



Review

Green concept of neuromarketing based on a systematic review using the bibliometric method

Negin Sangari¹, Payvand Mirzaeian Khamseh¹ and Shib Sankar Sana^{2,*}

¹ Department of Management, Faculty of Social Sciences and Economics, Alzahra University, Tehran, Iran

² Department of Mathematics, Kishore Bharati Bhagini Nivedita College, Ramkrishna Sarani, Behala, Kolkata, 700060, India

* **Correspondence:** Email: shib_sankar@yahoo.com.

Abstract: Unlike traditional marketing methods, neuromarketing has shown new insights and higher prediction accuracy. This research uses the bibliometric method to analyze the objectives like the analysis and integration of the green concept of neuromarketing, recognition of the useful authors, the years of publication of documents, authoritative journals that publish articles in this field and keywords around the concept of neuromarketing. The tools presented in neuromarketing expand and improve the perception of the enthusiasts and researchers in this field, and it compares the results obtained from different approaches. From the methodological point of view, this research is qualitative and based on Iden et al.'s (2017) model, consisting of four steps of planning, selecting, extracting and implementing and combining it with setting of Silva's (2015) articles in the form of a review. A bibliometric system is implemented, and VOS viewer software was used to analyze the results.

The findings are presented in two phases. In the first phase, the performance analysis, the share of the annual production of neuromarketing documents, the percentage of the production of authoritative quarterly journals of this field, the share of the output of related subject areas, the share of the countries' published articles and the share of the documents by productive authors were identified and studied. Also, knowledge maps were drawn in the second phase, and 17 clusters are found, including 109 items and 131 keywords. The theoretical contribution of this article consists of the field of green neuromarketing, which is categorized into four clusters with themes of sustainability and green consumption. The results of this study were obtained based on the framework of theory, context, method, antecedents, decisions, and outcomes. All the keywords related to neuromarketing were categorized from the analysis of the previous articles and its features were studied in the proposed model.

Keywords: systematic review; neuromarketing; bibliometrics; VOS viewer; drawing knowledge maps

JEL Codes: G41, M31, Z33

1. Introduction

Global trade in goods is predicted to expand at rates of 1.7% in 2023 and 3.2% in 2024. Additionally, the value of international trade in commercial services could rise by 15% to 6.8 trillion USD in 2022 (WTO, 2023). However, there are drawbacks to the quick pace of economic growth, such as the depletion of natural resources and environmental degradation (Adebayo, 2023), and the ongoing environmental degradation is now a concern for both developed and developing regions worldwide. Green consumption behavior is a pro-social behavior that contributes to the sustainable development of the environment and society and is expected to become a new driving force for sustainable economic growth (Wei et al., 2023).

On the other hand, in recent years, studies in the field of neuromarketing have become very widespread, and this concept has also experienced in exponential growth (de Oliveira and Giraldo, 2017; Zhu et al., 2022; Zhang et al., 2023; Lee et al., 2018). Marketers and managers have had access to a variety of commercial applications thanks to neuromarketing for more than 15 years (Hakim et al., 2021). Doing so allows for the evaluation of consumers' emotional and cognitive reactions (Zhao et al., 2022), which lowers administrative costs (Baldo et al., 2022). It is the latest technique to understand consumers' preferences, eventually leading to a greater understanding of human cognition and integration of biological and social sciences (Vyas & Seal, 2022).

In the last decade, the understanding of decision-making and consumer behavior from neurophysiologic methods such as electroencephalography, galvanic skin response, heart rate, facial expressions and functional magnetic resonance imaging has also increased significantly (Baldo et al., 2022; Figner et al., 2019; Stillman et al., 2020). Measuring neural and physiological activity is vital to predict consumers' preferences and future decision or assess of the success of marketing (Hakim et al., 2021).

At the beginning of the entry of neuroscience methods into marketing, there was a question among the thinkers of this field whether the introduction of neuroscience topics into the field of marketing management is necessary and valuable in the marketing management systems (Kansra et al., 2022; Rawnaqueet al., 2020; Plassmann et al., 2015; Fortunato et al., 2014; Solnais et al., 2013). In addition, researchers' understanding of neuromarketing was somewhat different, and there was no consensus because researchers in this part of neuroscience often lacked sufficient knowledge to conduct research (Zhu et al., 2022). Therefore, despite the many advantages of neuromarketing compared to traditional methods, its adoption has been very slow, accompanied by severe challenges and doubts (Plassmann et al., 2015; Stanton et al., 2017). There is a need to critically discuss whether neuroscience has the potential to serve marketing effectively (Lee et al., 2018).

However, some other studies have shown that compared to traditional marketing, predicting consumer behavior in marketing (Knutson and Genevsky, 2018; Krampe et al., 2018; Motoki et al., 2020) through neuroscience is more scientific (Berkman and Falk, 2013; Smidts et al., 2014; Lee et al., 2018). Despite the benefits of these tools, it can be inferred from their findings that questionnaires, focus groups and interviews frequently fall short of producing quantitative and accurate measures for

prediction, that it can be challenging to put together representative focus groups and that they are not entirely confidential or anonymous (Hakim et al., 2021). Therefore, they are less suitable for evaluating consumers' perception, and thus, a more detailed, specialized and comprehensive empirical investigation is crucial (Kolar et al., 2021).

In addition, due to the lack of integrated studies among all types of methods and seeking to clarify the effectiveness of each of these methods, there is a need for more and more extensive studies (Baldo et al., 2022), which the importance of expanding studies around neuromarketing reveals (Zhu et al., 2022). Therefore, this lack of coordination in the basic definitions of neuromarketing and doubt in the practical application of neuroscience methods has led to misleading research (Plassmann et al., 2012; Lee et al., 2018). In this study, the researchers seek to fill this theoretical void through a systematic review of neuromarketing (Hsu, 2017; Hsu & Cheng, 2018; Lim, 2018; Hamelin et al., 2020; Garczarek-Bąk et al., 2021; Luna-Nevarez, 2021; Frederick, 2022) in reliable databases such as Scopus and Web of Science and searching among reputable journals with rankings, two, three, four and four-star ABS (Association of Business Schools) list and their science metrics should be implemented and corrected in the community's VOS (Visualization of Similarities) viewer software.

One of the refined definitions of neuromarketing, which is contrasted with traditional marketing methods, was established by de Oliveira and Giraldi (2017), based on Plassmann et al.'s (2015) studies, and it is signal recording technology and non-invasive brain imaging to obtain consumer feedback directly on marketing stimuli (Fortunato et al., 2014; Lee et al., 2017; Nilashi et al., 2020; Rawnaque et al., 2020; Zhu et al., 2022). Usually, non-invasive brain signal recording technology is used to study attention and present and analyze user experiences concerning the effectiveness of advertisements (Bakalash and Riemer, 2013; Adil et al., 2018; Clark et al., 2018), including soft data analysis software that is usually used in scientometrics, such as VOS viewer, SALSA, PRISMA and Cite Space (Zhu et al., 2022).

Therefore, we sought to answer the question of how the integration of previous studies in the field of neuromarketing can categorize the green views of consumers. Consequently, we sought to understand the current state of research in the field of neuromarketing and to clarify the importance of what level of neuromarketing is in related research. We pursue the following main objectives: a) analyzing and integrating the concept of neuromarketing, b) recognizing productive authors, years of document publication, authentic journals publishing articles in this field and keywords around this concept, c) introducing the methods and tools of neuroscience (Gountas et al., 2019; Pagan et al., 2020; Ćirović et al., 2022) in marketing and d) expanding and improving the perceptions of the interested and researchers in this field by examining and comparing the results.

In the following, we have used a five-step process: 1) a review of the theoretical literature and review of the background of neuromarketing, 2) a systematic review to select valid scientific articles in the field of neuromarketing and their analysis, 3) finding the answer to the central question of this research of creating a deep and integrated understanding of the concept of neuromarketing, 4) knowing the tools and methods of neuroscience in marketing and 5) summarizing, analyzing and presenting key findings. Along with practical suggestions for conducting future research, the explanation and integration of the concept of neuromarketing is discussed in this article.

The paper presents an integrated framework merging neuromarketing with a green perspective, offering insights into the relationship between neural processes and consumer decision-making. By combining neuroimaging data and physiological measurements, it delves into emotional reactions and how neural responses influence consumer preferences. Additionally, the paper analyzes publication trends and collaboration patterns, highlighting the global nature of neuromarketing research and

discussing emerging themes. This contribution aids in understanding the field's evolution, current state and potential future directions.

2. Literature review

2.1. Neuromarketing

Lee et al. (2007) defined neuromarketing as using neuroscience methods, including psychology and direct brain activity, to analyze and understand human behavior related to marketing actions. However, the word “neuromarketing” was first introduced in June 2002 by an advertising company in the United States (Zhu et al., 2022). In the most recent book published in this field, Halkiopoulou et al. (2022) described neuromarketing as a growing multidisciplinary field that combines consumer behavior, neuroscience and economics to target industries with new and more effective methods than traditional marketing which is armed in response to changing market conditions. Therefore, neuromarketing is an interdisciplinary research field that seeks to explain conscious and unconscious emotional, cognitive, physiological and psychological reactions, behaviors and thoughts related to marketing and its various sub-fields (de Oliveira and Giraldo, 2017; Zhu et al., 2022). Usually, in this part of marketing, neural marketing technologies are used to discover consumer preferences, which have attracted a lot of interest and attention from marketing research companies (Murphy et al., 2008). The techniques, which are used to study attention, emotional memory and user experience in advertising (Bakalash and Reimer, 2013; Adil et al., 2018; Clark et al., 2018), consist of fMRI (Gómez-Carmona et al., 2022; De Vries et al., 2018; Motoki et al., 2019) functional magnetic resonance imaging, electroencephalography (EEG) (Kirschstein & Köhling, 2009), positron emission tomography (PET), magnetoencephalography (MEG), transcranial magnetic stimulation (TMS), galvanic skin response (GSR) and eye tracking (Zhu et al., 2022). In this study, we seek to systematically examine and integrate the positions of each of these concepts and tools among international studies in the form of functional analysis and drawing knowledge maps. The following will discuss the empirical background of the articles related to neuromarketing.

2.2. Sustainable development goals

For achieving the 2030 UN goals for sustainable development, the United Nations (UN) proposed 17 Sustainable Development Goals (SDGs) in 2015, totaling 169 targets. These objectives cover a wide range, from climate change to poverty (Qazi et al., 2023; Nasir et al., 2023). Ensuring sustainability (Bandari et al., 2022) means meeting the needs of the present generation while also protecting the ability of future generations to meet their own needs (Pérez-Martínez et al., 2023). It involves embracing environmentally sustainable and socially responsible strategies for managing resources, fostering economic progress and promoting social fairness (Aly et al., 2022). In order to achieve a more sustainable and inclusive world, the SDGs constitute an ambitious agenda that calls for action at all levels, from local to worldwide, as well as the active engagement of governments, civil society, corporations and individuals (Biglari et al., 2022).

2.3. Corporate social responsibility

Corporate social responsibility (CSR) has been a popular research topic in management since the 1950s (Bergamaschi and Randerson, 2016; Mariani et al., 2023). Scholars have defined CSR in various ways, reflecting changes in social movements related to civil rights and environmental issues (Carroll, 2016; Mariani et al., 2023). Corporate social responsibility (CSR) refers to a company's efforts to incorporate eco-friendly practices into its stakeholder-focused management strategies, while also addressing concerns that are important to stakeholders; and it encompasses economic, regulatory, voluntary and ethical aspects and involves a company's activities, processes and relationships with stakeholders (Mariani et al., 2023).

This approach aims to help businesses achieve their identified Sustainable Development Goals (SDGs) as well (Le, 2023). Based on the stakeholder framework, corporate social responsibility (CSR) can be classified into two categories. The first is internal CSR, which concerns employees, while the second is external CSR, which covers consumers, suppliers, actors in the distribution system, partners and the ecosystem (Farooq et al., 2017). According to a study, adopting management practices that prioritize external stakeholders can promote eco-friendly behavior in the supply chain and meet their expectations. This, in turn, can improve employees' attitudes toward the business (Le, 2023).

2.4. Sustainable consumption

Sustainability is a societal goal that seeks to ensure long-term human coexistence on Earth (Ghaffar & Islam, 2023). As consumers play an important role in the transition to a sustainable consumption pattern (Piracci et al., 2023), sustainability is a way of life that reduces negative environmental effects while also allowing people, households, communities and even the entire world to live fulfilling lives (Mishra et al., 2021). Furthermore, sustainable consumption (SC) refers to using products and services in order to limit their negative impact on the environment while meeting human needs both now and in the future (Marzouk & Mahrous, 2020).

Consumers interested in health and those concerned with environmental issues were discovered to have the same identity profile. Because private values, such as healthiness and price, appeal to the majority of consumers, marketers and policymakers are recommended to build on such features to promote sustainable consumption rather than depending just on sustainability values to be sufficient (Piracci et al., 2023).

2.5. The empirical background of the research

Baldo et al. (2022), in an article titled "The Heart, Brain, and Body of Marketing: Complementary Roles of Neurophysiologic Measures in Tracking Emotions, Memory, and Ad Effectiveness," reported that heart rate interval was associated with emotional valence, while the skin conductance response was related to emotional arousal in all types of stimuli and has a complementary role in predicting the effectiveness of advertisements.

In their 2021 article "How Moment-to-Moment EEG Measures Enhance Ad Effectiveness Evaluation: Peak Emotions During Branding Moments as Key Indicators," Kolar et al. (2021) showed that moment-to-moment electroencephalography advertising indicators like the peak of emotion during branding moments increased the effectiveness of advertising.

In their study “Machines Learn Neuromarketing: Improving Preference Prediction from Self-Reports Using Multiple EEG Measures and Machine Learning,” Hakim et al. (2021) found that the most predictive electroencephalographic measures were frontal power in the alpha band, hemispheric asymmetry in the beta band and inter-subjective correlation in the delta and alpha bands.

Savelli et al. (2022) in their “How to Communicate Typical–Local Foods to Improve Food Tourism Attractiveness,” used neuroscience techniques, including implicit priming testing, eye tracking and electroencephalography. They found that health was the most attractive feature. After that, the geographical indications and stability were perceived as the most attractive features of the typical local food product.

Jai et al. (2021), in their study “Seeing It Is Like Touching It: Unraveling the Effective Product Presentations on Online Apparel Purchase Decisions and Brain Activity (An fMRI Study),” used machine learning, looking for an answer to the question of whether different neural circuits are involved in purchasing decisions according to different types of visual sensory information or not. The results showed that functional neuroimaging accuracy is high in predicting purchase decisions using brain activity in product evaluation. This study clarified that areas of the brain (such as the cerebellum) are less relevant to purchase decisions but are influential in predicting online apparel purchase decisions in the context of product rotation video viewing.

In their study “Can Neuromarketing Add Value to the Traditional Marketing Research? An Exemplary Experiment with Functional Near-Infrared Spectroscopy (fNIRS) (Shen & Morris, 2016; Cakir et al., 2018),” Meyerding and Mehlhose (2020) aimed to determine the feasibility of an infrared spectroscopy system and performed two experiments. The results showed that it is possible to measure the activation of the brain’s frontal cortex related to the brand using fNIRS, so its use can reduce the costs of neuroimaging.

Levallois et al.’s (2021) study, entitled “The Emergence of Neuromarketing Investigated Through Online Public Communications,” through a systematic review, sought to clarify whether neuromarketing separately as an academic discipline and as an industry (with a transfer of knowledge from the first to the second) was developed or was a joint creation action. The results showed that neuromarketing had developed an identity through a set of practices and debates that engage interwoven communities of academic researchers and practitioners.

Ramsøy (2019) conducted a systematic review entitled “Building a Foundation for Neuromarketing and Consumer Neuroscience Research: How Researchers Can Apply Academic Rigor to the Neuroscientific Study of Advertising Effects” to provide an essential foundation for the use of neuroscience and related methods in the study of advertising effects.

