co-Authors per Doc	3,92	Co-Authors per Doc	5,37
International co-authorships %	30	International co-authorships %	31,71
DOCUMENT TYPES		DOCUMENT TYPES	
Article	50	Article	41

Figure 4 shows the annual average production of publications in the field of neuromarketing, while Figure 5 shows the annual average production of research on the use of neuromarketing and artificial intelligence. While the average number of publications in the field of neuromarketing in 2021 was approximately 8, this number decreased by more than 300% to 2.5 in 2023. While the number of publications on the combined use of neuromarketing and artificial intelligence was 3 in 2021, this number increased by 100% in 2023, increasing to an annual average of 6 publications. Although the evaluation was conducted to cover the last 14 years, it is understood that 50 studies evaluated in the field of neuromarketing were conducted in this period, while the majority of the studies (41 studies) in the field of neuromarketing and artificial intelligence were conducted in the last five years. This shows that the interest in the use of artificial intelligence in neuromarketing research is increasing.

Figure 4. Neuromarketing Research

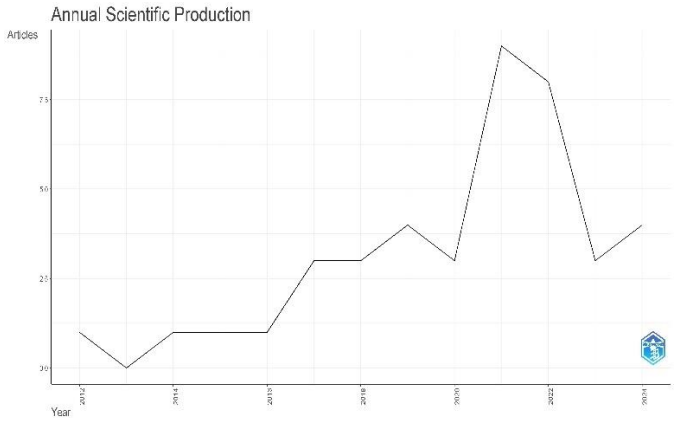
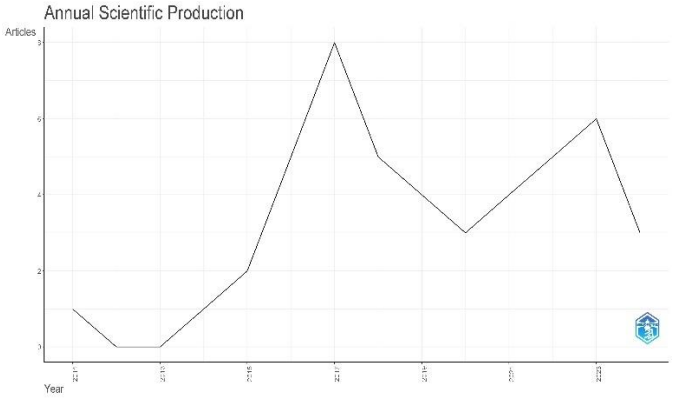
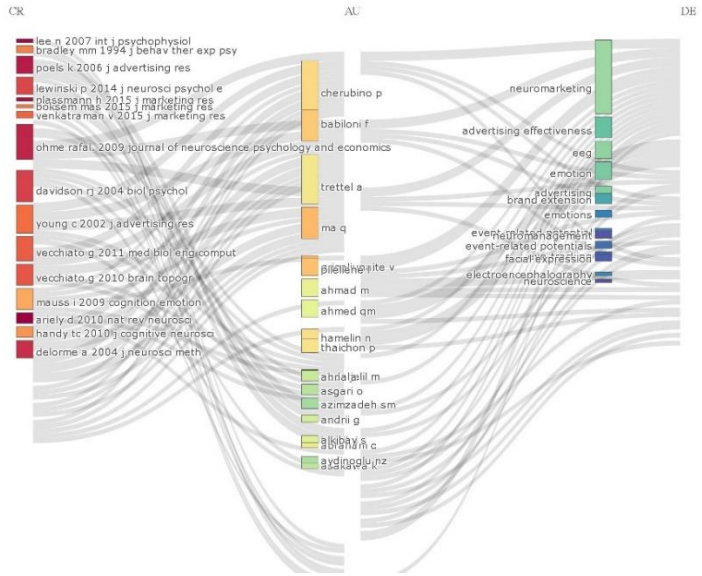


Figure 5. Neuromarketing and Artificial Intelligence Research



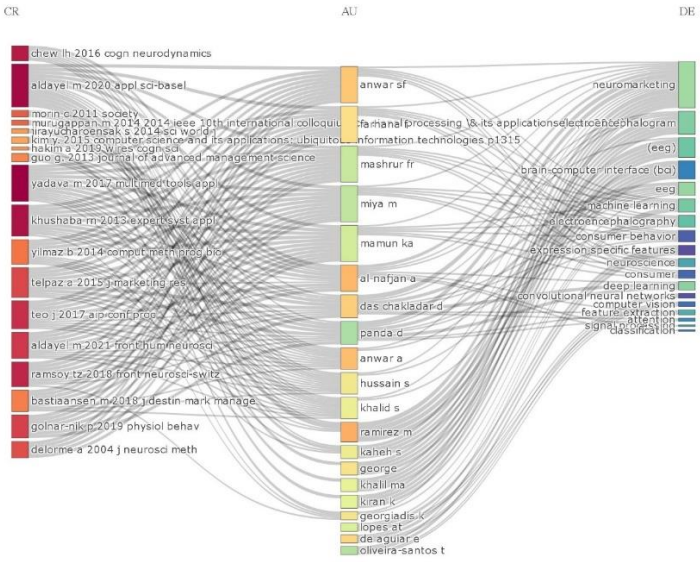
While Cherubino and Babiloni are the researchers who have done the most work in the field of neuromarketing, the most frequently used keywords by the authors are neuromarketing and EEG, as seen in Figure 6. This shows that one or two neuroscientific tools are usually used in the studies.

