

Neuromarketing research through the years: A bibliometric review of technological advancements and multisensory studies

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ARTICLE INFO

Keywords:

Neuromarketing
Emerging technologies
Consumer neuroscience
Consumer behavior
Neuroeconomics

ABSTRACT

The current study examines the changes in neuromarketing studies between 2015 and 2024, particularly in the context of new technologies incorporating multisensory interventions. It attempts to identify significant trends, influential texts, and topical developments that shape the field. A bibliometric method was employed to review 307 publications within the study's framework, using the Scopus database. Bookmarked by methods such as keyword co-occurrence, co-citation, cluster analysis, performance analysis, and science mapping techniques, these are implemented using programs like VOSviewer or Biblioshiny. The results show a significant increase in the number of neuromarketing studies, with notable works from Italy, Spain, and the USA. The literature has been utilizing neuroimaging instruments, artificial intelligence, and virtual reality in the quest to comprehend consumer behavior. Four main research clusters have arisen on consumer neuroscience, marketing innovation, ethical issues, and decision-making processes. The study concludes that the phenomenon of neuromarketing has been dynamic, interdisciplinary, and technologically paced, while also raising moral concerns. It points to the increased use of data-driven and immersive marketing solutions, which access the unconscious reactions of customers. These implications suggest that neuromarketing has the potential to elevate marketing by engaging in a personalized manner, while also conveying a message about responsible methods and ethical guidelines as the discipline expands in breadth and depth.

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<https://doi.org/10.1016/j.teler.2026.100332>

Received 4 May 2025; Received in revised form 3 April 2026; Accepted 13 April 2026

Available online 22 April 2026

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1. Introduction

Picture a future where marketers can tap directly into your brain's responses to create irresistible products and advertisements. This is the promise of neuromarketing, where science meets commerce to decode the mysteries of consumer behavior. Neuromarketing is a marketing study that examines customers' sensorimotor, cognitive, and emotional responses to marketing stimuli [1]. The central concept of neuromarketing is closely tied to brain activity, enabling an understanding of customers' subconscious minds, their preferences, motives, and expectations, and predicting their behavior [2]. Human brain activity is unreasonable since 80 % of purchasing decisions are made subconsciously or involuntarily [3]. Over the last decade, the growing emphasis on neuromarketing has led to a significant increase in novel insights and practical applications in the field of marketing [4]. Initially coined by Professor Ale Smidt in 2002, the word "neuromarketing" refers to the examination of the brain and its cognitive processes within the context of consumer behavior. Due to the brain's imperceptibility, neuromarketing enables the use of neuroscientific technologies, such as fMRI, to study subconscious reactions and observe people's brain activity in response to marketing techniques they are unaware of [5].

Recent research has shown that traditional methods for deciphering decision-making processes, such as self-reporting techniques, do not effectively examine how the human subconscious influences ultimate decision-making [6]. Scholars are concerned about the inaccuracy and unreliability of traditional approaches to understanding consumer behavior [7]. Possible misinterpretation of responses by the researcher arises from the inherent difficulty of orally expressing emotions during interviews or self-report assessments [8]. In the last decade, consumer psychology, with the help of neuroscientific techniques such as functional magnetic resonance imaging (fMRI), has attracted increasing attention in business and marketing research to predict customer purchase behavior [9]. As such, Neuroscience has concentrated on emotional reactions with fMRI and electroencephalography (EEG) in marketing for 10 years [10], to comprehend the neurological side of consumer behaviour. The results from the fMRI experiment showed that most of the customer activities and decision-making take place on a nonconscious level, but have a substantial influence on purchasing [11, 12]. Neuromarketing methods can be classified into three broad categories: (a) neuroimaging including magnetoencephalography (MEG), positron emission tomography (PET), galvanic skin response (GSR), steady state topography (SST), EEG, and functional near-infrared spectroscopy (fNIRS), (b) physiological (electrocardiogram (ECG), eye-tracking (ET), facial expression recognition and magnetoencephalography (EEG)) and (c) behavioral measures [13]. Contrary to the conventional methods, new marketing uses cutting-edge medical devices such as fMRI for the study of customers' minds, and also the acquired information will be used to ameliorate marketing ploys and processes [14,15]. Previous studies have shown that marketing academics are drawn to the field of neuromarketing, which promises to enhance the value of marketing and achieve better results by utilising advanced brain mapping processes [16]. This strategy enables marketers to develop an effective approach that deeply resonates with consumers, ultimately shaping the overall customer journey and driving business growth. Among the main difficulties, we find developing tools that combine novel technologies, such as artificial intelligence (AI), virtual reality (VR), and machine learning, with classical neuromarketing measures. Such solutions could completely revolutionize our capability to deliver true consumer understanding. However, current application of neuromarketing is only in its infancy, and researchers and practitioners should not discount the role of this new field, as Neuromarketing may provide more reliable data than traditional methods, so as to elucidate how the customer makes a decision [17,18]. This chasm is a barrier to understanding and leveraging these tools for market intelligence.

There is also growing interest in multisensory integration, or the

study of how sensory inputs such as vision, audition, olfaction, taste, and touch affect what customers do. However, relatively few studies have been conducted on the collective effects of convergence of a multitude of rapidly advancing technologies and multimodal approaches [19–21]. Furthermore, there are no in-depth bibliometric studies that chart out the co-evolution of these emerging themes within neuromarketing. There is an urgency to fill this gap, especially in the current competitive context, where holistic and engaging consumer experiences have become increasingly crucial.