This study has three foundations: 1) distinction between basic, translational and applied research; 2) conceptual explanation; and 3) a framework for validating neuroscience-based criteria as a solid scientific foundation and a valid discipline for researchers, practitioners and purchasers of commercial neuroscience methods. In the continuation of the theoretical literature and the experimental background of this study, the research method is examined, and then the findings are analyzed.

3. Research methodology

Bibliometrics is one of the fields of research in scientometrics and is used to investigate and analyze a specific scientific field that produces extensive and scattered research trends (Faroudi et al., 2021; Kumar et al., 2020). In order to organize articles related to neuromarketing (Lee et al., 2007),

this research has used a systematic review based on the bibliometric method (Lim et al., 2021; Akhter et al., 2019). In the present study, for several reasons, including 1) analysis and integration of the concept of neuromarketing (Nemorin, 2017), 2) recognition of productive authors, years of publication of documents, reliable journals publishing articles in this field and keywords around this concept, 3) drawing the scientific field, structure and tools presented in neuroscience in marketing and 4) identifying the critical research clusters along with the main structures and infrastructures of neuromarketing, a bibliometric method was used to analyze the articles.

The two main axes of formation in the bibliometric method include a) performance analysis and review of the actions of researchers, academic institutions and the successes of each country in advancing the field of study and b) drawing knowledge maps that show the time trends and current issues in each period (Donthu et al., 2021). In addition, this systematic review, based on Iden et al.'s (2017) model, consists of four steps: planning, selection, extraction and implementation. Also, to increase the accuracy of the choice of previous research in this study, for the process of selecting articles, Silva's (2017) method was used.

From the combination of Iden et al.'s (2017) model and Silva's (2017) article selection process, the steps in Figure 1 show the process: A) identifying articles and then extracting them from reliable scientific databases and removing duplicate articles; B) screening articles, studying the titles and abstracts and selecting articles related to the topic; C) re-screening, reviewing the introductions and results of the previous stage articles and selecting related articles; and D) evaluation, review based on the purposes of the screened articles and their final selection.

In addition to the process of selecting articles using Silva's (2017) method and modeling the stages of a systematic review based on Iyden et al.'s (2017) method, we considered criteria for entering articles into the screening process, which are mentioned below:

First, the first database that we considered was Scopus, which is known as the largest and most comprehensive scientific database. Therefore, this database was first examined, and the articles that are at least indexed in this database were extracted. Then, in the next phase, the Web of Science database was also used to make the article search comprehensive.

Second, in this study and to compile an article with a systematic review method, only valid articles published in English were included in the research phases.

Third, in the search sections of the Scopus and Web of Science databases, the term "neural marketing" with the filter "title, abstract and keywords" for all years until the end of 2022 was used, and 1201 original articles were extracted. Then, because many sources were found to be inappropriate or irrelevant, several articles were excluded from the review process. In the following stages, according to the remaining parts of the articles, including the title, abstract, introduction and results, some other articles were removed. The introduction and conclusion of 39 articles were reviewed and evaluated and entered into the software to answer the central question of the study and content analysis. In the next part, the research findings will be analyzed and evaluated in two phases: descriptive analysis and then analysis of the research content.

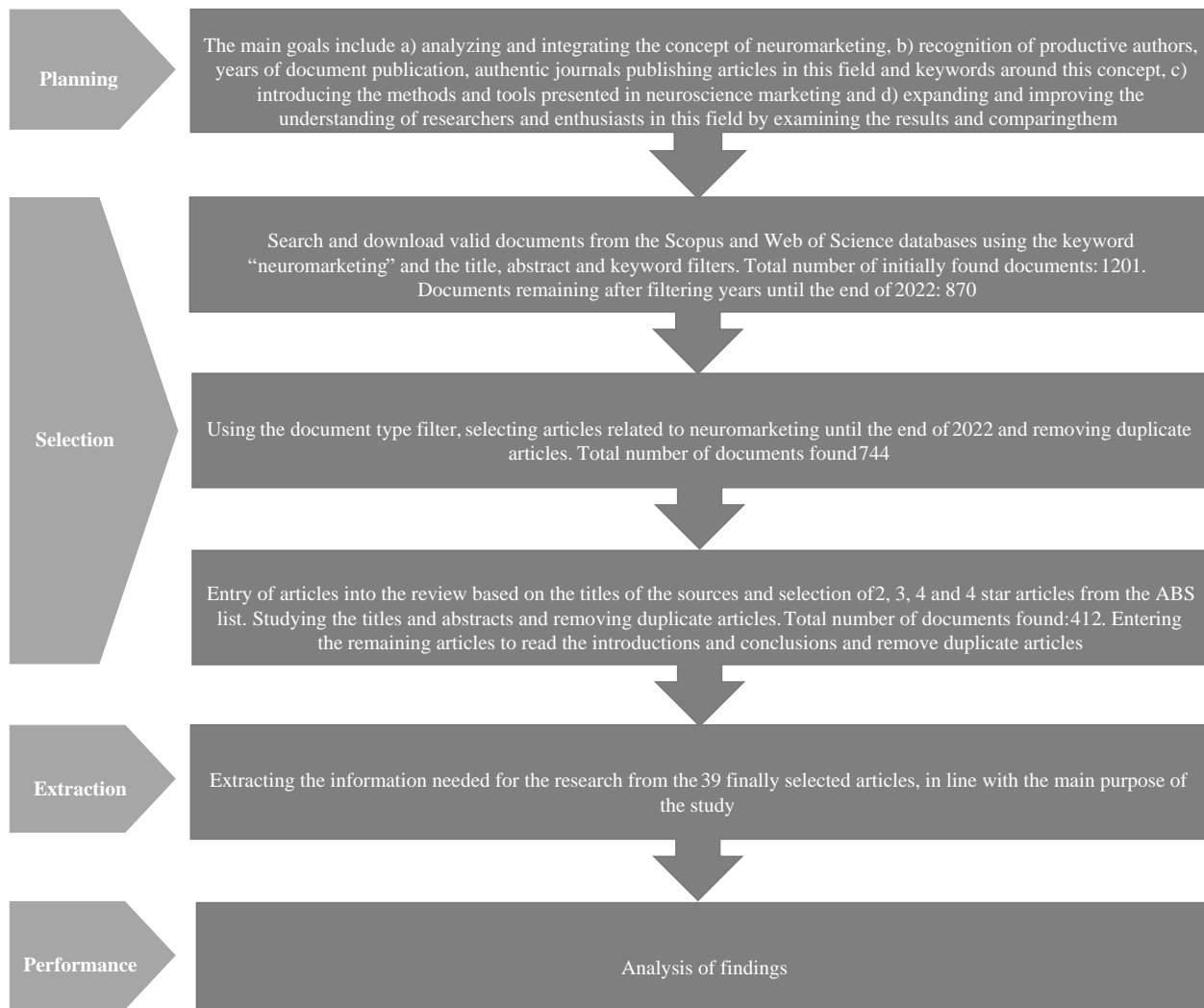


Figure 1. The executive process of selecting articles using Silva’s method (2015) and modeling the stages of a systematic review using Iden et al.’s (2017) method.

4. Research findings

4.1. Functional analysis of the study

Figure 2 offers a comprehensive overview of the trajectory of neuromarketing literature production. The data reveals a remarkable surge in the publication of neuromarketing documents, peaking in the year 2022. Interestingly, the nascent years of this discipline’s inclusion in prestigious marketing journals witnessed a concurrent dip in article output, particularly during 2014 and 2015. However, the encouraging highlight is the commendable surge in 2022, with a noteworthy 8 high-quality publications. This upward trajectory underscores the palpable enthusiasm and enduring scholarly interest in this dynamic field.

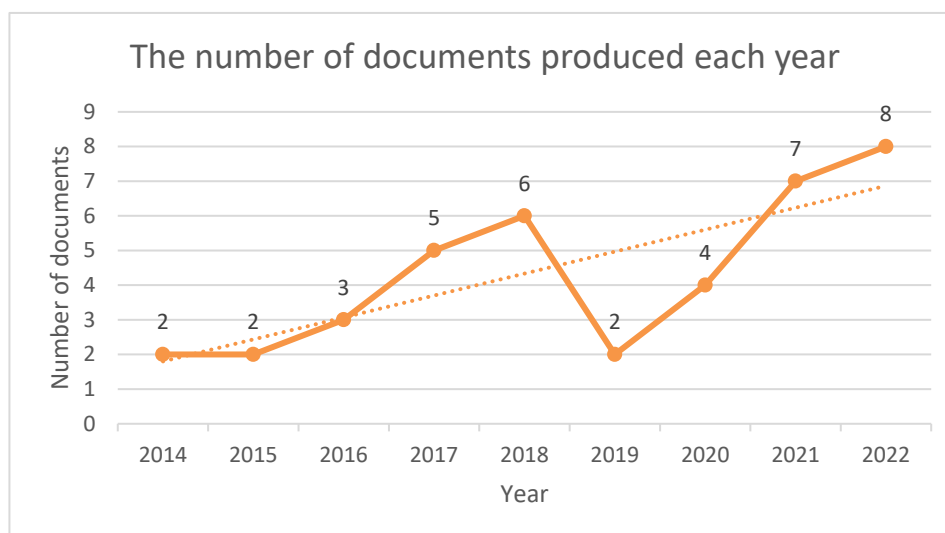


Figure 2. The trend of published documents in neuromarketing in journals ranked 3, 2, 4 and *4 on the ABS list, from the beginning of the entry of this field in studies until the end of 2022 in Scopus and Web of Science citation databases.

Figure 3 delves into the prominent journals contributing to the realm of neuromarketing. The notable leaders in this domain include the *Journal of Advertising Research* and the *Journal of Business Research*, each yielding 5 documents. The *European Journal of Marketing* follows with 4 publications. Furthermore, notable contributions from journals such as *Psychology and Marketing*, *Journal of Consumer Behavior* and *Journal of Retailing and Consumer Services* are evidenced by their production of 3 documents each. Additional authoritative journals make appearances, with their contributions ranging from two articles to one article.

In Figure 4, an intricate delineation of subject areas engaged by neuromarketing literature emerges. Remarkably, the lion's share of documents, accounting for 47.1%, is rooted in business, management and accounting subjects. Psychology comes to the fore as well, with 11.4% of articles. The domain of arts and humanities secures a robust 10%, solidifying its position in third place. Figure 5 spotlights the leading countries contributing to neuromarketing literature. The United States emerges as a prominent leader, producing 11 articles, with Australia and United Kingdom following with 5 articles each. South Korea, France, Italy and India secure noteworthy positions by contributing 3 articles each. Furthermore, Germany, Bosnia and Herzegovina, and Brazil exhibit their presence in subsequent ranks.

Figure 6 delves into the notable authors shaping neuromarketing research. Notably, Lee et al. (2014; 2017; 2018) stands out by producing three articles in top-tier journals with high ABS scores, attaining the premier rank. Following are Hamelin and Thaichon, each credited with two articles, securing the second position. Other scholars also make contributions, placing them in subsequent positions. The forthcoming sections will transition into a comprehensive content analysis, delving into the integration of the neuromarketing concept, classification of pertinent tools and presentation of the research's conceptual model. The study's conclusions, practical implications and managerial recommendations will follow.

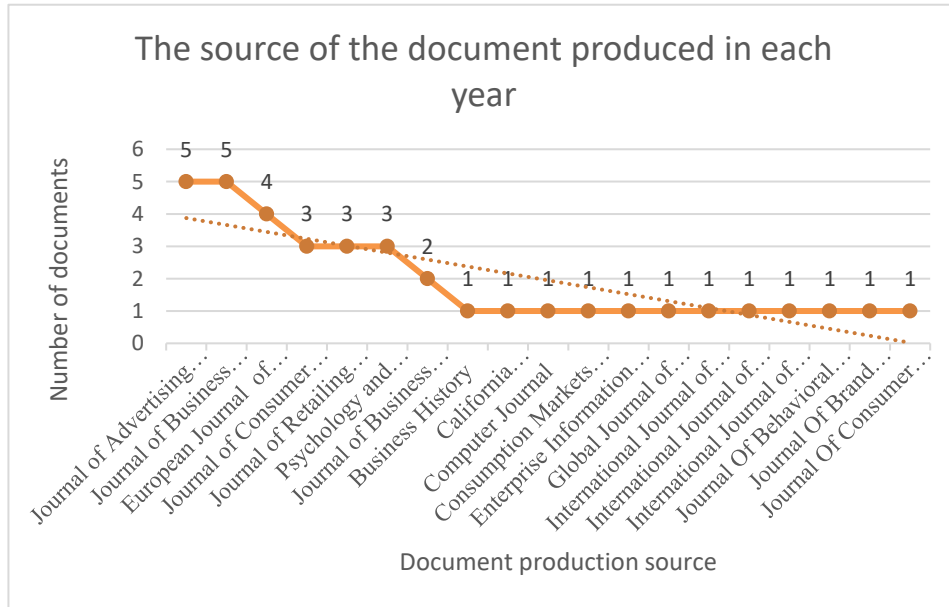


Figure 3. Shares of the production of authoritative quarterly journals in the field of neuromarketing by the number of published documents from the beginning of this field in studies until the end of 2022 in Scopus and Web of Science reference databases.

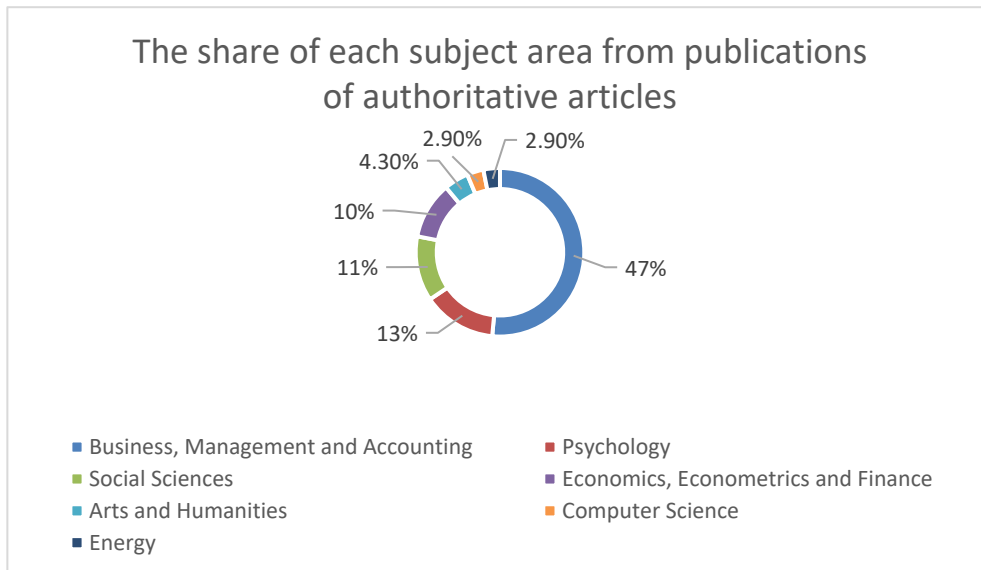


Figure 4. The production shares of subject areas related to neuromarketing in percentages, from the beginning of the introduction of neuromarketing to studies until the end of 2022 in Scopus and Web of Science reference databases.