Figure 6. Sources, Authors and Keywords for Neuromarketing



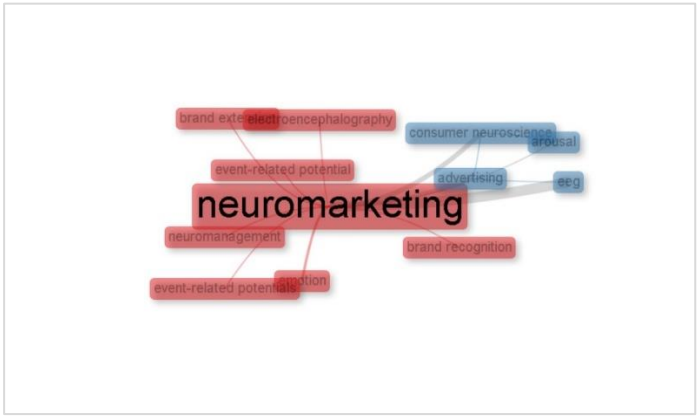
While Anwar and Farhan are the researchers who have done the most work in the field of neuromarketing and artificial intelligence, the most frequently used keywords by the authors are neuromarketing, EEG, machine learning and deep learning, as seen in Figure 7. This shows that more than one neuroscientific tool and artificial intelligence are usually used together in the studies.

Figure 7. Sources, Authors and Keywords for Neuromarketing and Artificial Intelligence



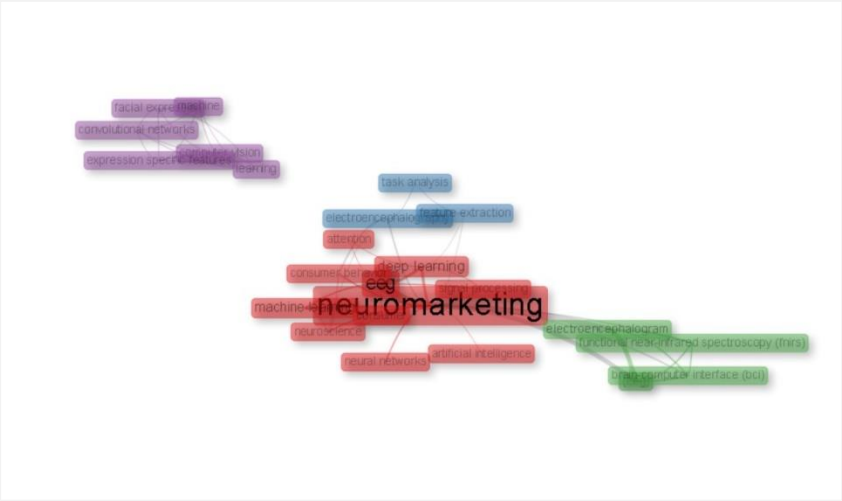
In the analysis conducted to reveal the conceptual structure of the studies (according to the abstracts of the studies), it is seen in Figure 8 that in the study conducted in the field of neuromarketing, the concepts of neuromarketing and only EEG are included in the same cluster and other neuroscientific tools are not present. This situation shows that generally one or at most two neuroscientific tools are used in the studies conducted. However, it is understood that all reactions created by more than one stimulus can be tried to be measured with a single tool.

Figure 8. Co-occurrence Network for Neuromarketing



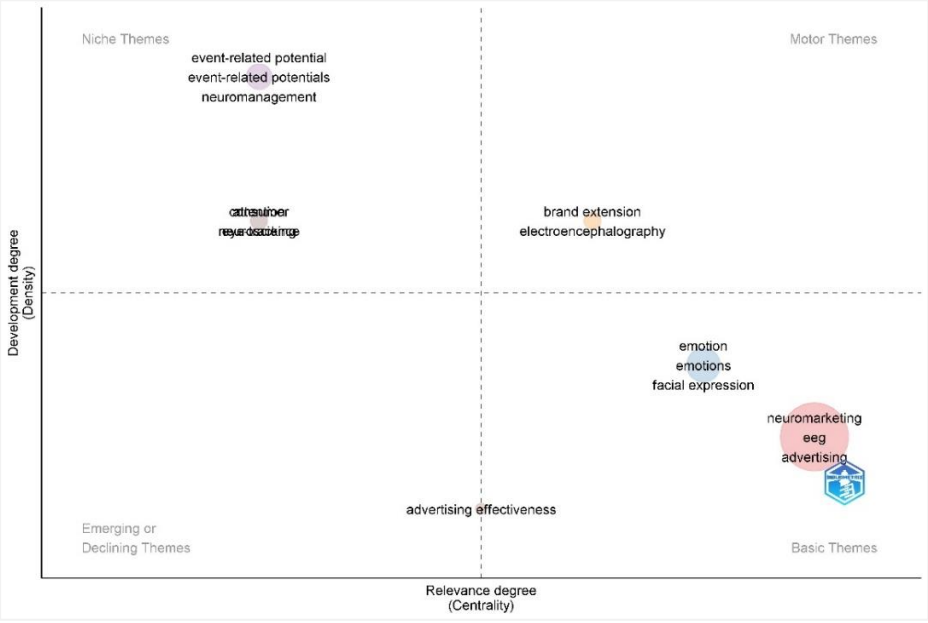
However, in the analysis of the conceptual structure of studies on neuromarketing and artificial intelligence (according to the abstracts of the studies), it is seen in Figure 9 that neuroscientific tools such as neuromarketing, EEG, facial annotation and fMRI are used and the concepts of artificial intelligence, machine learning and deep learning are also included in the same cluster. This shows that more than one neuroscientific tool is used in the studies and artificial intelligence is effective in the studies.

Figure 9. Co-occurrence Network for Neuromarketing and Artificial Intelligence



Another analysis made regarding the conceptual structure is the thematic mapping analysis made according to the keywords used by the authors. In the studies conducted in the field of neuromarketing, neuromarketing, EEG and facial description topics are included together according to the keywords used by the authors and these are the main topics as seen in Figure 10. It is understood that the concepts of EEG and brand extension are motor themes. This situation shows that neuroscientific tools are used limitedly in the studies conducted in the sense of neuromarketing.