Using bibliometric analysis, this study developed the scientific mapping and performance analysis of the research articles chosen for the neuromarketing research. Through performance analysis, one can gain insight into the trends in recent publications, the journals that cover the subject, the research methodologies employed, and the top authors, institutions, and countries. Word clouds and cluster analysis are utilized in science mapping to identify key subjects, significant themes, and citation network analysis [22].

This research aims to conduct a comprehensive bibliometric analysis of the published literature on incorporating multidimensional integrations and novel technologies in behavioral marketing from 2015 to 2024. The study is organized around three fundamental research objectives (ROs) that aim to gain insight into the growth and development of neurological marketing research, with a specific emphasis on technical improvements and multisensory techniques.

RO1. To assess the progression of the neuromarketing literary work throughout this time, to catalogue seminal works in the field, and to map out where studies have been conducted about various educational and geographical contexts.

RO2. To examine how neuromarketing studies have developed thematically to emerging technology and multimodal methods.

RO3. To explore the intricate web of relationships among neuromarketing as a scientific community through the third question being studied.

In the current era of competitiveness and a dynamically changing digital market, the role of the consumer's unconscious motivation in decision-making is even more essential than before. Reading the subconscious mind of consumers, Neuromarketing (combining neuroscience, psychology, and marketing) holds out the prospect of uncovering these formerly subconscious responses by directly assessing the brain activity and physiology of the consumer at the point of purchase. This method is highly effective, as it surpasses conventional self-report measures, which, in most cases, fail to accurately identify automatic processes of emotion and cognition [23,24].

Although neuromarketing tools (fMRI, EEG, eye-tracking) are increasingly being applied, a significant research gap exists: the technological progress and aspect of multisensory integration remain unexplored in terms of bibliometric mapping, which examines how new technologies have influenced and situated the field of neuromarketing studies over the last decade. This gap needs to be bridged to understand the current state of the field and to inform future research.

Through a structured study of publication trends, most influential publications, critical authors, organizations, and thematic groups in the field of neuromarketing, this analysis represents a better view of scholars and practitioners, of how neuromarketing studies have become less homogeneous and more varied as the field has developed and expanded, in particular through the adoption of new technologies and techniques. Such an integrated approach to the problem can provide a foundation for more adequate research design, ethical conduct, and commercial strategies.

Although previous literature reviews have been based on specific techniques or a given period, this one is one of the few to undertake a large-scale bibliometric study from 2015 to 2024, with the express aim of examining the impact of technological advances and multisensory

implementations on the discipline. Besides, by integrating performance analysis with science mapping methods, the study reveals not only who and what have influenced it most, but also how and why research topics have evolved and changed over time.

In addition, this systematic bibliometric analysis seeks to summarise current understanding, filling in possible research gaps, and pointing out new perspectives for future studies on this interdisciplinary subject. This data-driven and structured process, typically including a structured review protocol (e.g., Preferred Reporting Items for Systematic Reviews and Meta-Analyses—PRISMA), makes it possible to synthesize findings and to identify key areas for future empirical investigation in a valid, reliable way. Interdisciplinary neuromarketing, which integrates neuroscience, psychology, and marketing, is one of the main areas that has benefited from technological development to improve measures of consumer cognitive and emotional responses.

The remainder of the paper is organized as follows: the second section provides an overview of the classical literature on the topic of neuromarketing, including its historical context and previous bibliometric studies. Section 3 outlines the methodology, describes how the data were collected (using Scopus data), and explains the bibliometric tools employed. Section 4 presents the findings in terms of publication trends, including the most popular publication, the top 5 journals, authors, institutions, countries, and keyword searches. These findings are presented in Section 5, and important gaps and future research directions are also proposed. At last, the conclusions are provided at the end of Section 6.

2. Literature review

The astounding hypothesis, proposed by Nobel Laureate Francis Crick, suggests that all human feelings, ideas, and actions, including consciousness itself, are the result of neuronal activity in the brain. This idea presents marketers with the potential that studying neurobiology could reduce the ambiguity and speculation that have historically hindered efforts to understand consumer behavior [25]. Neuromarketing, as a field, has experienced crucial growth and evolution primarily between 2015 and 2024, marked by the integration of emerging technologies and a deeper understanding of the multidimensional effects of consumer behaviour [26].

2.1. Conceptual foundations and historical progress of neuromarketing

Neuromarketing is an applied market research approach that combines neuroscience, including behavioral psychology concepts, to analyze brain activity and get a deeper understanding of customer responses to goods, companies, and advertising stimuli [3]. Neuroimaging was the predominant technique in the early neuromarketing research to detect and examine consumer reactions. However, more recent studies have expanded to include artificial intelligence and virtual reality as a means to develop more immersive, data-driven marketing solutions. This evolution illustrates a trend toward more ecologically valid studies, out of the traditional laboratory environment and artificial consumer scenarios. Ultimately, marketing utilizes neuroscience to explain how it influences consumers' behavior and purchasing processes [27]. In 2002, Smidts introduced the term 'neuromarketing' to characterize and elucidate the application of neuroscientific approaches to marketing activity. Several U.S. organizations, including Brighthouse and SalesBrain, were pioneers in providing neuromarketing research and consulting services that promoted the application of technology and cognitive neuroscience expertise. While Smidts is acknowledged as the originator of the term neuromarketing [28], the field originated in 1999 when Professor Gerry Zaltman conducted the first fMRI (functional magnetic resonance imaging) study specifically applied to marketing [29,30]. Lee et al. [31] embrace a comparable strategy, acknowledging that neuromarketing involves the application of neuroscientific methodologies in marketing to analyze and grasp human behavior. A multitude of prominent

corporations across diverse sectors utilize neuromarketing methodologies to gain a deeper understanding of client behaviour and preferences. The phrase "neuromarketing" likely originated in a June 2002 press release by BrightHouse, an advertising agency based in Atlanta. The statement announced the creation of a business division that will use fMRI for marketing research [32].