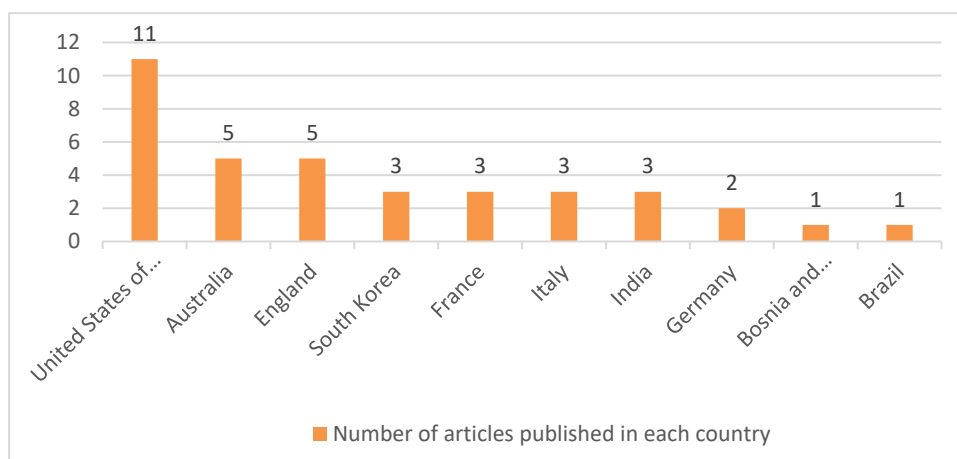


Figure 5. The share of countries producing articles in the field of neuromarketing from the beginning of the introduction of neuromarketing to studies until the end of 2022 in Scopus and Web of Science reference databases.

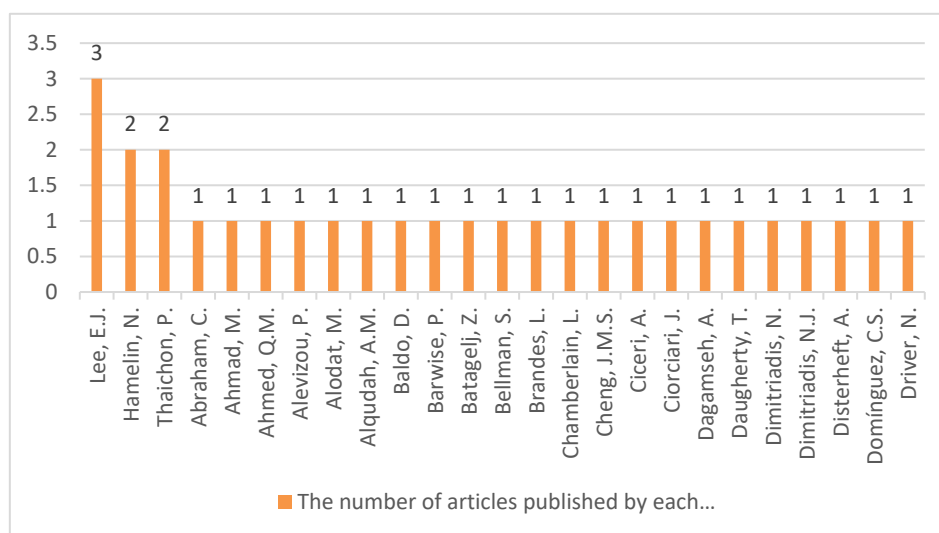


Figure 6. The shares of the production of documents by the top authors of neuromarketing from the beginning of the introduction of neuromarketing to studies until 2022 in the Scopus citation database.

4.2. Drawing knowledge maps

Co-occurrence analysis of words: The bibliometric approach incorporates co-occurrence analysis of words to gauge the semantic connections among a group of terms, elucidating the core themes within the studied domain. In this investigation, VOS viewer software was employed for comprehensive keyword analysis. This encompassed both the author-assigned keywords and the article-listed keywords. The results unveiled a network of 17 distinct clusters, comprising a total of 109 items and 131 keywords, as visually depicted in Figure 7.

The application of VOS viewer's analytical capabilities highlighted a direct correlation between keyword frequency and the magnitude of visibility. This relationship is manifest in the sizes of the circles,

where larger diameters correspond to higher keyword frequencies (Rana et al., 2022; Negrete-Cardoso et al., 2022). Moreover, communication lines' thicknesses and the rings' proximities on the map collectively indicate the intensities of interrelation. In light of this visualization, the following observations can be made:

The foremost cluster, occupying the primary position, focuses on consumer neuroscience as its principal theme. This central topic interweaves with ten affiliated subjects, forging 18 interconnections. The frequency strength reaches 22, accompanied by 5 co-occurrences.

In the second cluster of significance, advertising is the core topic, encompassing nine related subjects. Within this framework, 24 interconnections are established, underscored by a frequency strength of 28 and 5 co-occurrences.

The third pivotal cluster, ranked eighth overall, revolves around EEG (Lee et al., 2014; Qananwah et al., 2022) as its principal theme. This category integrates eight pertinent subjects, linked through 18 interconnections. The frequency strength stands at 22, accentuated by 3 co-occurrences, making it the most recurrent pattern.

By systematically uncovering these clusters and their interrelationships, this co-occurrence analysis provides a robust overview of the prevailing themes and their interconnectedness within the realm of neuromarketing, affording researchers a comprehensive landscape to navigate and explore.

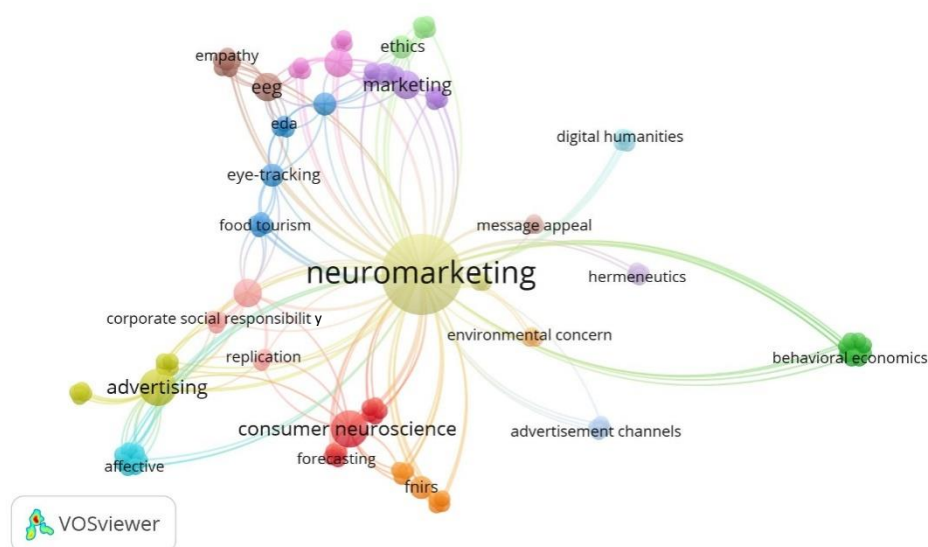


Figure 7. Vocabulary co-occurrence map of the most critical topics in neuromarketing.

Consumer neuroscience represents a burgeoning interdisciplinary field nestled at the juncture of neuroscience and marketing (Liu et al., 2023; Oliveira et al., 2022). Positioned as the first cluster of paramount importance in the knowledge map, it encapsulates a comprehensive exploration of cognitive processes and neural mechanisms that underpin consumer behavior, perception, decision-making and responses to marketing stimuli. It encompasses the intricate terrain of neural responses to advertising (Daugherty et al., 2018; Singh et al., 2020), product design and brand perception, aiming to unravel the enigmatic interplay between neurobiology and consumer preferences. Characterized by a multidisciplinary fusion of neuroscience methodologies, psychology and marketing insights, consumer neuroscience not only advances our comprehension of consumer behavior on a fundamental level but also underscores its profound implications for devising effective marketing strategies.

Ranked as the second cluster of significance in the knowledge map, advertising stands as a cornerstone of modern marketing endeavors. At its core, advertising involves the strategic communication of products, services or ideas to a target audience, engendering a particular response or behavior. Within the context of neuromarketing, advertising assumes a pivotal role as it delves into the neurological responses elicited by various advertising stimuli. This entails the analysis of consumer emotional engagement, attention and cognitive processes in response to diverse advertising formats. Advertising research within the domain of neuromarketing seeks to unearth the neural signatures that distinguish effective campaigns from less impactful ones, ultimately contributing to the refinement of advertising strategies that resonate with consumers on a deeper level.

Electroencephalography captures the intricate dance of neuronal activity within the brain by recording electrical signals generated by neural firing. Renowned for its temporal precision, EEG provides insights into the dynamic interplay of brain regions during various cognitive tasks, including those associated with consumer behavior (Kolar et al., 2021; Varan et al., 2015). In neuromarketing, EEG emerges as a valuable tool for gauging consumers' real-time neural responses to stimuli, enabling researchers to unearth subtle nuances in attention, emotional engagement and cognitive processes. The integration of EEG findings bolsters our understanding of how specific marketing stimuli elicit neurophysiologic responses, thereby enriching our comprehension of consumer decision-making processes. These subjects collectively contribute to the intricate tapestry of insights that underpin the evolution of contemporary marketing strategies.

The first cluster of consumer neuroscience: The first cluster with red color composition is the densest cluster and has 10 items, 12 links, frequency strength 22 and 5 co-occurrences. The titles found in this cluster are arousal, brand recognition, consumer neuroscience, electroencephalography, emotional valence, forecasting, machine learning, neurophysiologic method, preference prediction and purchase intent (Figure 8).

Within the confines of this red-hued enclave, the very essence of consumer neuroscience is unveiled. The term "arousal" invokes the emotional dimensions that galvanize consumer responses, while "brand recognition" delves into the intricate landscape of consumer cognizance and brand association. At the core, "consumer neuroscience" itself signifies the holistic realm that merges neurobiology and consumer behavior, guided by the insights of electroencephalography ("EEG")—an elemental technique for capturing neural activity. The emotional nuances are accentuated through "emotional valence," where the valence of emotional responses shapes consumer inclinations. The cluster further extends to "forecasting" and "machine learning," emblematic of predictive methodologies harnessing neural data. The "neurophysiologic method" underscores the meticulous approaches engendering empirical insights, whereas "preference prediction" and "purchase intent" encapsulate the culmination of consumer responses into discernible choices.

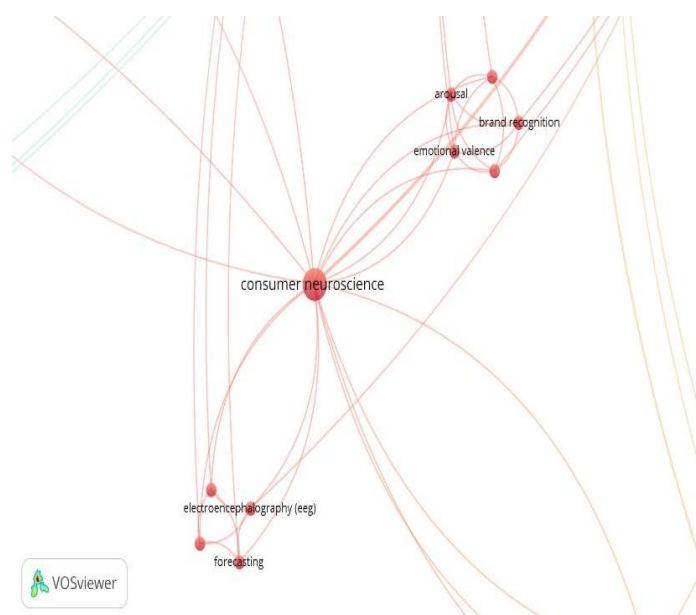


Figure 8. Co-occurrence map of words of the first cluster in neuromarketing.

In a symphony of co-occurrences, this cluster evokes a comprehensive landscape where the tendrils of neuroscience converge with the intricacies of consumer behavior, fomenting a robust discourse that resonates within the ambit of contemporary marketing scholarship. Through its intensity, diversity and interplay, this cluster inextricably links the neural substrates with the tapestry of consumer decision-making, unveiling the profound synergies that shape the emergent discipline of consumer neuroscience (Figure 8).

The second cluster of behavioral economics: The second cluster with green color composition, the second dense cluster, includes nine items, nine links, frequency strength 9 and 1 co-occurrence. The titles found in this cluster are behavioral economics, discourse, empiricism, philosophy of science, psychology, research methods, basic sciences, semiology and semiotics (Figure 9).

Within this cluster, the concept of “behavioral economics” takes center stage, emblematic of a scholarly discourse that fuses economics with psychology to illuminate the intricacies of human decision-making. Discourse resonates as a pivotal element, underscoring the intellectual exchange surrounding behavioral economics. Empiricism underscores the empirical foundations that underpin this field, while “philosophy of science” contextualizes the philosophical nuances inherent in its methodology. As psychology intertwines with economics, “psychology” denotes a central discipline bridging the cognitive underpinnings of behavior with economic choices. “Research methods” symbolizes the investigative methodologies deployed to decipher behavioral patterns, while “basic sciences” and “semiology” provide foundational insights into the theoretical underpinnings.

This verdant cluster reflects a synergy between cognition, choice and economics, encapsulating the very essence of behavioral economics. The co-occurrence underscores the interconnectedness of these themes, forming a collective mosaic that enriches the scholarly discourse. Thus, the second cluster stands as a testament to the intricate interplay of disciplines, exemplifying the nuanced intersection of economics and psychology within the realm of behavioral economics (Figure 9).

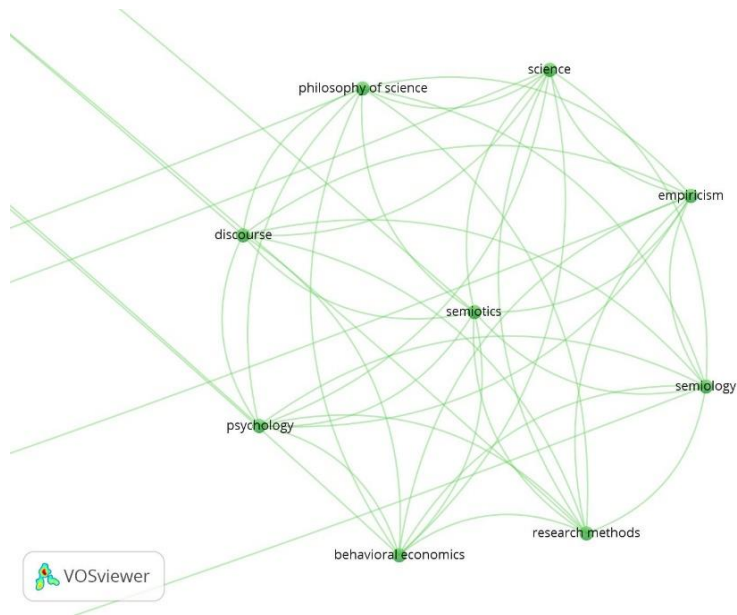


Figure 9. Co-occurrence map of words of the second cluster in neuromarketing.

The third cluster of decision-making: The third cluster with a blue color combination, and the third dense cluster, includes 9 items, 11 links, frequency strength 11 and 2 co-occurrences (Figure 10). The topics found in this cluster are decision-making, EDA (electro-dermal activity), eye tracking, food tourism, implicit priming test, marketing communication, marketing communications, neuroscience methods and typical local food.

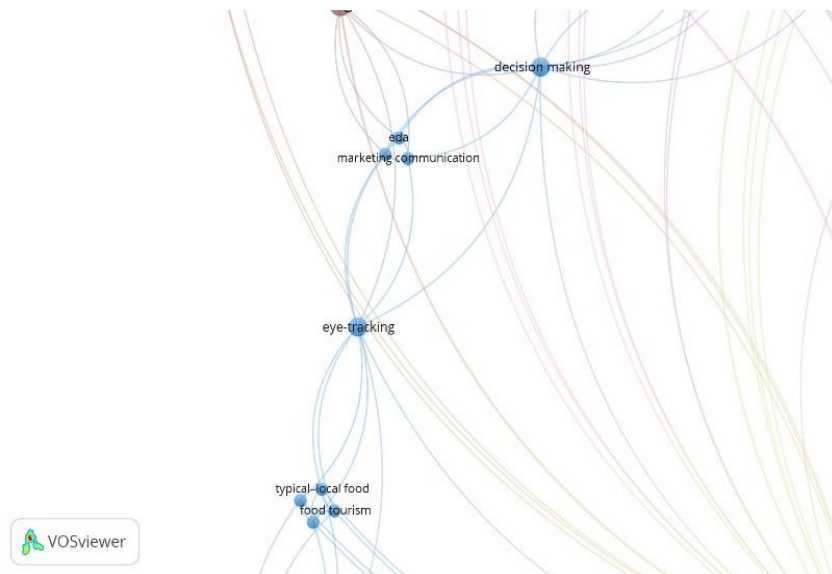


Figure 10. Co-occurrence map of words of the third cluster in neuromarketing.