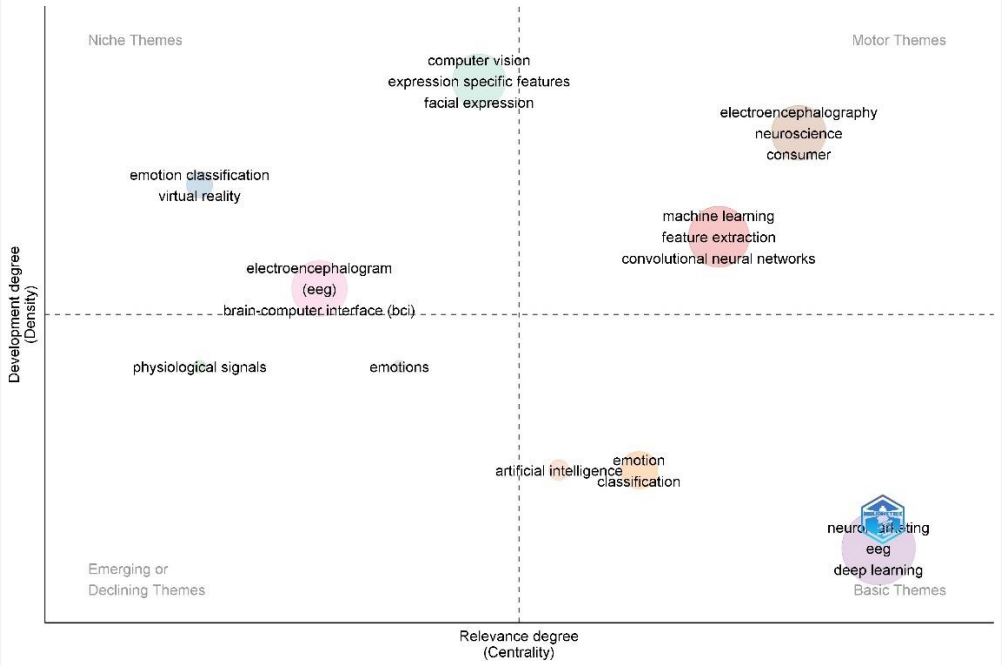
Figure 10. Conceptual Structure Map for Neuromarketing (According to Author Keywords)



However, in the thematic mapping made according to the keywords used by the authors in the studies on neuromarketing and artificial intelligence, it is seen in Figure 11 that the basic topics of neuromarketing, EEG, deep learning, artificial intelligence, and emotion classification are included together and that these are the basic topics. It is understood that the concepts of machine learning, feature extraction, EEG, and consumer neuroscience are motor themes. In addition, the concepts of emotion

classification, EEG, and brain-computer interface are niche concepts and they will be used much more frequently in the near future. This situation shows that more neuroscientific tools will be used in neuromarketing and artificial intelligence and the obtained data can be processed by artificial intelligence with the help of systems such as brain-computer interface.

Figure 11. Conceptual Structure Map for Neuromarketing and Artificial intelligence (According to Author Keywords)

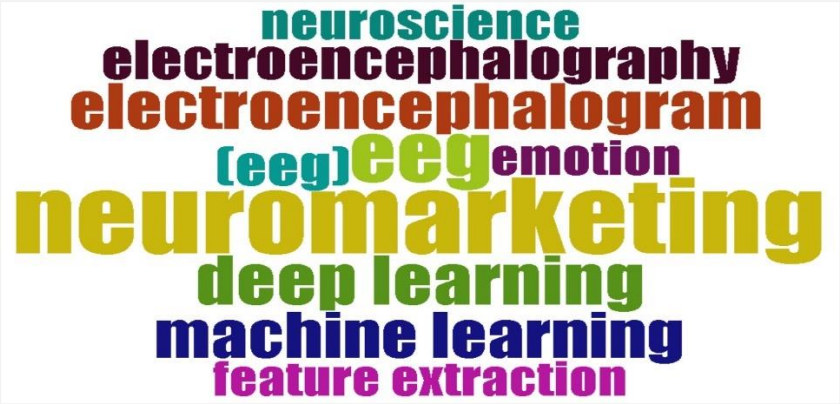


The most frequently used word cloud analysis based on author keywords is shown in Figure 12, where the most frequently used words in the field of neuromarketing are neuromarketing and EEG.

Figure 12. Neuromarketing Wordcloud

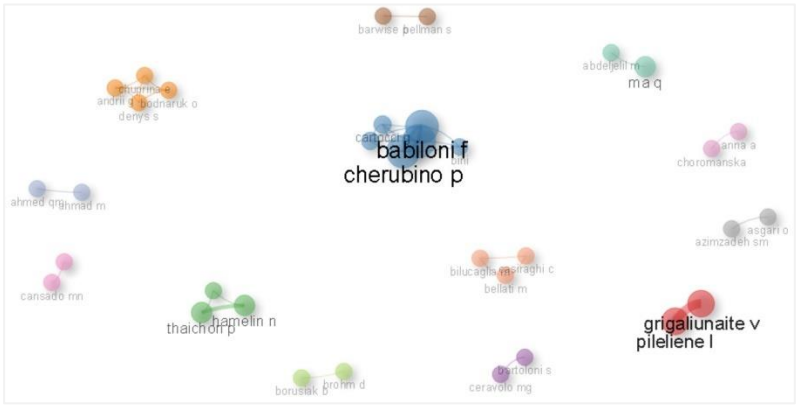
In the most frequently used word cloud analysis based on author keywords, it is seen in Figure 13 that the most frequently used words in the field of neuromarketing and artificial intelligence are neuromarketing, EEG, machine learning and deep learning. This shows that neuromarketing and artificial intelligence-based research is increasing.