2.2. The evolution of neuromarketing methodologies

Neuromarketing employs a variety of techniques, with some focusing on direct brain activity observation and others on physiological responses external to the brain. Examples of these techniques include eye tracking, GSR, Facial Action Coding System (FACS), Electroencephalography (EEG), Magnetoencephalography (MEG), and fMRI. The development of neuromarketing calls for an organized survey of the progress made in technology, which drives the direction of the neuromarketing studies, allowing a comprehensive review of the methodologies used and their implications on the study of consumer neuroscience [33]. This systematic review will enable specific recognition of dominant research themes, research methods, and theoretical foundations in the burgeoning neuromarketing literature [34,35].

The various methodologies now accessible share a common objective—to investigate the cognitive, sensorimotor, and affective reactions of consumers to particular marketing stimuli [36], and ascertain whether alterations in these stimuli result in changes in body signals [37]. Cognitive and neuroimaging techniques, known as neuromarketing tools, have been employed to investigate the influence of advertising on the neurological processes and decision-making of consumers [38–40]. Given the capacity to record and examine brain activity using neuroimaging techniques, these tools have become crucial for the early evaluation of marketing efforts such as advertising [41,42]. Furthermore, neuromarketing methodology can be applied in various fields or industries to understand the physiological processes of the consumer's brain and predict client decision-making [13]

2.3. The rise of data-driven and immersive marketing

The literature indicates a shift towards data-driven and immersive marketing strategies that engage customers' subconscious responses. This move reflects the growing popularity of phigital products, which are more personal and innovative. The study by Anwar et al. [24] showed the necessity of being close to the users from a customer engagement perspective in a personalized way in an innovative manner. This encompasses neuroimaging and physiological tools to measure neural responses towards marketing stimuli to aid in marketing effectiveness [26,43]. This increasing interest in data-based solutions, especially based on sophisticated neuroscientific methodologies, represents a big change from traditional marketing strategies based on explicit consumer feedback [44]. This methodological development has facilitated a more in-depth examination of the unconscious determinants of consumer behavior by going beyond self-reported data to access the genuine neural-physiological responses [45]. The development of data fusion methods, particularly of multimodal analysis of biosignals, has become a significant trend in improving the precision and scope of measuring in neuromarketing research [46]. This gives marketing researchers a unique perspective on the underlying neural processes in decision-making and brand preference, which may be able to help product offerings to be more in tune with consumer expectations [47]. This type of integration offers a more comprehensive view of consumer behaviour, as it extends beyond superficial observations and examines the underlying, and often unconscious, cognitive and affective mechanisms that influence the consumer's purchase decision [48]. This expansion highlights the critical role of interdisciplinary cooperation, involving the neuroscience, data science, and marketing domains to ultimately maximise the potential of these advanced analytical tools [49]. Increasingly, 'Big Data' has expanded the power of such

capabilities to increasingly detailed consumer psychological "states and traits" that can be exploited for strategic targeting purposes [50]. This requires an ethical reflection about data protection and manipulative practices [51]. The development of more sophisticated machine learning algorithms and artificial intelligence has sharpened the analysis of these complex datasets, enabling the detection of subtle patterns in brain activity that relate to specific consumer behaviors and preferences [52].

2.4. Industry adoption and early applications of neuromarketing

Recent advances in imaging technology, most notably fMRI, positron emission tomography, and single-photon emission computed tomography, hold the promise of the ability to directly image the neurodynamic processes that underlie psychic states [45,53]. Several well-known companies have used neuromarketing up to this point, including PepsiCo, Coca-Cola, Hyundai, Intel, Microsoft, eBay, Sky TV, Johnson & Johnson, HBO, IBM, McDonald's, P&G, Unilever, and ESPN [54]. Major players, including PayPal, Mercedes-Benz, and P&G, utilized neuromarketing to design and brand their products, solicit customer feedback, gain insights into their offerings, and increase market share [8,16]. The inaugural scholarly article in the field of neuromarketing focused on the brain's reactions to emotions (such as pleasure and arousal) in response to television advertising.

This study included fMRI as the primary method of investigation. In their study, Granka et al. [55] collected data using eye trackers to investigate consumer behavior on search engines and the factors influencing their selection of certain results. They found that typically, only the first two results are accessed Tichindean et al. [56]. Frito-Lay used the EEG technology to determine that consumers respond strongly to eating Cheetos, turning their fingers orange with residual cheese dust. This led to the creation and launch of a campaign to engage the customer with the brand mascot and several tasks. It was well received and won the Grand Ogilvy Award from the Advertising Research Foundation.

In essence, neuromarketing seeks to understand the cognitive processes and underlying motivations that drive consumers' product or brand choices, utilizing established neuroscientific techniques [29]. The study of neuromarketing is an interdisciplinary field that combines theories of consumer behavior with components of psychology and neuroscience to understand the factors that influence customers' ultimate purchasing decisions [57].