Within the sphere of decision-making, this cluster encapsulates the very essence of consumer choices and their cognitive underpinnings. “Eda” resonates as a pivotal technique, unveiling hidden insights within data, while “eye tracking” delves into the intricate tapestry of visual attention and its role in shaping decisions. “Food tourism” signifies the nexus of travel and gastronomic experiences,

infusing decision-making processes with cultural nuances. “Implicit priming tests” evoke the subconscious mechanisms that prime consumer choices, while “marketing communication” and “marketing communications” embody the art of influencing decisions through strategic messaging. “Neuroscience methods” weave an empirical foundation into decision-making analysis, while “typical local food” underscores how cultural contexts mold preferences.

Amidst this tapestry, the co-occurrences underscore the intricate interplay of themes, fostering a holistic exploration of decision-making paradigms within the realm of marketing. This cluster stands as a testament to the multifaceted nature of choices and their cognitive underpinnings, epitomizing the nuanced interplay between consumer psychology and marketing strategies (Figure 10).

The fourth cluster of advertising: The fourth dense cluster with the yellow color combination has 9 items, 24 links, frequency strength 28 and five co-occurrences. The titles found in this cluster are advertising, driving attitude, emotion, emotional, face recognition, memory, psychophysiology, road safety campaigns and skin conductance (Figure 11).

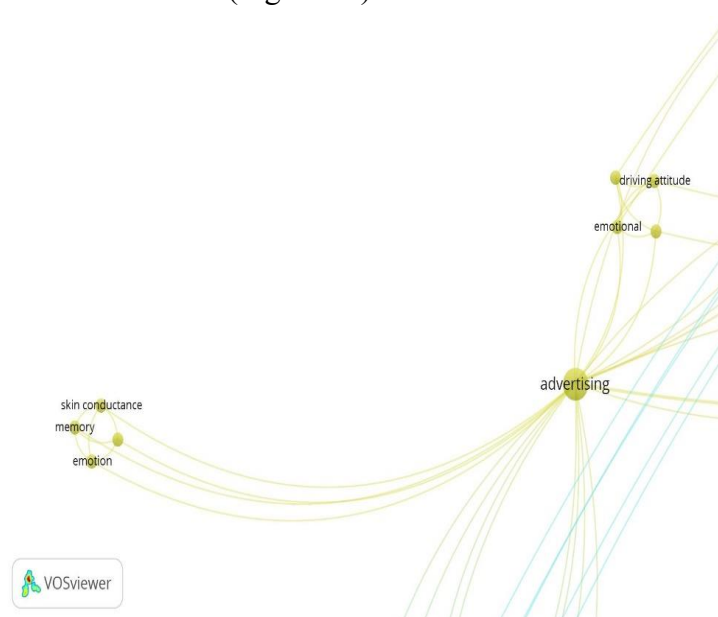


Figure 11. Co-occurrence map of the vocabulary of the fourth cluster in neuromarketing.

At its nucleus, “advertising” resonates as the lynchpin, embodying the art of persuasive communication that shapes consumer behaviors and perceptions. “Driving attitude” signifies the link between advertising and vehicular behavior, while “emotion” and “emotional” underscore the affective dimensions and advertising evokes within audiences. “Face recognition” delves into the cognitive processes governing facial identification and its role in advertisement efficacy, while “memory” unravels the intricate web of recall and memory nurtured by advertising endeavors. “Psychophysiology” delves into the physiological responses engendered by advertisements, while “road safety campaigns” accentuate the intersection between advertising and social responsibility. Finally, “skin conductance” probes the somatic reactions that advertisements can elicit, underscoring the depth of consumer engagement.

Intricately woven through a web of interrelations, the fourth cluster’s co-occurrences attest to the intricate network of associations within the realm of advertising research. This cluster, resonating with vibrancy and scholarly dynamism, stands as a testament to the convergence of marketing communication and human psychology, shaping the contours of contemporary advertising strategies (Figure 11).

The fifth cluster of circular economy: The fifth cluster with the purple color combination, the fifth dense cluster has 9 items, 12 links, frequency strength 14 and 3 co-occurrences (Figure 12). The titles found in this cluster are circular economy, consumer behavior, environmental performance, fMRI, hormones, marketing, marketing research, sustainable consumption and sustainable development goals.

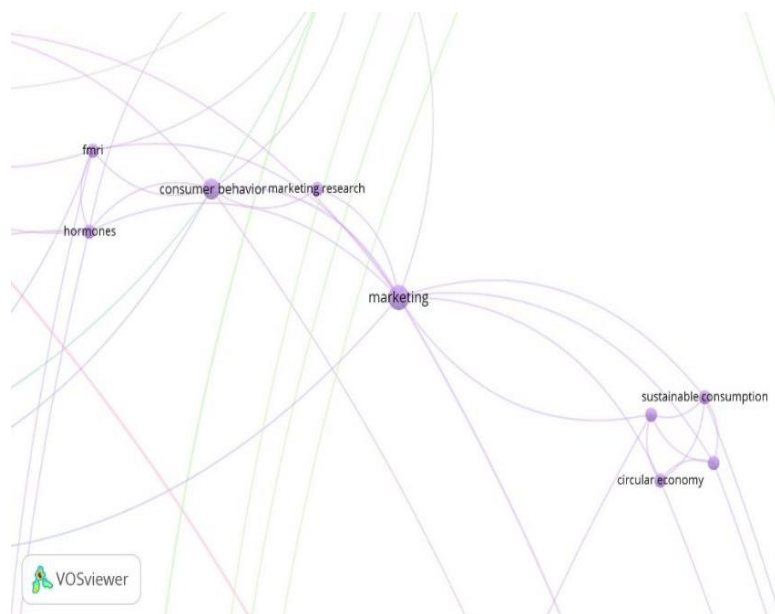


Figure 12. Co-occurrence map of the words of the fifth cluster in neuromarketing.

At its heart, the concept of the “circular economy” symbolizes a transformative paradigm shift in economic models, emphasizing sustainability, resource efficiency and reduced waste. “Consumer behavior” unravels the intricate interactions between consumers and the principles of circularity, while “environmental performance” underscores the holistic ecological impact of circular economic practices. “fMRI” ventures into the neural substrates, uncovering the cognitive underpinnings that shape consumer responses to circular economy initiatives. The “hormones” theme elucidates the physiological dimensions underpinning consumer choices in the context of sustainability.

As “marketing” and “marketing research” interweave with this cluster, they reflect the inextricable bond between circular economy principles and strategic communication. “Sustainable consumption” embodies the ethos of conscious choices, while “sustainable development goals” contextualize circularity within the broader framework of global sustainability objectives.

The co-occurrences in this cluster serve as conduits of knowledge, unfurling the profound interconnectedness between the circular economy and a myriad of marketing research dimensions. This cluster, enriched by its interplay of concepts, reinforces the resonance between economic transformation, consumer psychology and sustainable practices within the context of contemporary marketing (Figure 12).

The sixth cluster of attitude change: With the turquoise color combination, the sixth dense cluster has eight items, nine links, frequency strength 9 and 1 co-occurrence (Figure 13). The topics found in this cluster are attitude change, biometric data, cognitive, eye tracking, facial expression analysis, retention and storytelling.

The foundational theme of “attitude change” reverberates as the lynchpin, encapsulating the intricate dynamics by which consumer perspectives evolve through the impact of marketing initiatives. “Biometric

data” unfurls as a pivotal tool, probing the physiological underpinnings that inform changes in consumer attitudes. “Cognitive” dimensions underscore the intellectual intricacies that influence shifts in perceptions, while “eye tracking” plunges into the visual cues and stimuli that propel attitude alterations.

The interplay between “facial expression analysis” and “retention” unravels the enigmatic relationship between emotional cues and enduring memory, shedding light on how storytelling and emotion-laden messages drive lasting changes in consumer attitudes. “Storytelling,” the last thematic thread within this cluster, delves into the art of narrative persuasion, illuminating how narratives mold and reshape consumer perspectives. The co-occurrence, though solitary, embodies the intricate web of inter-connectedness within this cluster, underpinning the scholarly journey of understanding how attitudes transform and metamorphose within the context of marketing research. As these themes harmonize, the sixth cluster stands as a testament to the interplay of cognitive, emotional and narrative dimensions in fostering shifts in consumer attitudes, emblematic of the intricate dynamics that underlie the realm of marketing (Figure 13).

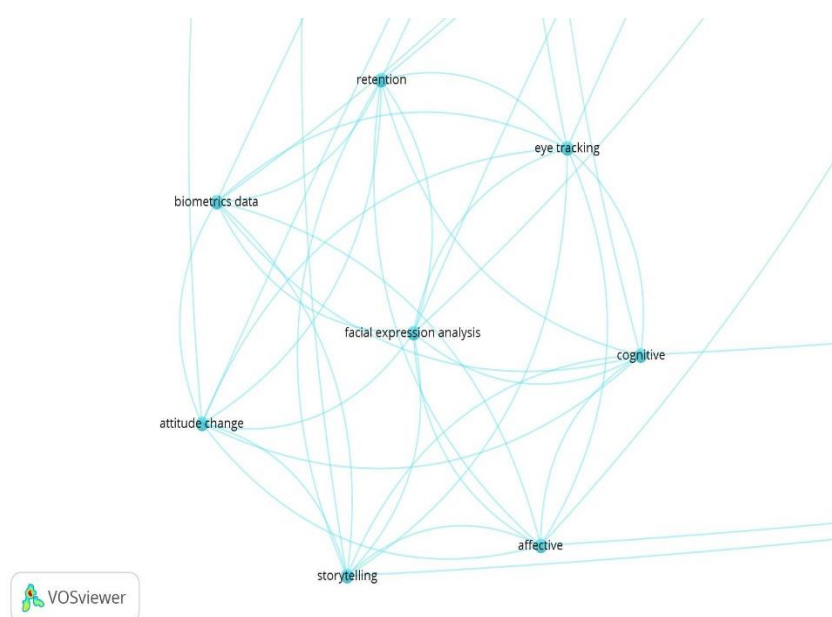


Figure 13. Co-occurrence map of words of the sixth cluster in neuromarketing.

The seventh cluster of attention: With the orange color combination, the seventh dense cluster has seven items, five links, frequency strength 5 and 1 co-occurrence (Figure 14). The titles found in this cluster are attention, brain activity, decision making, fNIRS, neuroimaging, optical brain imaging, purchase behavior and purchase decision.

The core theme of “attention” serves as the nucleus, emblematic of the cognitive process that governs the allocation of cognitive resources to stimuli. “Brain activity” delves into the neural mechanisms that orchestrate attention processes, while “decision making” casts light upon how attention informs and shapes consumer choices. The advent of advanced techniques such as “fNIRS” and “neuroimaging” revolutionize our understanding by probing the neural underpinnings of attention phenomena. The inclusion of “optical brain imaging” within this cluster reflects the advancements that empower researchers to visualize and understand the cerebral underpinnings of consumer attention. “Purchase behavior” and “purchase decision” within this cluster underscore how the intricacies of attention are entwined with the consumer’s journey, spanning from stimuli perception to decision-making.



Figure 14. Co-occurrence map of the vocabulary of the seventh cluster in neuromarketing.

The co-occurrence, while singular, epitomizes the symbiotic interplay of themes within this cluster, illuminating how attention cascades through a labyrinthine journey, influencing cognitive processes and guiding consumer choices. As these themes harmonize, the seventh cluster stands as a testament to the intricate intersections of neural dynamics and cognitive decision-making, underscoring the profound interplay between human attention and the marketing landscape (Figure 14).

The eighth cluster of the anterior cingulate cortex: With brown color composition, the eighth cluster has eight items, seven links, frequency strength 7 and 1 co-occurrence (Figure 15). Titles found in this cluster include the anterior cingulate cortex, customer equity, EEG, emotional mechanism, empathy, theta and willingness to pay. At the heart of this cluster resides the “anterior cingulate cortex,” an enigmatic neural region known for its role in emotional processing, cognitive control and decision-making. “Customer equity” amplifies the integration of neural understanding into the economic dimensions of consumer relationships, resonating with the essence of sustainable business growth. “EEG” emerges as a vanguard technique, unraveling the neuronal intricacies that shape consumer responses, while “emotional mechanism” delves into the neurological substrates underpinning the intricate dance of emotions within consumer behavior.

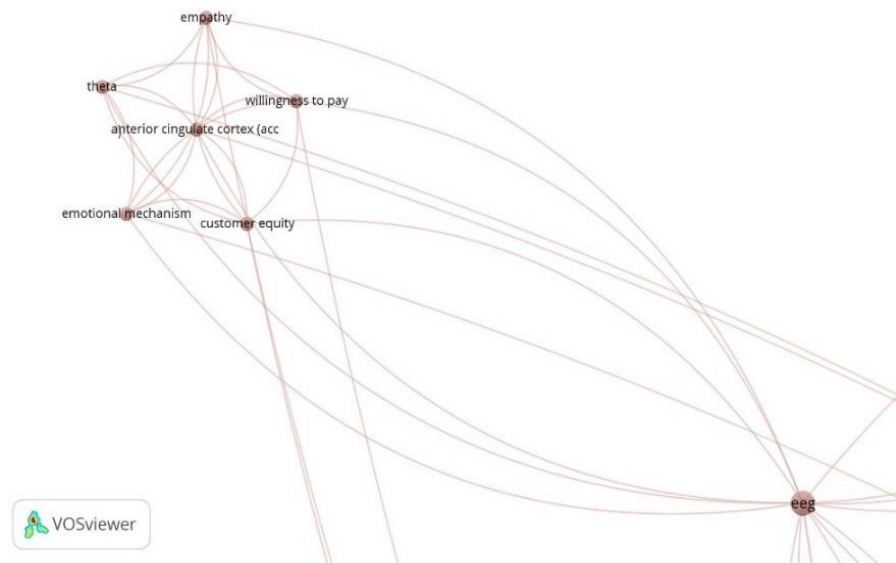


Figure 15. Co-occurrence map of the vocabulary of the eighth cluster in neuromarketing.

The thematic chord of “empathy” strikes a resonant note, intertwining neural empathy processes with marketing dynamics, exemplifying the intersection of emotion and strategy. The presence of “theta,” an oscillatory pattern often tied to cognitive and emotional processing, mirrors the cluster’s thematic exploration.

The co-occurrence within this cluster encapsulates the unity between diverse threads, accentuating the harmonious symphony between neural substrates, emotional nuances and consumer choices. As these themes intertwine, the eighth cluster stands as a testament to the inextricable fusion between neurophysiology (Wajid et al., 2021) and marketing intricacies, resonating with the symphony of the anterior cingulate cortex and its profound implications (Figure 15).

The ninth cluster of advertising impact: With magenta color composition, the ninth cluster has 7 items, 14 links, a frequency strength of 16 and 3 co-occurrences (Figure 16). The titles found in this cluster are advertising impact, electroencephalogram, focus group, marketing practices, marketing science, marketing theory and neuroscience.

At its nucleus, “advertising impact” reigns supreme as the focal point of this cluster—the intricate web of influences woven by marketing endeavors. The inclusion of “electroencephalogram” accentuates the role of advanced neural measurement techniques in deciphering the cognitive footprints of advertising experiences. “Focus group” serves as a methodological cornerstone, intertwining qualitative insights with the quantitative nuances that underpin advertising’s effects.

Amidst this scholarly ensemble, “marketing practices,” “marketing science” and “marketing theory” form an interconnected triad, showcasing the nexus of empirical application, theoretical underpinnings and methodological precision in unraveling advertising’s resonances. The thematic thread of “neuroscience” underscores the overarching context, bridging the neural substrates with marketing endeavors, echoing the symbiotic dance between science and strategy.