Figure 13. Neuromarketing and Artificial Intelligence Wordcloud



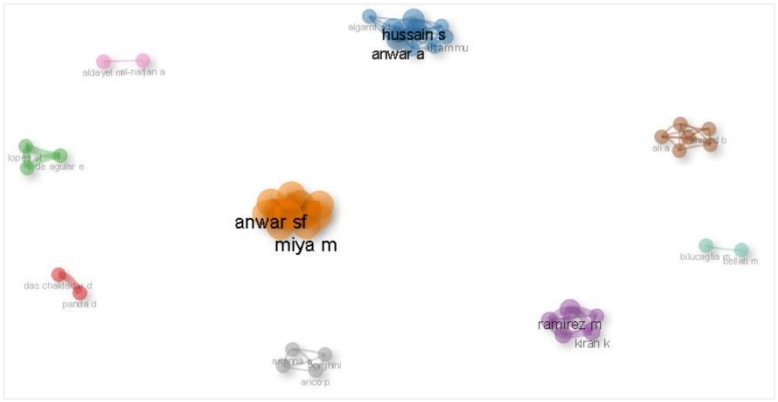
In the collaboration analysis conducted among the authors to examine the studies in terms of social structure, Cherubino and Babiloni stand out in the field of neuromarketing as seen in Figure 14. The connection consisting of 13 clusters, the fact that the nodes and connections in the collaboration are relatively high compared to other author collaborations, indicates that the studies are frequently conducted between certain authors and multidisciplinary approaches are limited.

Figure 14. Collaboration Network among Authors in Neuromarketing



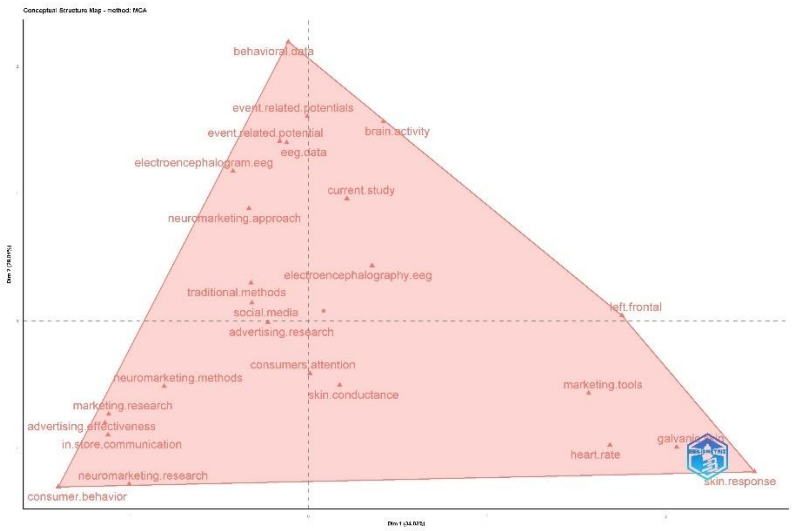
In the collaboration analysis conducted among the authors to examine the studies in terms of social structure, Anwar and Miya stand out in the field of neuromarketing and artificial intelligence as seen in Figure 15. In the connection consisting of 9 clusters, it is seen that Anwar is included in more than one cluster and the collaboration nodes and connections between the authors are high. This shows that the authors and multidisciplinary approaches are adopted more.

Figure 15. Collaboration Network among Authors in Neuromarketing and Artificial Intelligence



When the conceptual structure map of studies conducted in the field of neuromarketing is examined (according to Multiple Correspondence Analysis, Bigrams and Abstarcts analysis), it is seen in Figure 16 that the concepts of EEG, social media, advertising research are close to the center, but the concepts of galvanic skin, heart rate, skin conductance and neuromarketing research are far from the center. This situation indicates that neuroscientific tools have not yet been used sufficiently in neuromarketing research. According to factor analysis, it is understood that the concepts are gathered in a single cluster and different neuroscientific tools are not included.

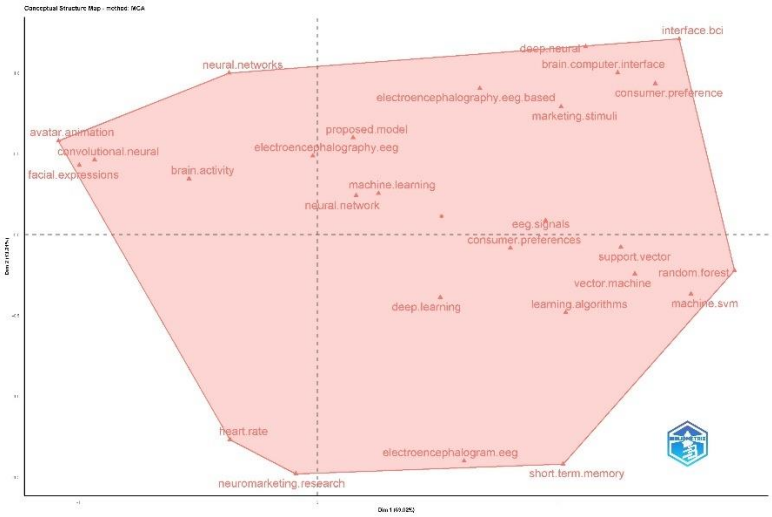
Figure 16. Neuromarketing Factor Analysis



When the conceptual structure map of studies conducted in the field of neuromarketing and artificial intelligence is examined (according to Multiple Correspondence Analysis, Bigrams and Abstarcts analysis), it is seen in Figure 17 that neuroscientific tools and approaches such as EEG, heart rate, facial expressions, brain activity and neural networks are included. At the same time, it is seen that concepts such as deep learning, machine learning, brain-computer interface also evoke approaches related to artificial intelligence and are collected under the same factor. This indicates that

neuroscientific tools are being used more in neuromarketing research and that the demand for processing the obtained data through artificial intelligence-based algorithms may gradually increase.