3. Methodology

This study compiles data retrieved from the Scopus database to conduct a review of neurological marketing research. To conduct the evaluation, our investigation utilized the resources of the Scientific Procedures and Rationales for Systematic Literature Reviews (SPAR-4-SLR). According to Paul et al. [58], it consists of three primary stages: assembly, arrangement, and evaluation of articles.

3.1. Research design

Consistent with prior bibliometric studies [59,60], the present research employed Scopus as the data source for its comprehensive coverage and export compatibility with bibliometric tools. The time window 2015–2024 was selected because 2015 represents an identifiable inflection point in the bibliometric growth curve, based on preliminary exploratory retrievals conducted prior to full dataset assembly [34]. These initial scans revealed a marked and sustained increase in annual neuromarketing publications beginning in 2015, following a comparatively stagnant period between 2010 and 2014. Thus, selecting 2015 ensures coverage of the field's decade of methodological, technological, and conceptual consolidation.

A specific search query was created to collect the necessary publications on the subject efficiently. The keyword combination used to do a scientific mapping of neuromarketing was:

TITLE-ABS-KEY ("neuromarketing")

Since it encompasses the whole area where marketing and neuroscience meet, "neuromarketing" was chosen as the primary search keyword. The importance of this keyword in summarising numerous research papers that investigate the neural bases of consumer behaviours and decision-making has been stressed in academic journals. In addition, numerous discussions with professionals in the field have confirmed the term's usefulness in describing new approaches and developments in neuromarketing studies. The strength of the search string "TITLE-ABS-KEY ('neuromarketing') in producing an accurate and extensive corpus of literature, essential for scientifically mapping the field, is supported by these expert recommendations and methodological guidelines in academic research [43].

Related expressions such as "consumer neuroscience" and "neuroeconomics" were evaluated but deliberately excluded to maintain conceptual focus and prevent topic drift into general cognitive or economic neuroscience domains. A pilot retrieval confirmed that adding these terms produced a corpus dominated by non-marketing studies. Therefore, the single-term query ensured specificity and reproducibility.

Although "consumer neuroscience" and "neuroeconomics" were excluded to maintain conceptual precision, exploratory test queries showed that including these terms would have substantially altered the thematic composition of the dataset. Specifically, preliminary tests resulted in the retrieval of a disproportionately high number of cognitive neuroscience and behavioral economics papers without marketing relevance, thereby diluting neuromarketing-specific clusters. Including such terms would likely expand the network toward decision science and medical neuroimaging domains, shifting the thematic centrality away from marketing, sensory processing, and advertising studies. This reinforces the methodological validity of retaining a single-term, field-specific query.

3.2. Article inclusion methods

To ensure that the research papers retrieved using the defined search string were of high quality and relevant, strict filtration procedures were applied in the Scopus database for this neuromarketing study. Initially, 981 articles were identified through the search. They were then alphabetized according to year, subject, document type, publication stage, and language. The keywords "neuromarketing," "business, management, and accounting," "articles," "book chapters," "conference papers," "reviews," and "books" were selected based on their English-language status and having reached the final publication stage.

Based on the recommendations made by Paul et al. [58], pre-print articles were first omitted from further consideration because they were not yet finalized. Editorials, conference reviews, notes, errata, brief surveys, retracted articles, and data studies were excluded because they were not thoroughly examined. This was done to ensure that only academic content that had been peer-reviewed and of high quality was kept for the analysis.

Neuromarketing is a cross-disciplinary field that overlaps with management, accounting, and business. Hence, these areas were given priority throughout the filtering process. This methodical procedure narrowed the field to 307 articles that fit the criteria. After that, we based our study on the publications that we downloaded. The efficiency of the search string, which was based on a single keyword, ensured that the retrieved papers were highly relevant to neuromarketing. We conducted a thorough evaluation of the available research in neuromarketing, without excluding any additional publications that showed in the Fig. 1.

3.3. Analysis technique

This study used bibliometric analysis to evaluate a curated collection of 307 publications comprehensively. As part of this evaluation,