The co-occurrences, while few in number, bear witness to the intricate tapestry of thematic connections within this cluster, reflecting the scholarly quest to decode the multifaceted dimensions of advertising’s impact. As these threads interweave, the ninth cluster stands as a testament to the

profound interplay between cognitive processes, marketing strategies and the lasting resonance of advertising's influence (Figure 16).

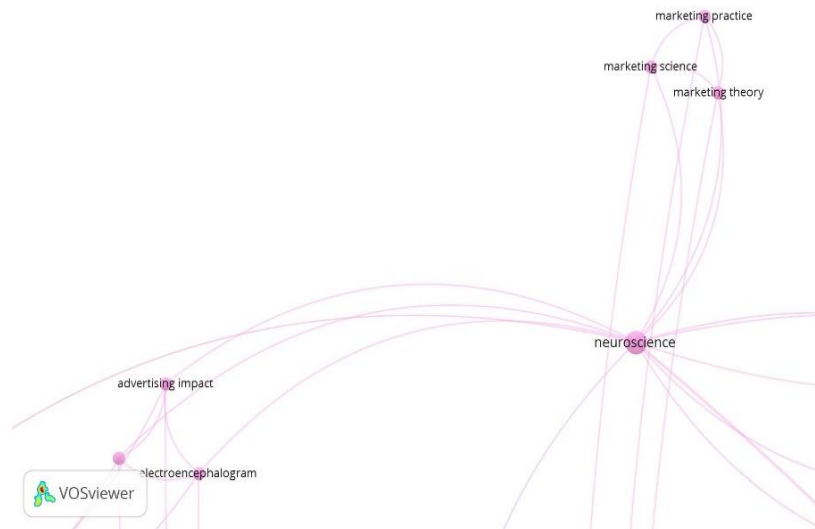


Figure 16. Co-occurrence map of words of the ninth cluster in neuromarketing.

The tenth cluster of corporate social responsibility: The 10th cluster is pink, and the 10th has 6 items, 13 links, a frequency strength of 16 and 3 co-occurrences (Figure 17). The titles found in this cluster are corporate social responsibility, electroencephalography, event-related potential frontal lobe, green consumers and replication.

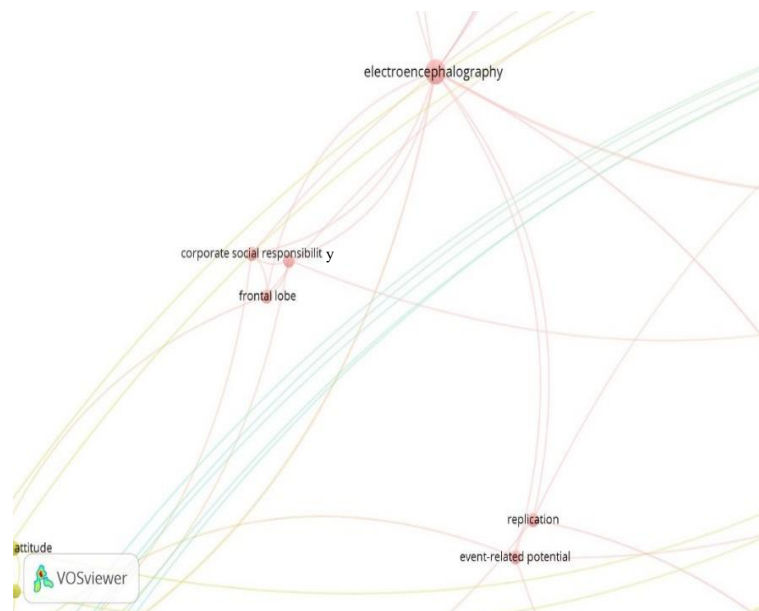


Figure 17. Vocabulary co-occurrence map of the 10th cluster in neuromarketing.

At the nucleus of this cluster resides “corporate social responsibility,” emblematic of the evolving mandate for businesses to embrace ethical, social and environmental considerations.

“Electroencephalography” adds an innovative layer, revealing how neural signatures respond to CSR initiatives, shedding light on the neural underpinnings of socially responsible choices.

The thematic harmony deepens with “event-related potential frontal lobe,” a neurological marker exploring cognitive responses to CSR initiatives, while “green consumers” magnifies the role of socially conscious individuals in driving sustainable practices. Amidst this, “replication” occupies a pivotal stance, emphasizing the scholarly imperative to validate findings and foster cumulative knowledge.

The co-occurrences within this cluster epitomize the harmonious symphony of themes, resonating with the intricate interplay between corporate responsibility, cognitive responses and the ongoing scholarly quest for robust validation. As these threads intertwine, the tenth cluster stands as a testament to the evolving fusion of ethics, neural signatures and the dynamic influence of corporate social responsibility within the marketing sphere (Figure 17).

The eleventh cluster of consumer sentiment: With pistachio green color composition, the eleventh cluster has five items, five links, frequency strength 5 and 1 co-occurrence (Figure 18). Topics found in this cluster include consumer sentiment, ethics, regulations, social media and user-generated content.

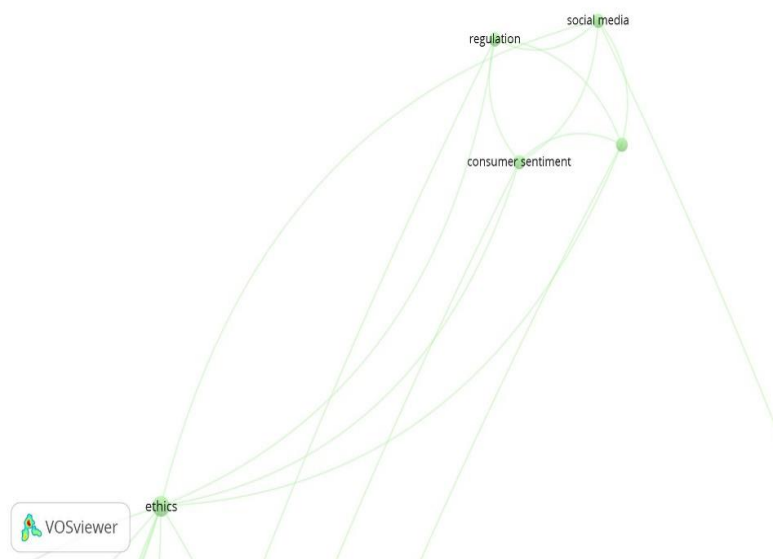


Figure 18. Co-occurrence map of the vocabulary of the 11th cluster in neuromarketing.

At its core, “consumer sentiment” reigns supreme, embodying the emotional tapestry that underlies consumer behaviors and perceptions. “Ethics” interweaves as a guiding compass, navigating the complex ethical considerations inherent in understanding and influencing consumer sentiment within marketing strategies.

The regulatory underpinnings are embraced by “regulations,” emphasizing the nuanced interface between consumer sentiment and the legal landscape. “Social media” steps onto the stage as a dynamic canvas, portraying the vibrant interplay between consumer sentiment and digital platforms, while “user-generated content” sheds light on the dynamic discourse emerging from engaged consumers.

The solitary co-occurrence within this cluster embodies the unity between these themes, resonating with the symphony of consumer sentiment, ethics, regulations, social media and the manifold narratives woven through user-generated content. As these threads intertwine, the eleventh

cluster stands as a testament to the multifaceted tapestry of emotions, ethics and regulatory frameworks within the realm of consumer sentiment (Figure 18).

The twelfth cluster of advertising channels: With a purple colour combination, the twelfth cluster has 4 cases, 4 links, frequency strength 4 and 1 co-occurrence (Figure 19). The topics found in this cluster are advertising channels, facial analysis, GSR sensors and omnichannel business.

At the nucleus of this cluster resides “advertising channels,” epitomizing the pivotal conduits through which marketing messages traverse to reach diverse audiences. “Facial analysis” unfurls as a technologically driven lens, probing the emotional nuances within consumers’ expressions as they engage with varied advertising channels.

“GSR sensors” usher in a dimension of physiological engagement, unveiling the intricate interplay between advertising channels and the physiological responses they evoke. Amidst this, “omnichannel business” stands as a focal point, exemplifying the holistic orchestration of diverse channels to create a seamless consumer experience.

The solitary co-occurrence encapsulates the thematic unity, reflecting the resonating harmonies between advertising channels, facial analysis, GSR sensors and the multifaceted realm of omni-channel business strategies. As these threads interweave, the twelfth cluster stands as a testament to the intricate dance between technological insights, physiological markers and the strategic choreography of advertising messages across diverse channels (Figure 19).

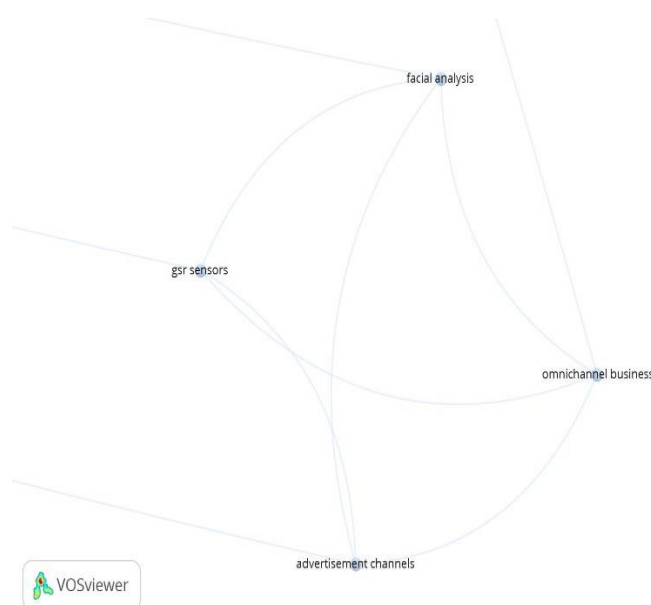


Figure 19. Co-occurrence map of twelfth cluster words in neuromarketing.

The thirteenth cluster of content engagement: The 13th cluster has yellow color composition and has four items, three links, three frequency strengths and one co-occurrence (Figure 20). The titles found in this cluster are content engagement, event-related potentials, neuromarketing and social media marketing.

At its core, “content engagement” emerges as the fulcrum of this cluster, capturing the multifaceted dynamics that govern the interactions between consumers and varied content forms. “Event-related potentials” illuminate the neurological responses underpinning content engagement, lending insights into cognitive processing as consumers engage with diverse stimuli. “Neuromarketing”

assumes its rightful place, wielding scientific methodologies to decode the neural substrates of consumers' behaviors as they navigate content landscapes. Amidst this, "social media marketing" takes center stage, revealing the intricate strategies employed to foster engagement within the virtual realms.

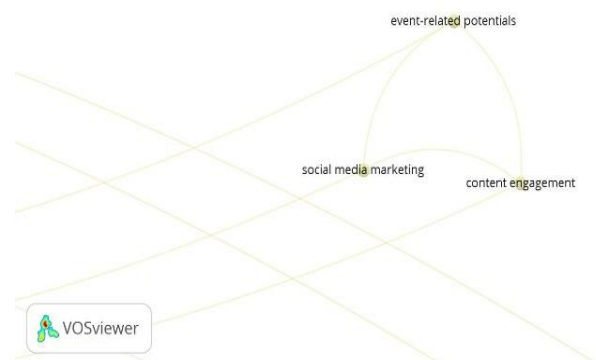


Figure 20. Co-occurrence map of the vocabulary of the 13th cluster in neuromarketing.

The solitary co-occurrence mirrors the thematic harmony, echoing the interplay between content engagement, event-related potentials, neuromarketing and the dynamic avenues of social media marketing. As these threads intertwine, the thirteenth cluster stands as a testament to the evolving confluence of neurological responses, digital landscapes and the captivating realm of content engagement within marketing narratives (Figure 20).

The fourteenth cluster of hermeneutics: The 14th cluster has the lily color combination and has four items, four links, frequency strength 4 and 1 co-occurrence (Figure 21). The titles found in this cluster are hermeneutics, market practice, philosophy of technology, and science and technology.

At its core, "hermeneutics" assumes prominence, embodying the interpretive framework that unravels the layers of meaning within marketing phenomena. "Market practice" interlocks, revealing the practical manifestations of hermeneutical insights in the dynamic realm of business and consumer interactions.

"Philosophy of technology" interweaves, casting a discerning gaze upon the symbiotic relationship between technological advancements and the philosophical underpinnings that shape their trajectory. Amidst this discourse, "science and technology" stand as steadfast pillars, shedding light on the interplay between empirical investigation and technological advancements within marketing.

The solitary co-occurrence symbolizes the thematic union, reflecting the harmonious blend of hermeneutics, market practice, philosophy of technology and the intricate intertwinement of science and technology. As these strands intertwine, the fourteenth cluster stands as a testament to the nuanced dance between interpretive methodologies, pragmatic implementations and the philosophical realms that underpin marketing narratives (Figure 21).

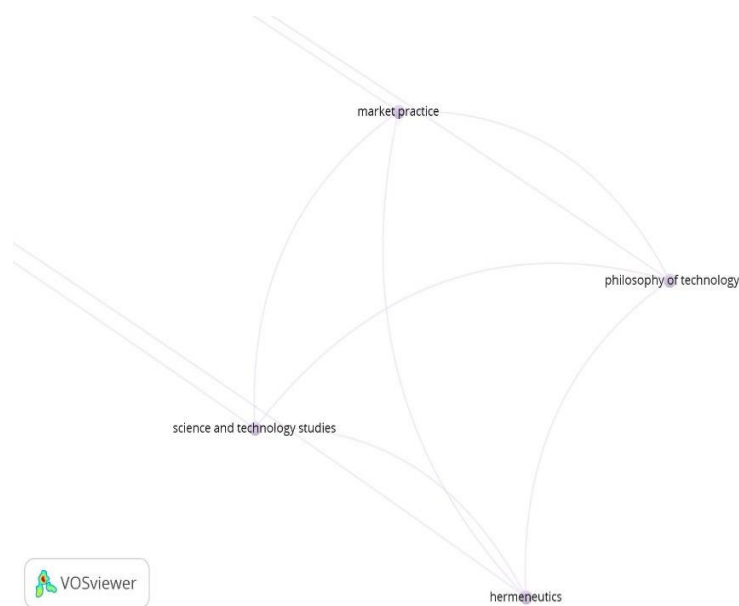


Figure 21. Co-occurrence map of words of the 14th cluster in neuromarketing.

The fifteenth cluster of digital humanities: The 15th cluster has a cyan color combination and has four items, four links, four frequency strengths and one co-occurrence (Figure 22). Titles found in this cluster include digital humanities, neuro-economics, university-industry relations and the World Wide Web.

At its nucleus, “digital humanities” assumes prominence, embodying the marriage of technology and humanistic inquiry in dissecting the complexities of marketing landscapes. “Neuroeconomics” interlaces, forging an intricate bridge between neurological responses and economic decision-making, within the dynamic scope of marketing endeavors.

“University-industry relations” aspects intermingle, underscoring the symbiotic partnership between academic knowledge generation and its application in the practical realms of industry. Amidst this academic tapestry, “world wide web” stands resolute, casting its virtual net over the vast expanse of marketing possibilities in the digital era.

The solitary co-occurrence mirrors thematic unity, resonating with the harmonious convergence of digital humanities, neuro-economics, university-industry relations and the vast landscape of the World Wide Web. As these themes intertwine, the fifteenth cluster stands as a testament to the interplay between digital advancements, cognitive economics, academic-industrial synergies and the boundless virtual realm that shapes modern marketing narratives (Figure 22).

The sixteenth cluster of environmental concern: The 16th cluster has a yellow-orange color combination and has three items, three links, frequency strength 3 and 1 co-occurrence (Figure 23). Topics found in this cluster include environmental concern, persuasion and valence.



Figure 22. Co-occurrence map of words of the 15th cluster in neuromarketing.