Figure 17. Neuromarketing and Artificial Intelligence Factor Analysis



6. DISCUSSION

When the studies conducted in the field of neuromarketing are examined, it is seen that neuroscientific tools are generally used with one or at most two tools. The most frequently used tools are EEG, ET and fMRI. Psychoneuroendocrinological approaches have been neglected in studies based on neurophysiological and neuropsychological activation data. However, individuals make decisions not only when making purchasing decisions but also by using their past experiences, emotions and thoughts when making many decisions. Therefore, these decisions may differ depending on the environment and external stimuli in which the person is located. The underlying reason for this is that neural activity makes decisions under the influence of hormones and brain chemicals (neurotransmitters) when exposed to any external stimulus (marketing stimuli). Because when the consumer makes a decision, the neural activity that occurs in the relevant brain region (Broadman areas) occurs together with the release of brain chemicals. It is understood that this situation is neglected in the studies. Another issue is that the studies are conducted using one or at most two tools. This is because experimental designs are assumed to be costly, time-consuming, and difficult. In addition, obtaining all the data at the same time is another difficulty when more than one tool is used. For example, the eye movements and facial muscle differences or neurophysiological activity of the participant during the response to visual, auditory, etc. stimuli should be recorded and evaluated simultaneously. Therefore, it is of particular importance for businesses and marketing researchers to make greater use of neuroscientific tools in neuromarketing research and to evaluate the obtained data with artificial intelligence-based applications. Although there are studies in this field, especially by Seranmadevi & Kumar, (2019), Sha & Rajeswari,

(2019), Tjepkema, (2019), Huang & Rust, (2021), Haleem et al. (2022), Villegas, (2023), it is understood that they are not yet at the desired level.

7. CONCLUSION AND RECOMMENDATIONS

Neuroscientific tools and methods have an important place in neuroscience research and have found a wide range of use in various scientific studies. However, a large portion of these studies focus on neurophysiological activity and generally prefer the use of single neuroscientific tools. This limited approach may prevent a full understanding of consumer thinking and behavior patterns. Neural activities triggered by marketing stimuli occur simultaneously in many regions of the brain and mind, and this can manifest itself in both physical behavior and psychological attitudes. Therefore, neuroscientific research needs to be conducted with more comprehensive and integrated methods. Studies conducted using low-cost methods and tools, integrating these tools with a common experimental design, and processing the obtained data with advanced algorithms such as artificial intelligence or machine learning are of great importance. Any neural activity in the human brain is not limited to a single phenomenon or action; it is a complex set of responses that emerge as a result of the interaction of more than one neural network. In order to process this complex data accurately and effectively, advanced technologies such as artificial intelligence, computer interfaces and machine learning that can analyze millions of data simultaneously are needed. Otherwise, the data collected manually will be limited and will only cover a certain time period, which may cause the findings to be misleading. For example, in studies conducted in the field of neuromarketing, brain imaging techniques (such as fMRI, EEG) are frequently used during the analysis of consumers' responses to marketing stimuli. As a result of the research, the assumption that more effective results can be obtained with the combined use of eye tracking, EEG and fMRI, which are the most commonly used tools in neuromarketing research, is consistent with the study conducted by Yağcı et al. (2013). Another finding obtained in the research is that the processing of information obtained from digital platforms and other media with artificial intelligence-based algorithms is compatible with the study by Bowen (2009) and Maxwell et al. (2011) in terms of understanding consumer behavior and processes. Analyzing the findings obtained with neuromarketing tools regarding consumer habits, purchasing behaviors, likes and dislikes with artificial intelligence applications can yield much more realistic results. This is consistent with the research of Chatterjee et al. (2019). Considering the authors and keywords obtained in bibliometric analysis, it is accepted as a result of the research that artificial intelligence is an innovative system that automatically analyzes the data produced by consumers for marketers and produces healthier results for businesses without the need for human intervention for analysis. This result is consistent with Perakakis et al. (2019). In the context of customer experience, AI, businesses, chatbots, virtual assistants, sentiment analysis, and predictive modeling benefit from a wide range of AI domains supported solutions. These results are consistent with Villegas (2023), Haleem et al. (2022), Huang & Rust, (2021), Seranmadevi & Kumar, (2019), Sha & Rajeswari, (2019) Tjepkema, (2019). Neuromarketing has the potential to be more cost-effective than traditional

methods and can reveal valuable insights during the product design phase. This has an important place in reducing costs. These findings obtained in the research are similar to Ariely & Berns, (2010), Fortunato et al. (2014). As a result of comparing the studies conducted with neuroscientific tools and methods in the literature, it was revealed in the studies conducted by Tjepkema, (2019) and Huang & Rust, (2021) that evaluating the findings obtained only by human hands is difficult, costly, time-consuming and ineffective. As a result of the research, it was concluded that using only neuroscientific tools alone is not sufficient and that it is inevitable to benefit from machine learning, deep learning and artificial intelligence-based applications of the information obtained.

However, the use of these techniques alone is limited to monitoring activities in certain regions of the brain and cannot fully reflect the holistic functioning of the brain. Since there is an effort to access more than one piece of information in studies, it is necessary to use more than one neuroscientific method, tool and approach in studies. The main reason for this is that while only brain activities can be monitored with brain imaging techniques, different tools and methods need to be used together to examine other physiological reactions. For example, while brain activities are observed with EEG or fMRI, heat increases in the skin can be monitored with galvanic skin conductance, and changes in the autonomic nervous system can be examined with heart rate. Thanks to such a holistic approach, it is possible to understand the neurophysiological, psychological and biological reasons of consumer behavior much better. However, considering the size of the data obtained from the methods and tools used, it is quite difficult to process these data together (correlation or regression). Because the data in the data set is quite large. At this point, it is much easier and much more realistic to process such large data and derive meaningful results thanks to machine learning and artificial intelligence. Making large and complex data sets understandable not only within themselves but also in their relationships with each other with hidden patterns and structures with mathematical formulas provides a much better understanding of consumer emotions, cognition, thoughts and behaviors. In this way, neuromarketing guides marketing managers to reveal the deficiencies or flaws of a product or service that has not yet entered the production phase or to make more effective sales. However, research in the field of neuromarketing requires the coordinated work of researchers who are experts in the fields of neuroscience, marketing, psychology, data science, computer engineering and artificial intelligence. Because neuromarketing requires adopting a multidisciplinary approach. Otherwise, as in previous studies, some of the reasons behind consumer emotions, thoughts, cognition and behavior will always remain missing. Therefore, in neuromarketing research, more than one neuroscientific tool (ET, EEG, EMG, fMRI, ECG, GSR, heart beat, TMS etc.) should be used together and the obtained data should be evaluated together with artificial intelligence-based applications. Working together with experts from different fields will add depth to the research to be conducted and will enable the emergence of innovative solutions. In addition, it is important for marketers who want to conduct neuromarketing research to receive a certain level of neuroscience education. The main reason for this is that knowing