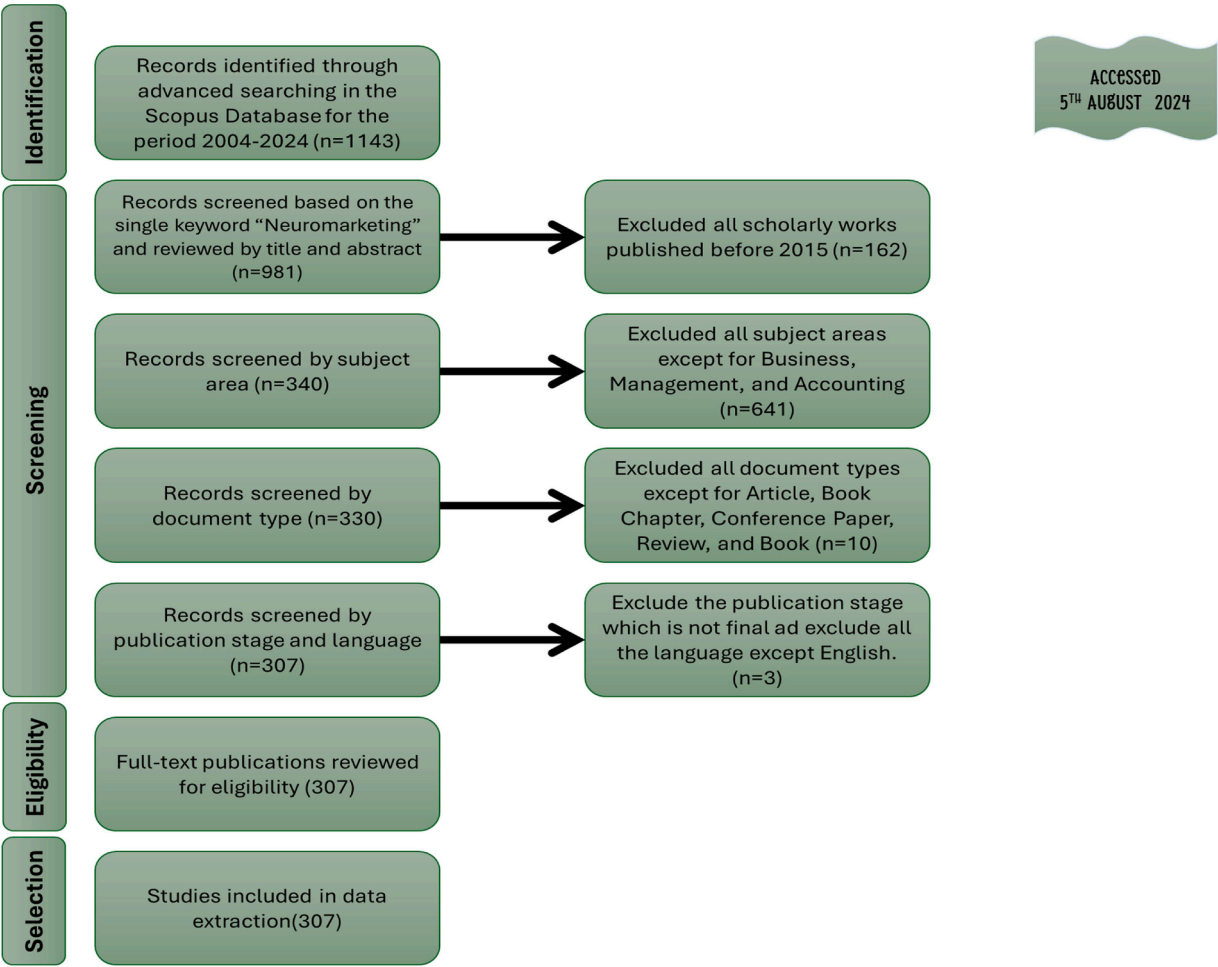


Fig. 1. The PRISMA process flow diagram.

statistical methods were employed to acquire data using a substantial corpus [59]. The present study incorporates scientific mapping methodologies to reduce possible exaggerations to the lowest possible level. It succeeds by focusing on statistical techniques to investigate an enormous quantity of material.

Bibliometric analyses were conducted using VOSviewer v1.6.20 and Biblioshiny for R (Version 4.3.1). Complete bibliographic data (authors, titles, keywords, citations) were exported in CSV and BibTeX formats from Scopus.

In VOSviewer, normalization was performed using the association-strength algorithm with a minimum keyword occurrence threshold = 5 for co-occurrence mapping. Fractional counting was adopted for author collaboration networks. In Biblioshiny, clustering employed the Louvain modularity algorithm with default resolution = 1. All figures generated from these analyses explicitly cite their data source as Scopus and the software environment. World-map visualizations employ a UN Geospatial Information Section base map for neutrality; they depict bibliometric counts only and imply no territorial claims.

This study generates the use of bibliometric techniques, notably evaluation of performance, to clarify current patterns of the publication's posting, identify crucial works of literature, and demonstrate contributing authors, academic institutions, and countries within the discipline of neuromarketing. It is all under the conclusions of earlier studies [61].

Additionally, this research combines temporal trends by developing word clouds and network assessments of keyword co-occurrence using VOSviewer [62]. Thus, it provides additional light on the root concepts and issues that serve as the conceptual underpinnings of neuroscience in

marketing.

By considering these aspects, the study creates a map of the current landscape and reveals substantial research gaps. Having this identification helps develop a research agenda that offers important insights into the possible future trajectories that the practice of neuromarketing will take, which in turn enriches both theoretical understanding and actual usage within the area.

4. Findings

A research domain's efficacy is assessed using performance analysis in bibliometric analysis [59]. This study analyzes the impact of top journals, researchers, educational institutions, and nations on the neuromarketing area by looking at patterns in published publications and identifying highly cited works. The study contexts and methodological approaches used in neuromarketing studies are also evaluated.

4.1. Publication trend

The publication trends in neuromarketing, with an emphasis on research articles produced between 2015 and 2023, are clearly illustrated by the "Annual Scientific Production" graph. The data indicate that research curiosity in neuromarketing has increased over the past few years, which is reflected in the general upsurge in scholarly production.