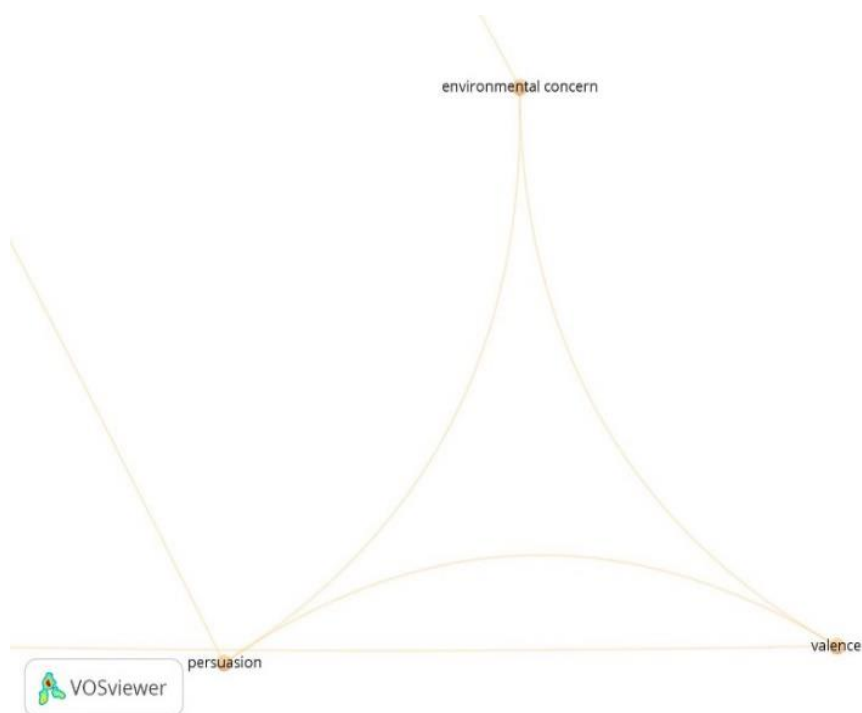


Figure 23. Co-occurrence map of words of the sixteenth cluster in neuromarketing.

At its core, “environmental concern” takes center stage, encapsulating the pivotal role of ecological consciousness in shaping modern marketing paradigms. “Persuasion” weaves seamlessly, exploring the nuanced interplay between communication strategies and the art of influencing consumer behavior in the direction of sustainable choices.

Within this discourse, “valence” assumes its place, delving into the emotional resonance that colors consumer responses to environmentally conscious messaging. The solitary co-occurrence reflects thematic cohesion, underscoring the harmonious alignment of environmental concern, persuasive tactics and the emotional valence that threads through these considerations.

As these themes converge, the sixteenth cluster serves as an emblem of the intricate interplay between environmental consciousness, persuasive communication and emotional resonance within the sphere of marketing research (Figure 23).

The 17th cluster of message appeal: The 17th cluster, with a light brown color combination, has three items, three links, frequency strength 3 and 1 co-occurrence (Figure 24). The topics found in this cluster are message appeal, neural actions and social media advertising.

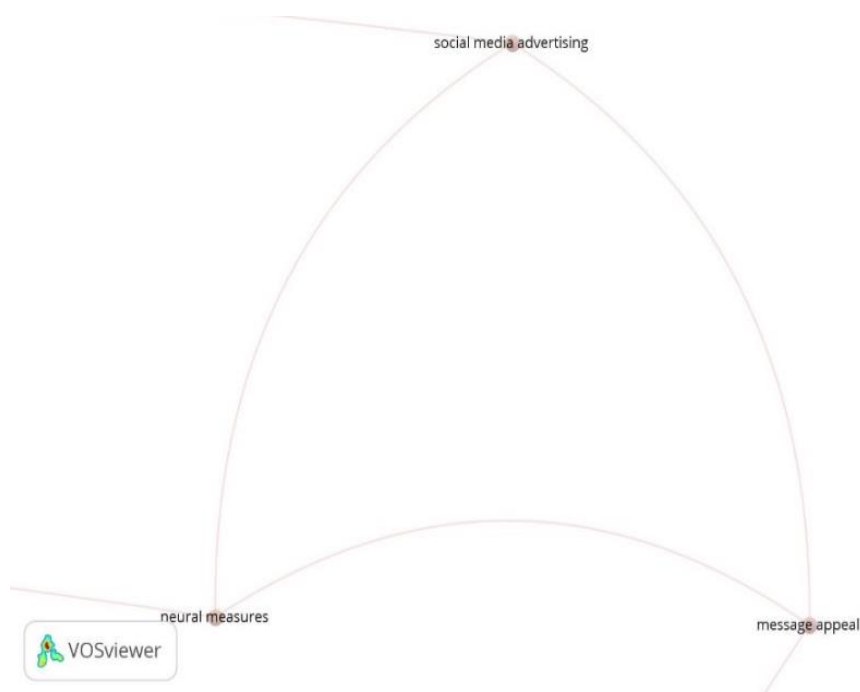


Figure 24. Co-occurrence map of words of the 17th cluster in neuromarketing.

At its core, “message appeal” assumes center stage, encapsulating the strategic craft of tailoring marketing messages to elicit specific consumer responses. “Neural measures” interweave harmoniously, delving into the intricate dance between neural processes and the cognitive reception of persuasive messages.

Within this discourse, “social media advertising” finds its place, exploring the unique landscape of digital platforms as a conduit for message dissemination and engagement. The solitary co-occurrence mirrors thematic unity, emphasizing the symbiotic interplay between message appeal, neural mechanisms and the evolving canvas of social media advertising.

As these themes converge, the seventeenth cluster stands as a testament to the strategic orchestration of message construction, the neural underpinnings of consumer response and the dynamic role of social media in shaping contemporary marketing narratives (Figure 24).

Analysis of co-reference pairs:

In this research, co-reference pairs were analyzed to examine the main foundation of the concept of neuromarketing and the integration of related ideas. Through this analysis, it is possible to analyze the authors, references and journals that have cited each other. At the end, utilizing VOS viewer software, the units of authors, organizations and the countries active in the field of producing neuromarketing articles were selected, and its map was observed and drawn in Figure 25. The co-occurrence map of organizations active in the field of producing neuromarketing articles is shown in Figure 26, and the co-occurrence map of active countries in the field of producing neuromarketing articles is given in Figure 27.

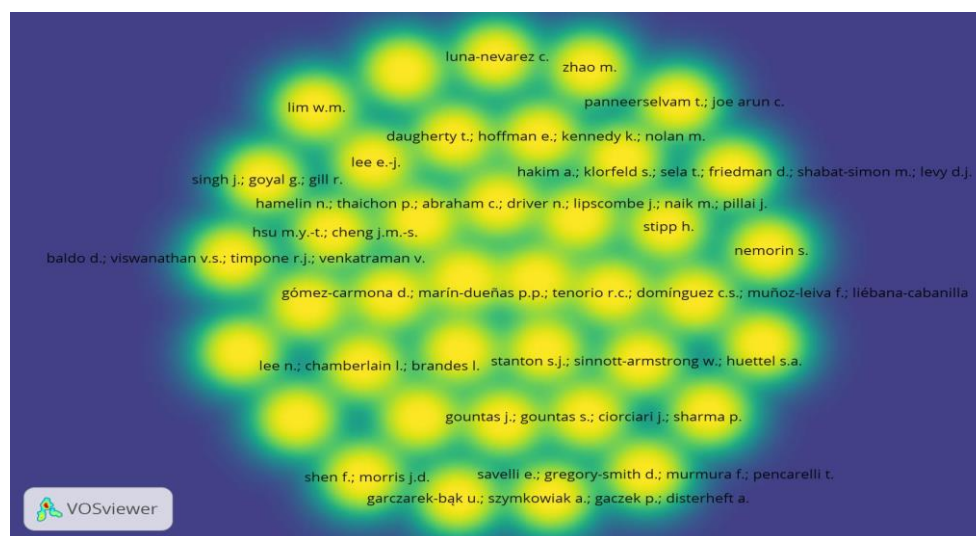


Figure 25. Co-occurrence map of active authors in the field of producing neuromarketing articles.

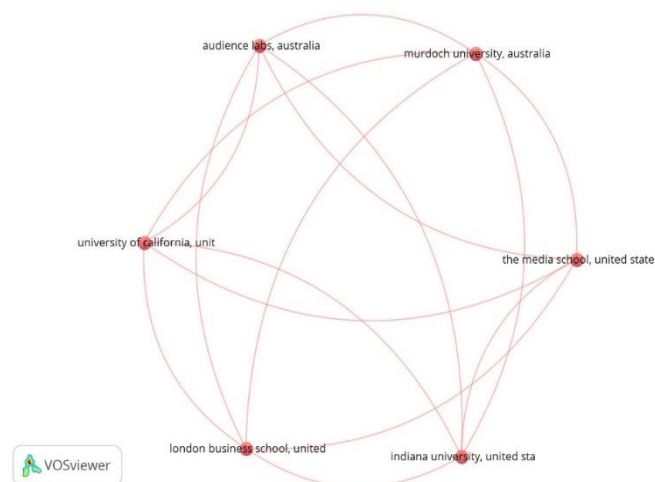


Figure 26. Co-occurrence map of organizations active in the field of producing neuromarketing articles.



Figure 27. Co-occurrence map of active countries in the field of producing neuromarketing articles.

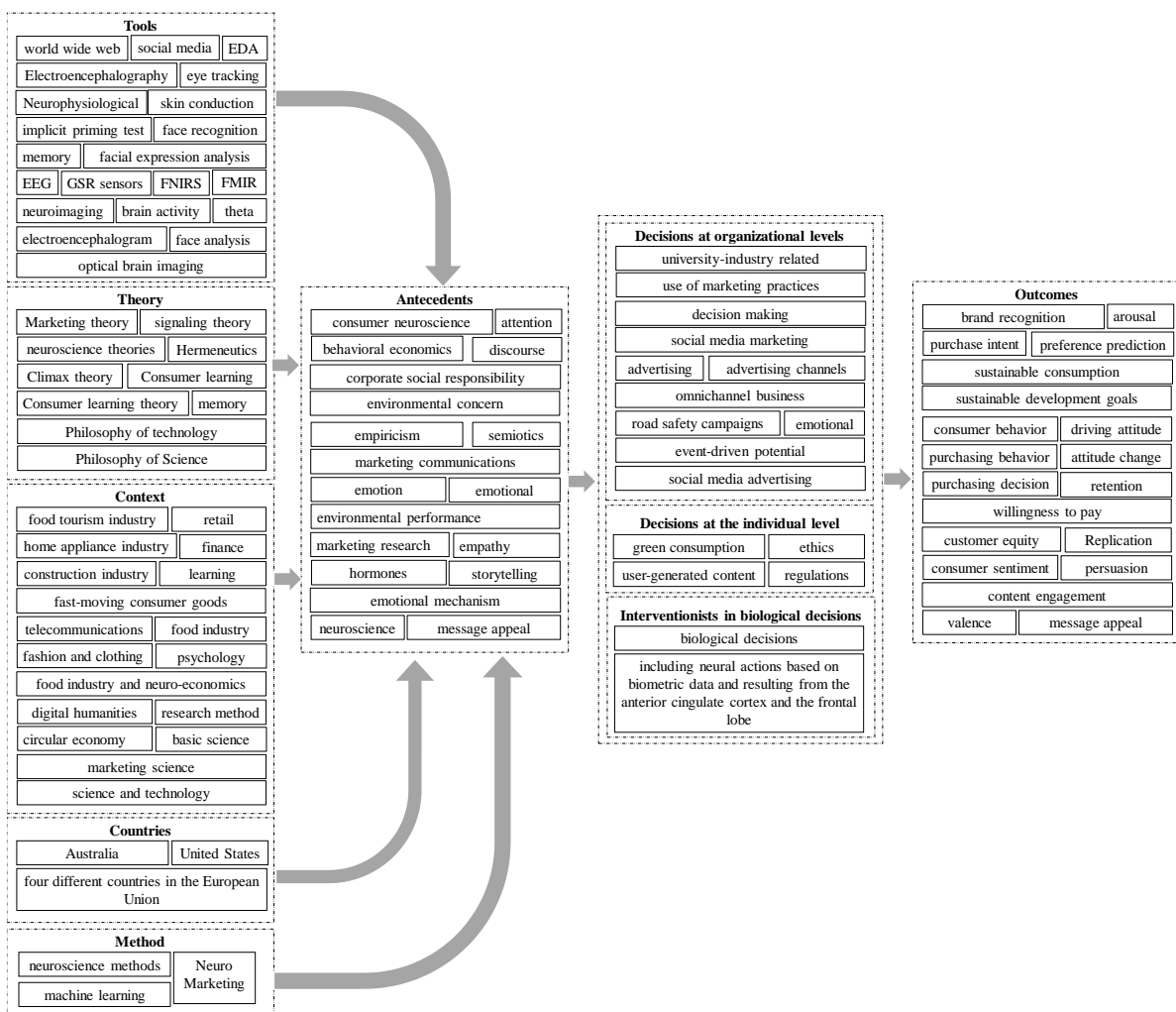


Figure 28. The model proposed by the researchers based on the ADO-TCM framework.

In the continuation of this research, the output of the analysis of co-occurrence and the analysis of co-citation in the TCM framework of theory, context, method (Paul et al., 2017) and also in the form of ADO, antecedents, decisions and results (Paul and Benito, 2018), answers related to the questions

raised in the introduction section were designed and studied clearly. In the following, each of the tools introduced in the research is briefly explained (Figure 28).

Electroencephalography (EEG) is a neuroimaging technique that records electrical activity in the brain using electrodes placed on the scalp. EEG has been widely used in both clinical and research settings to study brain function and to diagnose neurological disorders (Cahn et al., 2013; Cheng et al., 2008; Zhang et al., 2023). Eye tracking is a technique used to measure eye movements and gaze direction (Holmqvist et al., 2023; McDonald et al., 2022). Eye tracking has been widely used in both clinical and research settings to study visual perception, attention and cognition (Reilly and Peelle 2021; Powers et al., 2019).

Implicit priming tests are used to measure the effects of unconscious cognitive processes on behavior. In these tests, participants are exposed to a prime stimulus (e.g., a word, image or sound) that is intended to activate a specific mental concept or stereotype. The effect of the prime on subsequent behavior is then measured. These tests are used to study the implicit biases and associations that people hold, which may influence their behavior without their awareness (Yuan et al., 2023; Zhang et al., 2023).

Face recognition is a technology that identifies individuals by analyzing their facial features. It has become increasingly important in security and surveillance applications, as well as in areas such as human-computer interaction and social robotics (Li et al., 2005).

Skin conductance, also known as electro-dermal activity (EDA), is a physiological measure that reflects the electrical conductance of the skin, which can be influenced by changes in sympathetic nervous system activity (Qasim et al., 2022).

Functional near-infrared spectroscopy (fNIRS) is a non-invasive neuroimaging technique that measures changes in oxygenated and deoxygenated hemoglobin concentrations in the brain, which can be used to infer changes in neural activity (Hakimi et al., 2022; Keles et al., 2022).

Functional magnetic resonance imaging (fMRI) is a neuroimaging technique that measures changes in blood flow in the brain to infer neural activity (Chang et al., 2021).

Functional magnetic resonance imaging (fMRI) is a non-invasive neuroimaging technique that measures changes in blood flow in the brain to infer neural activity. When neurons are active, they require more oxygen and glucose, which is supplied by an increased blood flow to the region of the brain where the neurons are located. fMRI takes advantage of this relationship between neural activity and blood flow to create images of brain activity in response to various stimuli or tasks (Chen and Glover, 2021; Gazzaniga et al., 2021).

Galvanic skin response (GSR) sensors are a type of biometric sensor commonly used in neuromarketing to measure changes in the electrical conductivity of the skin, which can indicate changes in emotional arousal, attention and engagement. GSR sensors are often used in combination with other biometric sensors, such as electro-encephalo-graphy (EEG) and eye tracking, to gain insights into consumer behavior and preferences.