neuroscience at a certain level will add depth and richness to the studies so that the neuroscientific tools and methods used in the research can be used more effectively in the studies.

As a result, the use of more neuroscientific tools and methods together in studies to be conducted in the field of neuromarketing and the processing of the obtained data with machine learning, deep learning, and artificial intelligence applications will allow for a much better understanding of consumer behavior and processes. The adoption of a multidisciplinary approach and innovative technologies in future studies will take neuromarketing science to a much more advanced level than it is today. In order to better understand consumer behavior, decision-making, habits and tendencies, artificial intelligence-based applications in neuromarketing research should be used in marketing research. In this way, it will be easier to produce and implement consumer-centered, goal-oriented, high-satisfaction, cost-effective marketing strategies. This will not only increase the profitability of businesses, but will also allow for happier and more loyal customer relationships.

The study does not necessitate Ethics Committee permission.

The study has been crafted in adherence to the principles of research and publication ethics.

The author declares that there exists no financial conflict of interest involving any institution, organization, or individual(s) associated with the article.

The entire work was carried out by its only, stated author.

REFERENCES

Abbott, D. (2014). *Applied predictive analytics: Principles and techniques for the professional data analyst.* Wiley.

Al, U., Sezen, U., & Soydal, İ. (2019). *Türkiye'nin bilimsel yayınlarının sosyal ağ analizi yöntemiyle değerlendirilmesi.* Hacettepe Üniversitesi Proje Raporları No: 110K044.

Aldayel, M., Ykhlef, M., & Al-Nafjan, A. (2020). Deep learning for EEG-based preference classification in neuromarketing. *Applied Sciences*, *10*(4), 1525.

Aldayel, M., Ykhlef, M., & Al-Nafjan, A. (2021). Recognition of consumer preference by analysis and classification EEG signals. *Frontiers in Human Neuroscience*, *14*, 604639.

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959-975.

Ariely, D., & Berns, G. S. (2010). Neuromarketing: The hope and hype of neuroimaging in business. *Nature Reviews Neuroscience*, *11*(4), 284-292.

Bhandari, A. (2020). Neuromarketing Trends and opportunities for companies. In *Analyzing the Strategic Role of Neuromarketing and Consumer Neuroscience* (pp. 82-103). IGI Global.

Binodl, S., & Jothi, G. (2020). Customer's perception towards neuromarketing techniques adopted by Indian brands. *Studies in Indian Place Names, 40*(12), 1304-1307.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27-40.

Brenninkmeijer, J., Schneider, T. & Woolgar, S. (2020). Witness and silence in neuromarketing: Managing the gap between science and its application. *Science, Technology, & Human Values, 45*(1), 62-86.

Burgos-Campero, A. & Vargas-Hernandez, J. (2013). Analitical approach to neuromarketing as a business strategy. *Procedia - Social and Behavioral Sciences*, (99), 517-525.

Cannella, J. (2018). *Artificial Intelligence in marketing* [Unpublished Honors Thesis for Barrett], The Honors College at Arizona State University.

Cárdenas, G. (2019). Neuromarketing as an effective tool for education in sales and advertising. *Revista Latina de Comunicación Social*, (74), 1173-1189.

Chatterjee, S., Ghosh, S. K., Chaudhuri, R., & Nguyen, B., (2019). Are CRM systems ready for AI integration? A conceptual framework of organizational readiness for effective AI-CRM integration. *The Bottom Line*, (32), 144-157.

Clifton R., (2014). *Markalar ve markalaşma* (Çev. Meral Çiyan Şenerdi), Kültür Yayınları.

Conejo, F., Khoo, C., Tanakinjal, G. & Yang, L. (2007). Neuromarketing: Will it revolutionise business? *International Journal of Business and Management*, *2*(6), 72-76.

Cosic, D. (2016). Neuromarketing in market research. *Interdisciplinary Description of Complex Systems: INDECS*, *14*(2), 139-147.

De Oliveira, J. & Giraldi, J. (2017). What is neuromarketing? A proposal for a broader and more accurate definition. *Global Business and Management Research: An International Journal*, *9*(2), 19-29.

Duque-Hurtado, P., Samboni-Rodriguez, V., Castro-Garcia, M., Montoya-Restrepo, L. A., & Montoya-Restrepo, I. A. (2020). Neuromarketing: Its current status and research perspectives. *Estudios Gerenciales (Journal of Management and Economics for Iberoamerica)*, *36*(157), 525-539.

Elia, G., Margherita, A., & Passiante, G. (2020). Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process. *Technological Forecasting and Social Change*, 150, 119791.

Fortunato, V., Giraldi, J. & De Oliveira, J. (2014). A Review of studies on neuromarketing: Practical results, techniques, contributions and limitations. *Journal of Management Research*, *6*(2), 201-220.

Galandi, N., Briesemeister, B. B., Kant, T., & Hagen, D. (2022). Beyond neuromarketing: How neuroscience is penetrating new areas of business. *Neuromarketing in Business: Identifying Implicit Purchase Drivers and Leveraging them for Sales*, 109-125.