According to Fig. 2, about 20 articles were published in 2015. In 2016, that figure jumped to almost 30 articles, a substantial rise. This increase, however, was accompanied by a decrease in 2017. The field's

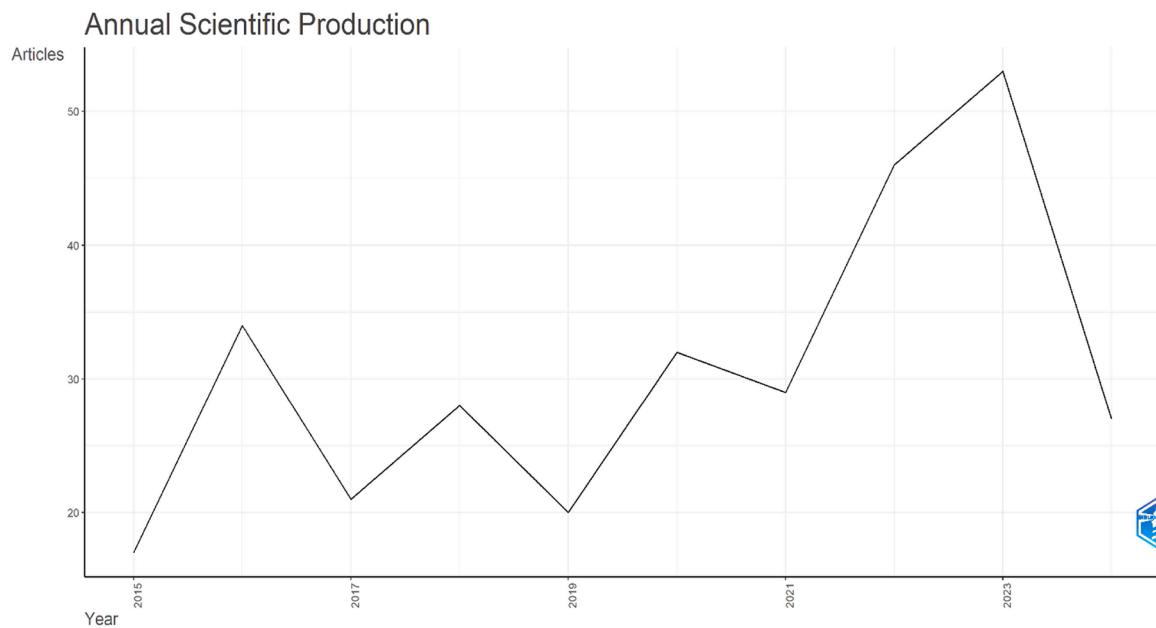


Fig. 2. Yearly publications on Neuromarketing 2015 to 2024 (using Biblioshiny).
Source: Scopus (Accessed on August 5, 2024).

publishing rate increased steadily from 2018 onwards, with a peak of over 50 articles published in 2022, notwithstanding these preliminary oscillations. This turning point indicates a rise in curiosity about research and contributions, reflecting the greatest amount of scholarly endeavor throughout the recorded period. According to the statistics, there appears to have been a precipitous drop in the number of publications in 2023. Possible causes for this decline include changes in research priorities, insufficient annual data, or external variables impacting publishing rates. Overall, the graph's pattern shows how neuromarketing has changed over the years, with booms and busts that suggest further study is needed to figure out what's behind the latest drop in writings.

4.2. Most influential articles

Several seminal articles have laid the groundwork for neuromarketing and continue to influence academic research and industry practice. Boksem & Smidts [63] have received 225 citations and continue to receive a vital 22.50 citations each year, making it one of the most referenced publications in this domain. This suggests that it continues to be relevant in predicting commercial success through neuromarketing techniques. Brain imaging data has the potential to provide valuable insights into consumer purchasing habits and market trends, as demonstrated by this study published in the *Journal of Marketing Research*. It is worth noting that an article by Weng Marc Lim [64] published in the *Journal of Business Research* provides a more accessible explanation of neuromarketing's multifaceted strategies. The article has had an enormous effect, with 139 total citations and an annual citation rate of 19.86. The article by Stanton, Sinnott-Armstrong, and Huettel [65] focuses on principles of ethics in executing neuromarketing. It has 109 citations and a citation rate of 13.63 per year, indicating its continued importance in promoting ethical practices. The study conducted in 2017 by Hamelin, Moujahid, and Thaichon [66] delves into the efficacy of advertising by appealing to people's emotions. Cited 90 times, with an average of 11.25 citations per year, it provides more evidence of the usefulness of sentimental evaluation in marketing practices. Finally, Bastiaansen et al. [67] used neuromarketing to improve marketing for destination strategies; their paper has 84 citations and a yearly citation rate of 12.00, demonstrating its impact on the marketing industry. Their sustained citation rates demonstrate that these

articles have made substantial contributions to the area of neuromarketing and are still having an impact on current research and discussions (see Table 1).

4.3. Top journals in neuromarketing within the business, management, and accounting

There have been 307 research articles published in 167 different publications regarding neuromarketing, according to an analytical analysis of the field's literature. The top ten journals that published at least five publications on neuromarketing accounted for 88 of these pieces or 28.66 percent of the total. Within the realm of neuromarketing, these periodicals mainly address topics related to accounting, business, and management. As far as article counts go, the top three journals are "Springer Proceedings in Business and Economics," "Developments in Marketing Science: Proceedings of the Academy of Marketing Science," and "Ethics and Neuromarketing: Implications for Market Research and Business Practice," with 17, 13, and 13 articles counted, respectively. With 323 citations, the "Journal of Business Research" was the most cited. The "Journal of Marketing Research" came in second with 225 citations, while the "European Journal of Marketing" came in third with 199 citations (see Table 2).

4.4. Top contributing author

Our extensive review of the neuromarketing literature reveals the names of numerous seminal figures whose work has had a profound impact on the development of this discipline that are shown in Table 3. With eight books to his credit, P. Cherubino is by far the most prolific of these writers. The next two authors, F. Babiloni and A. Trettel, each wrote seven papers; therefore, this is significantly more than their contemporaries.