Optical brain imaging in neuromarketing refers to the use of techniques such as functional near-infrared spectroscopy (fNIRS) and diffuse optical tomography (DOT) to measure changes in blood flow and oxygenation in the brain in response to marketing stimuli.

Facial analysis in neuromarketing refers to the use of technology to track and analyze facial expressions in response to marketing stimuli (de Oliveira and Prado, 2021).

5. Discussion

This research has identified the theoretical vacuum after examining databases in the field of neuromarketing and the lack of a systematic review from the beginning of this concept until the end of 2022. In this regard, the present research sought to answer the central question of understanding the current state of research in the field of neuromarketing and to clarify the critical level of neuromarketing in related research, pursuing the following main goals: a) analyzing and integrating the concept of neuromarketing, b) recognizing the productive authors, the years of document publication, authentic journals publishing articles in this field and keywords around this concept, c) introducing the methods and tools presented in neuroscience in marketing and d) expanding and improving the perception of those interested and researchers in this field, based on the model of Iden et al. (2017), consisting of the four steps of planning, selection, extraction and implementation.

Also, to increase the accuracy of the selection of previous research, in this study, for the process of selecting articles, the method of Silva (2015) was used. This research data was first identified from the reliable Scopus database and then from the reliable Web-of-Science database. Examining the results and comparing them at two levels of functional analysis, the scientific maps were drawn and were analyzed using a systematic bibliometric (Xu et al., 2021) review in VOS viewer software. In addition, it is based on the interpretation paradigm that the researcher and the investigated phenomenon interact with each other to discover, create and interpret facts (Khashei and Harandi, 2015); the researchers consider themselves to be an influential part of the research. During the investigation, they are obliged to check the accuracy and validity of the findings obtained from the software and have controlled many cases in a back-and-forth cycle.

In the first level, the share of the annual production of neuromarketing documents, production of authoritative quarterly journals in the field of neuromarketing, production of subject areas related to neuromarketing, and contribution of documents by productive authors were studied in performance analysis phase. Also, 17 clusters, including 109 items and 131 keywords, were found in the analysis section of drawing knowledge maps. The contributions of three clusters (e.g., the fifth cluster deals with green consumption and sustainable development goals, the tenth cluster deals with corporate social responsibility, the eleventh cluster pays attention to ethics, and finally, and the sixteenth cluster refers to environmental concerns), the synthesis of literature sustainability and green consumption are profiled in Normarketing's article. Green consumption plays a vital role in reducing the harmful impression of consumption on the environment and ecosystem. This is because green consumers can effectively force enterprises to produce green transformation, thus promoting the sustainable development of the overall economic structure (Wei et al., 2023).

In the next phase of this research, modeling the ADO-TCM framework of Paul et al. (2017), the previous essential structures were identified as context method, industry, theory, antecedents, decisions and results. In the initial part of the model, i.e., predictive structures such as a) the methodology in the analyzed articles, including neuroscience, neuromarketing and machine learning methods; b) In the tools section, tools such as world wide web, social media, electroencephalography, neurophysiologic, eye tracking, EDA, implicit priming test, face recognition, memory, skin conductance, facial expression analysis, fnirs, eeg, fmri, GSR sensors, optical brain imaging, neuroimaging, brain activity, theta, electroencephalogram, face analysis were considered; c) In this context, food tourism industry, in home appliance industry, construction industry, fast-moving consumer goods, telecommunications, finance, retail, fashion and clothing, food industry and neuro-economics, digital humanities, circular economy,

psychology, research method, marketing science, basic science, science and technology, and the country of Australia, the United States, along with four different countries in the European Union were studied; d) In the theory section, marketing theory, signaling theory, neuroscience theories, climax theory, marketing theories, consumer learning theory, hermeneutics, philosophy of technology, philosophy of science were analyzed. Also, in the second part of the antecedent's model under the title of consumer neuroscience, behavioral economics, discourse, empiricism, semiotics, marketing communication, emotion, emotional, environmental performance, hormones, marketing research, storytelling, attention, emotional mechanism, empathy, neuroscience, corporate social responsibility, message appeal; environmental concern was identified from the analyzed articles and its features were studied.

In the third part of the model, decisions are divided into three levels: 1) biological and less in people's control, 2) at the individual level and 3) at the organizational level. These respectively include 1) biological decisions, including neural actions based on biometric data and resulting from the anterior cingulate cortex and the frontal lobe, 2) decisions at the individual level such as green consumption, ethics, regulations and user-generated content and 3) decisions at the organizational level including university-industry relations, use of marketing practices, advertising decision making, social media marketing, advertising channels, omni-channel business, road safety campaigns, event-driven potential and social media advertising.

Finally, the outcomes of as the factors like arousal, brand recognition, purchase intent, preference prediction, driving attitude, consumer behavior, sustainable consumption, attitude change, retention, decision making, purchase behavior, purchasing decision, customer equity, willingness to pay, replication, consumer sentiment, content engagement, persuasion, valence, sustainable development goals were obtained and studied category-wise. It is hoped that the results of this systematic review can open the development pathways of the link between sustainability literature and neuromarketing.

6. Conclusions

This research aimed to provide a systematic bibliometric review of neuromarketing methodology up until the end of 2022, contributing to a comprehensive understanding of this concept. By analyzing reputable quarterly journals and reliable databases, the study visualizes the frequency of tool usage in neuromarketing laboratories and enhances knowledge development. The paper also suggests future research to explore the role of temporal dynamics in longitudinal periods, enhancing the generalization of findings in neuromarketing.

Neuromarketing involves utilizing neuroscience techniques to comprehend consumer responses to marketing stimuli. The paper proposes novel research applications for this field, including cross-cultural research, online consumer behavior analysis, brand perception assessment, social influence examination, emotional response measurement and product packaging assessment. These applications offer valuable insights into consumer behavior and contribute to more effective marketing strategies.

Furthermore, the study presents an integrated framework merging neuromarketing findings with a green perspective, providing a holistic view of the relationship between neural processes and consumer decision-making. By incorporating neuroimaging data and physiological measurements, the framework offers precise assessment of emotional reactions and their influence on consumer preferences. The research also examines publication trends and collaboration patterns, demonstrating the global nature of neuromarketing and highlighting emerging themes.

However, the study acknowledges limitations, such as potential differences in results due to keyword selection and filtering methods. The complex organization of the 17 discussed clusters is recognized as another challenge. Additionally, the research's scope is restricted to the Scopus and Web of Science databases, suggesting the possibility of expanding to other databases like Google Scholar in future studies.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

References

- Adebayo TS (2023) Trade-off between environmental sustainability and economic growth through coal consumption and natural resources exploitation in China: New policy insights from wavelet local multiple correlation. *Geol J* 58: 1384–1400. <https://doi.org/10.1002/gj.4664>
- Adil S, Lacoste-Badie S, Droulers O (2018) Face presence and gaze direction in print advertisements: how they influence consumer responses—an eye-tracking study. *J Advertising Res* 58: 443–455. <https://doi.org/10.2501/JAR-2018-004>
- Akhter S, Pauyo T, Khan M (2019) What is the difference between a systematic review and a meta-analysis? *Basic methods handbook for clinical orthopaedic research: a practical guide and case-based research approach*, 331–342. https://doi.org/10.1007/978-3-662-58254-1_37
- Aly E, Elsayah S, Ryan MJ (2022) A review and catalogue to the use of models in enabling the achievement of sustainable development goals (SDG). *J Clean Prod* 340: 130803. <https://doi.org/10.1016/j.jclepro.2022.130803>
- Bakalash T, Riemer H (2013) Exploring ad-elicited emotional arousal and memory for the ad using fMRI. *J Advert* 42: 275–291. <https://doi.org/10.1080/00913367.2013.768065>
- Baldo D, Viswanathan VS, Timpone, RJ, et al. (2022) The heart, brain, and body of marketing: complementary roles of neurophysiological measures in tracking emotions, memory, and ad effectiveness. *Psyc Mark* 39: 1979–1991. <https://doi.org/10.1002/mar.21697>
- Bandari R, Moallemi EA, Lester RE, et al. (2022) Prioritising Sustainable Development Goals, characterising interactions, and identifying solutions for local sustainability. *Env Sci Pol* 127: 325–336. <https://doi.org/10.1016/j.envsci.2021.09.016>
- Bergamaschi M, Randerson K (2016) The futures of family businesses and the development of corporate social responsibility. *Futures* 75: 54–65. <https://doi.org/10.1016/j.futures.2015.10.006>
- Berkman ET, Falk EB (2013) Beyond brain mapping: Using neural measures to predict real-world outcomes. *Curr Direc Psych Sci* 22: 45–50. <https://doi.org/10.1177/0963721412469394>
- Biglari S, Beiglary S, Arthanari T (2022) Achieving sustainable development goals: Fact or Fiction?. *J Clean Prod* 332: 130032. <https://doi.org/10.1016/j.jclepro.2021.130032>
- Cahn BR, Delorme A, Polich J (2013) Occipital gamma activation during vipassana meditation. *Cogn Proces* 14: 393–406. <https://doi.org/10.1007/s10339-009-0352-1>

- Cakir MP, Çakar T, Giriskan Y, et al. (2018) An investigation of the neural correlates of purchase behavior through fNIRS. *Eur J Mark* 52: 224–243. <https://doi.org/10.1108/EJM-12-2016-0864>
- Carroll AB (2016) Carroll's pyramid of CSR: Taking another look. *Int J Corp Soc Res* 1: 1–8. <https://doi.org/10.1186/s40991-016-0004-6>
- Chang L, Tsao DY, Liu T (2021) Distributed representation of visual objects by single neurons in macaque visual cortex. *Nat Commun* 12: 1–13. <https://doi.org/10.1523/JNEUROSCI.1958-14.2015>
- Chen JE, Glover GH (2021) Advances in BOLD fMRI methodology. *Tren Cogn Sci* 25: 511–527. <https://doi.org/10.1016/j.tics.2017.09.010>
- Cheng Y, Yang CY, Lin CP, et al. (2008) The perception of pain in others suppresses somatosensory oscillations: a magnetoencephalography study. *Neuroimage* 40: 1833–1840. <https://doi.org/10.1016/j.neuroimage.2008.01.064>
- Ćirović M, Dimitriadis N, Janić M, et al. (2022) More than words: Rethinking sustainability communications through neuroscientific methods. *J Cons Behav*. <https://doi.org/10.1002/cb.2125>
- Clark KR, Leslie KR, Garcia-Garcia M, et al. (2018) How advertisers can keep mobile users engaged and reduce video-ad blocking: Best practices for video-ad placement and delivery based on consumer neuroscience measures. *J Adv Res* 58: 311–325. <https://doi.org/10.2501/JAR-2018-036>
- Daugherty T, Hoffman E, Kennedy K, et al. (2018) Measuring consumer neural activation to differentiate cognitive processing of advertising: Revisiting Krugman. *Eur J Mark* 52: 182–198. <https://doi.org/10.1108/EJM-10-2017-0657>
- de Oliveira JHC, Giraldi JDME (2017) What is neuromarketing? A proposal for a broader and more accurate definition. *Glob Bus Manage Res* 9: 19–29. Available from: <http://gbmrjournal.com/pdf/vol.%209%20no.%202/V9N2-2.pdf>
- de Oliveira L, Prado JW (2021) Emotion and advertising effectiveness: A facial analysis study. *Int J Adv* 40: 455–472. Available from: <http://www.gbmrjournal.com/pdf/vol.%209%20no.%202/V9N2-2.pdf>
- De Vries EL, Fennis BM, Bijmolt TH, et al. (2018) Friends with benefits: Behavioral and fMRI studies on the effect of friendship reminders on self-control for compulsive and non-compulsive buyers. *Int J Res Mark* 35: 336–358. <https://doi.org/10.1016/j.ijresmar.2017.12.004>
- Donthu N, Kumar S, Pandey N, et al. (2021) Mapping the electronic word-of-mouth (eWOM) research: A systematic review and bibliometric analysis. *J Bus Res* 135: 758–773. <https://doi.org/10.1016/j.jbusres.2021.07.015>
- Farooq O, Rupp DE, Farooq M (2017) The multiple pathways through which internal and external corporate social responsibility influence organizational identification and multifoci outcomes: The moderating role of cultural and social orientations. *Acad Manage J* 60: 954–985. <https://doi.org/10.5465/amj.2014.0849>
- Figner B, Murphy RO, Siegel P (2019) Measuring electrodermal activity and its applications in judgment and decision-making research, In: *A Handbook of Process Tracing Methods*, Routledge, 161–183. <https://doi.org/10.4324/9781315160559-12>
- Foroudi P, Akarsu TN, Marvi R, et al. (2021) Intellectual evolution of social innovation: A bibliometric analysis and avenues for future research trends. *Ind Mark Manage* 93: 446–465. <https://doi.org/10.1016/j.indmarman.2020.03.026>
- Fortunato VCR, Giraldi JDME, de Oliveira JHC (2014) A review of studies on neuromarketing: Practical results, techniques, contributions and limitations. *J Manage Res* 6: 201–220. <https://doi.org/10.5296/jmr.v6i2.5446>

- Frederick DP (2022) Recent Trends in Neuro marketing—An Exploratory Study. *Int J Case Stud Bus IT Edu. (IJCSBE)*, 6: 38–60. <https://doi.org/10.47992/IJCSBE.2581.6942.0148>
- Garczarek-Bąk U, Szymkowiak A, Gaczek P, et al. (2021) A comparative analysis of neuromarketing methods for brand purchasing predictions among young adults. *J Brand Manage* 28: 171–185. <https://doi.org/10.1057/s41262-020-00221-7>
- Gazzaniga MS, Ivry RB, Mangun GR (2021) Cognitive neuroscience: The Biology of the Mind (5th ed.), W. W. Norton & Company. Available from: <https://www.amazon.com/Cognitive-Neuroscience-Biology-Mind-Fifth/dp/0393603172>
- Ghaffar A, Islam T (2023) Factors leading to sustainable consumption behavior: an empirical investigation among millennial consumers. *Kyber*. <https://doi.org/10.1108/K-12-2022-1675>
- Gómez-Carmona D, Marín-Dueñas PP, Tenorio RC, et al. (2022) Environmental concern as a moderator of information processing: A fMRI study. *J Clean Prod* 369: 133306. <https://doi.org/10.1016/j.jclepro.2022.133306>
- Gountas J, Gountas S, Ciorciari J, et al. (2019) Looking beyond traditional measures of advertising impact: Using neuroscientific methods to evaluate social marketing messages. *J Bus Res* 105: 121–135. <https://doi.org/10.1016/j.jbusres.2019.07.011>
- Hakim A, Klorfeld S, Sela T, et al. (2021) Machines learn neuromarketing: Improving preference prediction from self-reports using multiple EEG measures and machine learning. *Int J Res Mark* 38: 770–791. <https://doi.org/10.1016/j.ijresmar.2020.10.005>
- Hakimi N, Shahbakhti M, Sappia S, et al. (2022) Estimation of respiratory rate from functional near-infrared spectroscopy (fNIRS): A new perspective on respiratory interference. *Bios* 12: 1170. <https://doi.org/10.3390/bios12121170>
- Halkiopoulou C, Antonopoulou H, Gkintoni E, et al. (2022) Neuromarketing as an indicator of cognitive consumer behavior in decision-making process of tourism destination—An overview, In: *Transcending Borders in Tourism Through Innovation and Cultural Heritage: 8th International Conference, IACuDiT, Hydra, Greece, 2021*, Cham: Springer International Publishing, 679–697. https://doi.org/10.1007/978-3-030-92491-1_41
- Hamelin N, Thaichon P, Abraham C, et al. (2020) Story telling, the scale of persuasion and retention: A neuromarketing approach. *J Retail Cons Serv* 55: 102099. <https://doi.org/10.1016/j.jretconser.2020.102099>
- Holmqvist K, Örbom SL, Hooge IT, et al. (2023) Eye tracking: empirical foundations for a minimal reporting guideline. *Behav Res Method* 55: 364–416. <https://doi.org/10.3758/s13428-021-01762-8>
- Hsu M (2017) Neuromarketing: inside the mind of the consumer. *Calif Manage Rev* 59: 5–22. <https://doi.org/10.1177/0008125617720208>
- Hsu MYT, Cheng JMS (2018) fMRI neuromarketing and consumer learning theory: word-of-mouth effectiveness after product harm crisis. *Eur J Mark* 52: 199–223. <https://doi.org/10.1108/EJM-12-2016-0866>
- Iden J, Methlie LB, Christensen GE (2017) The Nature of Strategic Foresight Research: A Systematic Literature Review. *Technol Forecast Social Change* 116: 87–97. <https://doi.org/10.1016/j.techfore.2006.10.001>
- Jai TM, Fang D, Bao FS, et al. (2021) Seeing it is like touching it: Unraveling the effective product presentations on online apparel purchase decisions and brain activity (An fMRI Study). *J Int Mark* 53: 66–79. <https://doi.org/10.1016/j.intmar.2020.04.005>