Gangadharbatla, H., Bradley, S., & Wise, W. (2013). Psychophysiological responses to background brand placements in video games. *Journal of Advertising*, *42*(2-3), 251-263.

Golnar-Nik, P., Farashi, S., & Safari, M. S. (2019). The application of EEG power for the prediction and interpretation of consumer decision-making: A neuromarketing study. *Physiology & Behavior*, *207*, 90-98.

Grajdieru, E. (2017). Neuromarketing and its internal marketing applications. *Bulletin of the Transilvania University of Brasov. Series V: Economic Sciences*, 17-24.

Gupta, R., & Falk, T. H. (2016). Relevance vector classifier decision fusion and EEG graph-theoretic features for automatic affective state characterization. *Neurocomputing*, (174), 875-884.

Haenlein, M., & Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of Artificial Intelligence. *California Management Review*, *61*(4), 5-14.

Håkansson, H., Ford, D., Gadde, L.-E., Snehota, I. and Waluszewski, A. (2009). *Business in networks*. Wiley.

Haleem, A., Javaid, M., Qadri, M. A., Singh, R. P., & Suman, R. (2022). Artificial Intelligence (AI) applications for marketing: A literature-based study. *International Journal of Intelligent Networks.*

Halkin, A. (2018). Emotional state of consumer in the urban purchase: Processing data. *Foundations of Management*, *10*(1), 99-112.

Han, R., Lam, H. K., Zhan, Y., Wang, Y., Dwivedi, Y. K., & Tan, K. H. (2021). Artificial intelligence in business-to-business marketing: a bibliometric analysis of current research status, development and future directions. *Industrial Management & Data Systems*, *121*(12), 2467-2497.

Hilken, T., Chylinski, M., de Ruyter, K., Heller, J., & Keeling, D. I. (2022). Exploring the frontiers in reality-enhanced service communication: from augmented and virtual reality to neuro-enhanced reality. *Journal of Service Management*, *33*(4/5), 657-674.

Huang, M. H., & Rust, R. T. (2021). A strategic framework for artificial intelligence in marketing, *Journal of the Academy of Marketing Science*, *49*(1), 30-50

Huang, M.H. & R.T. Rust. (2018), Artificial Intelligence in Service, *Journal of Service Research*, 21(2), 155-172.

IBM THINK Blog. (2017). *Transparency and trust in the cognitive era*. IBM.

Jai, T. M., Fang, D., Bao, F. S., James III, R. N., Chen, T., & Cai, W. (2021). Seeing it is like touching it: unraveling the effective product presentations on online apparel purchase decisions and brain activity (an fMRI study). *Journal of Interactive Marketing*, *53*(1), 66-79.

Jarek, K. & G. Mazurek (2019), Marketing and Artificial Intelligence. *Central European Business Review, 8*(2), 46-55.

Kelleher, J. D. (2019). *Deep learning*. The MIT Press.

Khushaba, R. N., Greenacre, L., Kodagoda, S., Louviere, J., Burke, S., & Dissanayake, G. (2012). Choice modeling and the brain: A study on the Electroencephalogram (EEG) of preferences. *Expert Systems with Applications, 39*(16), 12378-12388.

Kietzmann, Paschen & Treen. (2018). Artificial intelligence in advertising: How marketers can leverage artificial intelligence along the consumer journey. *Journal of Advertising Research*, *58*(3), 263-267.

Krauskopf, E. (2018). A bibliometric analysis of the Journal of Infection and Public Health: 2008–2016. *Journal of Infection and Public Health, 11*(2), 224-229

Kumar, B., Sharma, A., Vatavwala, S., & Kumar, P. (2020). Digital mediation in business-to-business marketing: A bibliometric analysis. *Industrial Marketing Management*, (85), 126-140.

Kumar, S. (2015). Neuromarketing: The new science of advertising. *Universal Journal of Management 3*(12), 524-531.

Lajante, M., Droulers, O., Dondaine, T., & Amarantini, D. (2012). Opening the "black box" of electrodermal activity in consumer neuroscience research. *Journal of Neuroscience, Psychology, and Economics*, *5*(4), 238.

LaPlaca, P.J. & A. Lindgreen (2016), Letter from the Editors, *Industrial Marketing Management*, (53), 1-2.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature, 521*(7553), 436-444. https://doi.org/10.1038/nature14539

Lee, J., Suh, T., Roy, D., & Baucus, M. (2019). Emerging technology and business model innovation: The case of artificial intelligence. *Journal of Open Innovation: Technology, Market, and Complexity*, *5*(3), 44.

Lee, N., Broderick, A. J., & Chamberlain, L. (2007). What is 'neuromarketing'? A discussion and agenda for future research. *International Journal of Psychophysiology*, *63*(2), 199-204.

Lim, W. M. (2018). Demystifying neuromarketing. *Journal of Business Research*, (91), 205-220.

Lopes, A. T., De Aguiar, E., De Souza, A. F., & Oliveira-Santos, T. (2017). Facial expression recognition with convolutional neural networks: coping with few data and the training sample order. *Pattern Recognition*, *61*, 610-628.

Maxian, W., Bradley, S. D., Wise, W., & Toulouse, E. N. (2013). Brand love is in the heart: Physiological responding to advertised brands. *Psychology & Marketing*, *30*(6), 469-478.

Maxwell, A. L, Jeffrey, S. A, & Lévesque, M. (2011). Business angel early stage decision making. *Journal of Business Venturing*, *26*(2), 212-225.

McCarthy, J., Minsky, M., Rochester, N., & Shannon, C. (1955, August 31). *A proposal for the Dartmouth summer research project on artificial intelligence*. Stanford. http://www.formal.stanford.edu/jmc/history/dartmouth/dartmouth.html

McCorduck, P. (1982), *Machines who think: A personal inquiry into the history and prospects of Artificial Intelligence,* AK Peters/CRC Press.