To better understand individual contributions, we can use the fractionalized article count, which accounts for co-authorship. A.H. Alsharif's fractional count of 2.28 is quite high, showing central participation in numerous research networks and indicating a high degree of collaboration throughout his five publications. On the other hand, P. Cherubino highlights substantial teamwork with a fractional count of 1.23, which is minor but still noteworthy.

In Fig. 3, looking at the writers' output over time shows that these top

Table 1

Key publications in the field of neuromarketing.

Author(s)	Article Title	Source Title	Publication Year	Total Citations	TC per Year	Normalized TC
Maarten A.S. Boksem & Ale Smidts	Brain Responses to Movie Trailers Predict Individual Preferences for Movies and Their Population-Wide Commercial Success	Journal of Marketing Research	2015	225	22.50	8.09
Weng Marc Lim	Demystifying neuromarketing	Journal of Business Research	2017	139	19.86	7.25
Steven J. Stanton, Walter Sinnott-Armstrong & Scott A. Huettel	Neuromarketing: Ethical Implications of its Use and Potential Misuse	Journal of Business Ethics	2016	109	13.63	4.56
Nicolas Hamelin, Othmane El Moujahid & Park Thaichon	Emotion and advertising effectiveness: A novel facial expression analysis approach	Journal of Retailing and Consumer Services	2017	90	11.25	3.76
Marcel Bastiaansen, Sebastiaan Straatman, Eric Driessen, Ondrej Mitas, Jeroen Stekelenburg & Lin Wang	My destination in your brain: A novel neuromarketing approach for evaluating the effectiveness of destination marketing	Journal of Destination Marketing & Management	2018	84	12.00	4.38
Ming Hsu	Neuromarketing: Inside the Mind of the Consumer	California Management Review	2017	77	9.63	3.22
Nick Lee, Laura Chamberlain & Leif Brandes	Welcome to the jungle! The neuromarketing literature through the eyes of a newcomer	European Journal of Marketing	2018	77	11.00	4.01
Hakan Boz, Aytuğ Arslan & Erdoğan Koc	Neuromarketing aspect of tourism pricing psychology	Tourism Management Perspectives	2017	62	7.75	2.59
Charles Spence	Neuroscience-Inspired Design: From Academic Neuromarketing to Commercially Relevant Research	Organizational Research Methods	2019	60	10.00	4.32
Duane Varan, Annie Lang, Patrick Barwise, René Weber & Steven Bellman	How Reliable Are Neuromarketers' Measures of Advertising Effectiveness?	Journal of Advertising Research	2015	60	6.00	2.16

Table 2

Leading neuromarketing publications in business, management, and accounting.

Sources	Articles
Springer Proceedings in Business and Economics	17
Developments in Marketing Science: Proceedings of the Academy of Marketing Science	13
Ethics and Neuromarketing: Implications for Market Research and Business Practice	13
Analyzing the Strategic Role of Neuromarketing and Consumer Neuroscience	11
Journal of Business Research	7
Applications of Neuromarketing in the Metaverse	6
Asia Pacific Journal of Marketing and Logistics	6
European Journal of Marketing	5
Journal of Advertising Research	5
Journal of Neuroscience, Psychology, and Economics	5

Table 3

Influential researchers in the field of neuromarketing.

Authors	Articles	Articles Fractionalized
Cherubino P	8	1.23
Babiloni F	7	0.98
Trettel A	7	0.98
Alsharif AH	5	2.28
Rossi D	5	0.67
Cartocci G	4	0.50
Di Flumeri G	4	0.47
Grigaliunaite V	4	2.00
Pileliene L	4	2.00
Schmidt S	4	1.12

contributors consistently provide high-quality work. A.H. Alsharif's notable rise in publishing volume over the past several years indicates his expanding sphere of impact. In addition, P. Cherubino's steady production across the monitored time illustrates his unwavering dedication to pushing neuromarketing research forward.

With an H-index of 5, P. Cherubino, F. Babiloni, and A. Trettel are the most influential writers in terms of the influence of their citations. This statistic proves (see Fig. 4) that they are very productive, well-respected, and often referenced in the academic community.

Overall, the data show a complex landscape of impact and contribution, with P. Cherubino being the most prolific author in overall publications. Major players in the neuromarketing field include A.H. Alsharif, who has a high fractionalized count and a recent rise in publications, and authors like F. Babiloni and A. Trettel, who have excellent H-index scores. These findings emphasise the multifaceted academic influence of neuromarketing research and its ever-changing character.

4.5. Leading organizations in neuromarketing

A crucial component of our scientific mapping entails identifying the institutions that are leading the way in neuromarketing research. The Sapienza University of Rome is at the forefront, with 23 articles highlighting its pivotal position in the scholarly investigation of neuromarketing (see Table 4). The institution's extensive production not only demonstrates its commitment to developing neuromarketing but also its ability to influence and define the research agendas in this particular field.

The Universiti Teknologi Malaysia is notable for its 16 contributions, demonstrating a significant focus on neuromarketing studies in the Asian academic sphere, adopting the example set by Sapienza. This emphasizes the worldwide scope of neuromarketing study findings, demonstrating notable contributions from many countries and regions. The Rey Juan Carlos University of Spain, with 10 publications, and the Complutense University of Madrid, with 7 articles, are significant European contributors to the field of neuromarketing research, highlighting Spain's prominent role in this area. Similarly, the Polytechnic University of Marche in Italy, Sungkyunkwan University in South Korea, and the University of Sao Paulo in Brazil each contributed seven articles, showcasing international attention and diverse areas of focus throughout the subject of neuromarketing.