- Kansra P, Oberoi S, Gupta SL, et al. (2022) Factors limiting the application of consumer neuroscience: A systematic review. *J Cons Behav*. <https://doi.org/10.1002/cb.2131>
- Khashei V, Harandi AO (2015) Explaining strategic control model in weight industry: discourse exploration using grounded theory strategy. *J Strat Manage Stud* 6: 81–80.
- Keles HO, Karakulak EZ, Hanoglu L, et al. (2022) Screening for Alzheimer’s disease using prefrontal resting-state functional near-infrared spectroscopy. *Front Hum Neur* 16: 1061668. <https://doi.org/10.3389/fnhum.2022.1061668>
- Kirschstein T, Köhling R (2009) What is the source of the EEG? *Clin. EEG Neur* 40: 146–149. <https://doi.org/10.1177/155005940904000305>
- Knutson B, Genevsky A (2018) Neuroforecasting aggregate choice. *Curr Direct Psych Sci* 27: 110–115. <https://doi.org/10.1177/0963721417737877>
- Kolar T, Batagelj Z, Omeragić I, et al. (2021) How moment-to-moment EEG measures enhance ad effectiveness evaluation: Peak emotions during branding moments as key indicators. *J Adv Res* 61: 365–381. <https://doi.org/10.2501/JAR-2021-014>
- Krampe C, Strelow E, Haas A, et al. (2018) The application of mobile fNIRS to “shopper neuroscience”—first insights from a merchandising communication study. *Eur J Mark* 52: 244–259. <https://doi.org/10.1108/EJM-12-2016-0727>
- Kumar B, Sharma A, Vatavwala S, et al. (2020) Digital mediation in business-to-business marketing: A bibliometric analysis. *Ind Mark Manage* 85: 126–140. <https://doi.org/10.1016/j.indmarman.2019.10.002>
- Le TT (2023) The association of corporate social responsibility and sustainable consumption and production patterns: The mediating role of green supply chain management. *J Clean Prod* 414: 137435. <https://doi.org/10.1016/j.jclepro.2023.137435>
- Lee EJ, Kwon G, Shin HJ, et al. (2014) The spell of green: Can frontal EEG activations identify green consumers? *J Bus Eth* 122: 511–521. <https://doi.org/10.1007/s10551-013-1775-2>
- Lee N, Brandes L, Chamberlain L, et al. (2017). This is your brain on neuromarketing: Reflections on a decade of research. *J Mark Manage* 33: 878–892. <https://doi.org/10.1080/0267257X.2017.1327249>
- Lee N, Broderick AJ, Chamberlain L (2007) What is ‘neuromarketing’? A discussion and agenda for future research. *Int J Psych* 63: 199–204. <https://doi.org/10.1016/j.ijpsycho.2006.03.007>
- Lee N, Chamberlain L, Brandes L (2018) Welcome to the jungle! The neuromarketing literature through the eyes of a newcomer. *Eur J Mark* 52: 4–38. <https://doi.org/10.1108/EJM-02-2017-0122>
- Levallois C, Smidts A, Wouters P (2021) The emergence of neuromarketing investigated through online public communications (2002–2008). *Bus Hist* 63: 443–466. <https://doi.org/10.1080/00076791.2019.1579194>
- Li SZ, Jain AK, Huang T, et al. (2005) Face recognition applications. *Hand Face Recog*, 371–390.
- Lim WM (2018) Demystifying neuromarketing. *J Bus Res* 91: 205–220. <https://doi.org/10.1016/j.jbusres.2018.05.036>
- Lim WM, Yap SF, Makkar M (2021) Home sharing in marketing and tourism at a tipping point: What do we know, how do we know, and where should we be heading? *J Bus Res* 122: 534–566. <https://doi.org/10.1016/j.jbusres.2020.08.051>
- Liu Y, Zhao R, Xiong X, et al. (2023) A Bibliometric analysis of consumer neuroscience towards sustainable consumption. *Behav Sci* 13: 298–315. <https://doi.org/10.3390/bs13040298>

- Luna-Nevarez C (2021) Neuromarketing, ethics, and regulation: An exploratory analysis of consumer opinions and sentiment on blogs and social media. *J Cons Pol* 44: 559–583. <https://doi.org/10.1007/s10603-021-09496-y>
- Mariani MM, Al-Sultan K, De Massis A (2023). Corporate social responsibility in family firms: A systematic literature review. *J Small Bus Manage* 61: 1192–1246. <https://doi.org/10.1080/00472778.2021.1955122>
- Marzouk OA, Mahrous AA (2020) Sustainable consumption behavior of energy and water-efficient products in a resource-constrained environment. *J Glob Mark* 33: 335–353. <https://doi.org/10.1080/08911762.2019.1709005>
- McDonald MA, Tayebi M, McGeown JP, et al. (2022) A window into eye movement dysfunction following mTBI: a scoping review of magnetic resonance imaging and eye tracking findings. *Brain Behav* 12: e2714. <https://doi.org/10.1002/brb3.2714>
- Meyerding SG, Mehlhose CM (2020) Can neuromarketing add value to the traditional marketing research? An exemplary experiment with functional near-infrared spectroscopy (fNIRS). *J Bus Res* 107: 172–185. <https://doi.org/10.1016/j.jbusres.2018.10.052>
- Mishra S, Malhotra G, Chatterjee R, et al. (2021) Impact of self-expressiveness and environmental commitment on sustainable consumption behavior: The moderating role of fashion consciousness. *J Strat Mark*, 1–23. <https://doi.org/10.1080/0965254X.2021.1892162>
- Motoki K, Sugiura M, Kawashima R (2019). Common neural value representations of hedonic and utilitarian products in the ventral stratum: An fMRI study. *Sci Rep* 9: 1–10. <https://doi.org/10.1038/s41598-019-52159-9>
- Motoki K, Suzuki S, Kawashima R, et al. (2020) A combination of self-reported data and social-related neural measures forecasts viral marketing success on social media. *J Interact Mark* 52: 99–117. <https://doi.org/10.1016/j.intmar.2020.06.003>
- Murphy ER, Illes J, Reiner PB (2008) Neuroethics of neuromarketing. *J Cons Behav An Int Res Rev* 7: 293–302. <https://doi.org/10.1002/cb.252>
- Nasir O, Javed RT, Gupta S, et al. (2023) Artificial intelligence and sustainable development goals nexus via four vantage points. *Techn Soc* 72: 102171. <https://doi.org/10.1016/j.techsoc.2022.102171>
- Negrete-Cardoso M, Rosano-Ortega G, Álvarez-Aros EL, et al. (2022) Circular economy strategy and waste management: A bibliometric analysis in its contribution to sustainable development, toward a post-COVID-19 era. *Env Sci Poll Res* 29: 61729–61746. <https://doi.org/10.1007/s11356-022-18703-3>
- Nemorin S (2017) Neuromarketing and the “poor in world” consumer: how the animalization of thinking underpins contemporary market research discourses. *Cons Mark Cult* 20: 59–80. <https://doi.org/10.1080/10253866.2016.1160897>
- Nilashi M, Samad S, Ahmadi N, et al. (2020). Neuromarketing: a review of research and implications for marketing. *J Soft Comp Dec Supp Sys* 7: 23–31.
- Oliveira PM, Guerreiro J, Rita P (2022) Neuroscience research in consumer behavior: A review and future research agenda. *Int J Cons Stud* 46: 2041–2067. <https://doi.org/10.1111/ijcs.12800>
- Pagan NM, Pagan KM, Teixeira AA, et al. (2020) Application of neuroscience in the area of sustainability: Mapping the territory. *Glob J Flex Sys Manage* 21: 61–77. <https://doi.org/10.1007/s40171-020-00243-9>

- Paul J, Benito GRG (2018) A review of research on outward foreign direct investment from emerging countries, including China: what do we know, how do we know and where should we be heading? *Asia Pac Bus Rev* 24: 90–115. <https://doi.org/10.1080/13602381.2017.1357316>
- Paul J, Parthasarathy S, Gupta P (2017) Exporting challenges of SMEs: A review and future research agenda. *J World Bus* 52: 327–342. <https://doi.org/10.1016/j.jwb.2017.01.003>
- Pérez-Martínez J, Hernandez-Gil F, San Miguel G, et al. (2023) Analysing associations between digitalization and the accomplishment of the Sustainable Development Goals. *Sci Total Env* 857: 159700. <https://doi.org/10.1016/j.scitotenv.2022.159700>
- Piracci G, Casini L, Contini C, et al. (2023) Identifying key attributes in sustainable food choices: An analysis using the food values framework. *J Clean Prod* 416: 137924. <https://doi.org/10.1016/j.jclepro.2023.137924>
- Plassmann H, Venkatraman V, Huettel S, et al. (2015) Consumer neuroscience: applications, challenges, and possible solutions. *J Mark Res* 52: 427–435. <https://doi.org/10.1509/jmr.14.0048>
- Powers A, Fani N, Murphy L, et al. (2019) Attention bias toward threatening faces in women with PTSD: Eye tracking correlates by symptom cluster. *Eur J Psy* 10: 1568133. <https://doi.org/10.1080/20008198.2019.1568133>
- Qananwah Q, Alqudah AM, Alodat MD, et al. (2022) Detecting cognitive features of videos using EEG signal. *Comp J* 65: 105–123. <https://doi.org/10.1093/comjnl/bxaa180>
- Qasim MS, Bari DS, Martinsen ØG (2022) Influence of ambient temperature on tonic and phasic electrodermal activity components. *Phys Meas* 43: 065001. <https://doi.org/10.1088/1361-6579/ac72f4>
- Qazi A, Simsekler MCE, Al-Mhdawi MKS (2023) Exploring network-based dependencies between country-level sustainability and business risks. *J Clean Prod* 418: 138161. <https://doi.org/10.1016/j.jclepro.2023.138161>
- Ramsøy TZ (2019) Building a foundation for neuromarketing and consumer neuroscience research: How researchers can apply academic rigor to the neuroscientific study of advertising effects. *J Adv Res* 59: 281–294. <https://doi.org/10.2501/JAR-2019-034>
- Rana IA, Khaled S, Jamshed A, Nawaz A (2022) Social protection in disaster risk reduction and climate change adaptation: A bibliometric and thematic review. *J Integ Env Sci* 19: 65–83. <https://doi.org/10.1080/1943815X.2022.2108458>
- Rawnaque FS, Rahman K M, Anwar SF, et al. (2020). Technological advancements and opportunities in neuromarketing: a systematic review. *Brain Inf* 7: 1–19. <https://doi.org/10.1186/s40708-020-00109-x>
- Reilly RG, Peelle JE (2021) The left inferior frontal gyrus is sensitive to individual differences in reading comprehension ability: An eye-tracking study. *PLoS One* 16: e0245897. <https://doi.org/10.1371/journal.pone.0245897>
- Savelli E, Gregory-Smith D, Murmura F, et al. (2022) How to communicate typical–local foods to improve food tourism attractiveness. *Psy. Mark* 39: 1350–1369. <https://doi.org/10.1002/mar.21668>
- Shen F, Morris JD (2016) Decoding neural responses to emotion in television commercials: an integrative study of self-reporting and fMRI measures. *J Adv Res* 56: 193–204. <https://doi.org/10.2501/JAR-2016-016>
- Singh J, Goyal G, Gill R (2020) Use of neurometrics to choose optimal advertisement method for omnichannel business. *Ent Inf Sys* 14: 243–265. <https://doi.org/10.1080/17517575.2019.1640392>

- Silva M (2015) A systematic review of Foresight in Project Management literature. *Proc Comp Sci* 64: 792–799. <https://doi.org/10.1016/j.procs.2015.08.630>
- Smidts A, Hsu M, Sanfey AG, et al. (2014) Advancing consumer neuroscience. *Mark Lett* 25: 257–267. <https://doi.org/10.1007/s11002-014-9306-1>
- Solnais C, Andreu-Perez J, Sánchez-Fernández J, et al. (2013) The contribution of neuroscience to consumer research: A conceptual framework and empirical review. *J Econ Psy* 36: 68–81. <https://doi.org/10.1016/j.joep.2013.02.011>
- Stanton SJ, Sinnott-Armstrong W, Huettel SA (2017) Neuromarketing: Ethical implications of its use and potential misuse. *J Bus Eth* 144: 799–811. <https://doi.org/10.1007/s10551-016-3059-0>
- Stillman P, Lee H, Deng X, et al. (2020) Examining consumers' sensory experiences with color: A consumer neuroscience approach. *Psy Mark* 37: 995–1007. <https://doi.org/10.1002/mar.21360>
- Varan D, Lang A, Barwise P, et al. (2015) How reliable are neuromarketers' measures of advertising effectiveness? Data from ongoing research holds no common truth among vendors. *J Adv Res* 55: 176–191. <https://doi.org/10.2501/JAR-55-2-176-191>
- Vyas S, Seal A (2022) A deep convolution neural networks framework for analyzing electroencephalography signals in neuromarketing, In: *Proceedings of International Conference on Frontiers in Computing and Systems: COMSYS 2021. Singapore: Springer Nature Singapore*, 119–127. https://doi.org/10.1007/978-981-19-0105-8_12
- Wajid A, Raziq MM, Ahmed QM, et al. (2021) Observing viewers' self-reported and neurophysiological responses to message appeal in social media advertisements. *J Retail Cons Serv* 59: 102373. <https://doi.org/10.1016/j.jretconser.2020.102373>
- Wei Q, Lv D, Lin Y, et al. (2023) Influence of utilitarian and hedonic attributes on willingness to pay green product premiums and neural mechanisms in China: An ERP study. *Sustainability* 15: 2403. <https://doi.org/10.3390/su15032403>
- WTO (2023) Available from: https://www.wto.org/english/forums_e/public_forum23_e/public_forum23_e.htm
- Xu Z, Wang X, Wang X, et al. (2021) A comprehensive bibliometric analysis of entrepreneurship and crisis literature published from 1984 to 2020. *J Bus Res* 135: 304–318. <https://doi.org/10.1016/j.jbusres.2021.06.051>
- Yuan J, Zhang Y, Zhao Y, et al. (2023) The emotion-regulation benefits of implicit reappraisal in clinical depression: Behavioral and electrophysiological evidence. *Neur Bull* 39: 973–983. <https://doi.org/10.1007/s12264-022-00973-z>
- Zhang Y, Bian Y, Wu H, et al. (2023) Intuition or rationality: Impact of critical thinking dispositions on the cognitive processing of creative information. *Thin Skills Create* 48: 101278. <https://doi.org/10.1016/j.tsc.2023.101278>
- Zhao M (2022) The impact of cognitive conflict on product-service system value cocreation: An event-related potential perspective. *J Clean Prod* 331: 129987. <https://doi.org/10.1016/j.jclepro.2021.129987>
- Zhu Z, Jin Y, Su Y, et al. (2022). Evaluation of the neuromarketing research trend: 2010–2021. *Front Psyc* 13: 872468. <https://doi.org/10.3389/fpsyg.2022.872468>



AIMS Press

© 2023 the Author(s), licensee AIMS Press. This is an open access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>).