Meckl-Sloan, C. (2015). Neuroeconomics and neuromarketing, *International Journal of Business Management and Economic Research (IJBMER), 6*(2), 133-136

Mouline, A. (2019). *Understanding consumers' psychological behavior through neuroscience*. [Unpublished Master's Thesis]. Seinajoen Ammattikorkeakoulu Seinajoki University of Applied Sciences.

Mustak, M., Salminen, J., Plé, L., & Wirtz, J. (2021). Artificial intelligence in marketing: Topic modeling, scientometric analysis, and research agenda. *Journal of Business Research*, 124, 389-404.

Nazım Sha, S. & Rajeswari, M. (2019). Vosag teknolojisi yardımıyla yapay zeka kullanarak E-ticaret işinde marka değeri ve tüketici memnuniyeti yaratmak. *Uluslararası Yenilikçi Teknoloji ve Araştırma Mühendisliği Dergisi ,8*(8), 1510-1515.

Nemorin, S. & Gandy, Jr., O. (2017). Exploring neuromarketing and its reliance on remote sensing: Social and ethical concerns. *International Journal of Communication*, 11, 4824–4844.

Ohme, R., Reykowska, D., Wiener, D., & Choromanska, A. (2010). Application of frontal EEG asymmetry to advertising research. *Journal of economic psychology*, *31*(5), 785-793.

Oikonomou, V. P., Georgiadis, K., Kalaganis, F., Nikolopoulos, S., & Kompatsiaris, I. (2023). A sparse representation classification scheme for the recognition of affective and cognitive brain processes in neuromarketing. *Sensors*, *23*(5), 2480.

Rawnaque, F. S., Rahman, K. M., Anwar, S. F., Vaidyanathan, R., Chau, T., Sarker, F., & Al Mamun, K. (2020). Ttechnological advancements and opportunities in neuromarketing: A systematic review. *Brain Informatics*, *7*(10), 1-19.

Saxon, J. (2017). *Why your customers' attention is the scarcest resource in 2017*. IE School of Human

Schmidhuber, J. (2015). Deep learning in neural networks: An overview. *Neural networks*, 61, 85-117.

Sebastian, V. (2014). Neuromarketing and evaluation of cognitive and emotional responses of consumers to marketing stimuli. *Procedia - Social and Behavioral Sciences*, 127, 753-757.

Smart Insights. (n.d.). Artificial Intelligence (AI) for marketing. Smart Insights. https://www.smartinsights.com/tag/artificial-intelligence-ai-for-marketing/

Senior, C. & Lee, N. (2008). Editorial: A manifesto for neuromarketing science. *Journal of Consumer Behaviour*, *7*, 263-271.

Seranmadevi, R., & Kumar, A. (2019). Experiencing the AI emergence in Indian retail–Early adopters approach, *Management Science Letters*, *9*(1). 33-42.

Shukla, S. (2019). Neuromarketing: A change in marketing tools and techniques. *International Journal of Business Forecasting and Marketing Intelligence*, *5*(3), 267-284.

Singh, S. (2020). Impact of neuromarketing applications on consumers. *Journal of Business and Management, 26*(2), 33-52.

Somervuori, O., & Ravaja, N. (2013). Purchase behavior and psychophysiological responses to different price levels. *Psychology & Marketing*, *30*(6), 479-489.

Songur A. (2022). Aşkın nöroanatomisi. *LabMedia Magazine*, *13*(77), 26-27.

Stanton, S., Sinnott-Armstrong, W. & Huettel, S. (2017). Neuromarketing: Ethical implications of its use and potential misuse. *Journal of Business Ethics*, 144(4), 799-811.

Stas, A., Songa, G., Mauri, M., Ciceri, A., Diotallevi, F., Nardone, G. & Russo, V. (2018). Neuromarketing empirical approaches and food choice: A systematic review. *Food Research International*, 108, 650-664 https://doi.org/10.1016/j.foodres.2017.11.049

Statista, (2024). *Distribution of advertising spending worldwide in 2023*. Statista. https://www.statista.com/statistics/269333/distribution-of-global-advertising-expenditure/

Thomas, A. R., Pop, N. A., Iorga, A. M., & Ducu, C. (2017). *Ethics and neuromarketing. Implications for Market Research and Business Practice.* Springer.

Tjepkema, L. (2019). *What is artificial intelligence marketing & why is it so powerful*. Emarsys. https://emarsys.com/learn/blog/artificial-intelligence-marketing-solutions/

Ural, T. (2008). Pazarlamada yeni yaklaşım: Nöropazarlama üzerine kuramsal bir değerlendirme. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *17*(2), 421-432.

Van Esch, P. & J. Stewart Black (2021), Artificial Intelligence (AI): Revolutionizing digital marketing. *Australasian Marketing Journal, 29*(3), 199-203.

Venkatraman, V., Dimoka, A., Pavlou, P. A., Vo, K., Hampton, W., Bollinger, B., ... & Winer, R. S. (2015). Predicting advertising success beyond traditional measures: New insights from neurophysiological methods and market response modeling. *Journal of Marketing Research*, *52*(4), 436-452.

Villegas, F., (2023). *Artificial Intelligence customer experience: What is it, pros, cons and best tools*. QuestionPro. https://www.questionpro.com/blog/ai-customer-experience/

Wilson, R., Gaines, J. & Hill, R. (2008). Neuromarketing and consumer free will. *Journal of Consumer Affairs, 42*(3), 389-410.

Wirtz, J. (2021), Artificial Intelligence in marketing: Bibliometric analysis, topic modeling and research agenda, *Journal of Business Research*, (124), 389-404.

Yağci, M. I., Kuhzady, S., Balik, Z. S., & Öztürk, L. (2018). In search of consumer's black box: a bibliometric analysis of neuromarketing research. *Tüketici ve Tüketim Araştırmaları Dergisi*, *10*(1), 101-134.

Yasir, F. & Haq, M.A.U. (2022). Neuromarketing-seeing the unseen: Effect of in-store category artwork, structures and packaging on shopper's buying behaviors in Pakistan. *Journal of Marketing Strategies, 4*(2), 227-245.

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods, 18*(3), 429- 472.