These entities significantly contribute to the subject of neuromarketing by producing a large number of publications and improving the quality of research. They also promote alliances that push the limits of knowledge in this field. Their combined endeavors are essential in understanding how advertising approaches might be influenced and enhanced by utilizing neuroscience.

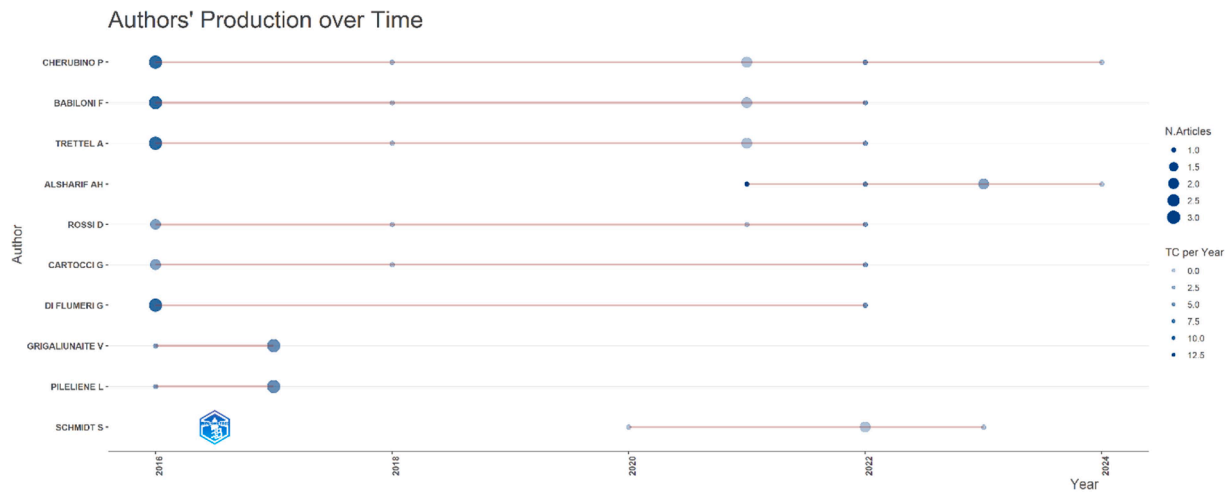


Fig. 3. Timeline of Author Publications (using Biblioshiny).
Source: Scopus (Accessed on August 5, 2024).

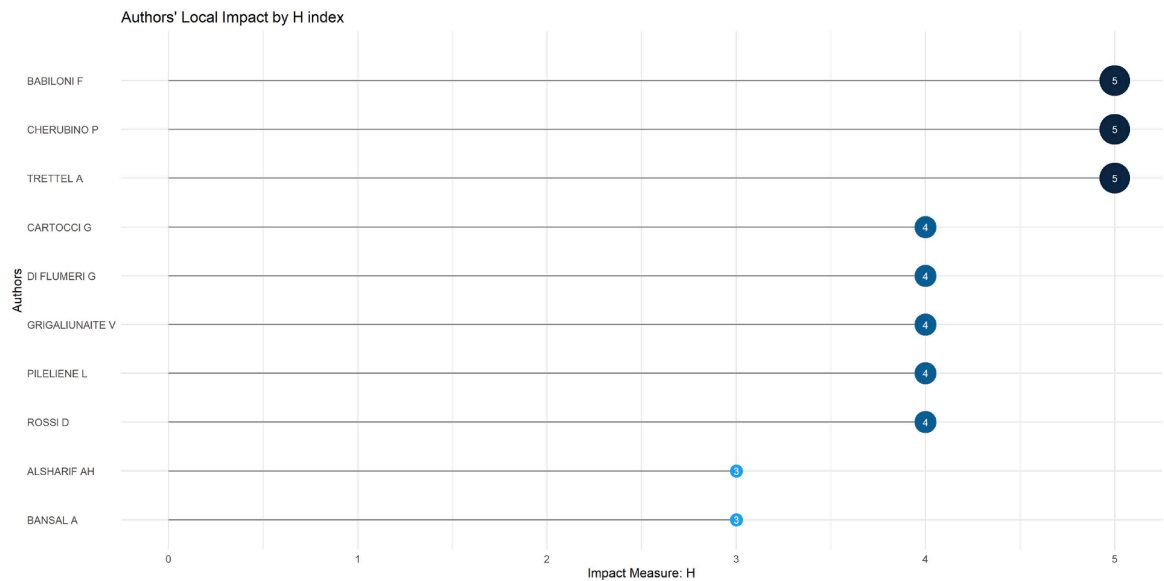


Fig. 4. Assessing the local impact of authors using the H-Index (using Biblioshiny).
Source: Scopus (Accessed on August 5, 2024).

Table 4
Leading institutions in the field of neuromarketing.

Affiliation	Articles
Sapienza University of Rome	23
Universiti Teknologi Malaysia	16
Rey Juan Carlos University	10
Complutense University of Madrid	7
Polytechnic University of Marche	7
Sungkyunkwan University	7
University of Sao Paulo	7
Agricultural University of Athens	6
Bucharest University of Economic Studies	6

4.6. Top neuromarketing contributing countries

Researchers from a wide variety of countries dominate the field of neuromarketing research on a global scale. Each of these countries brings something distinctive to the table. With 313 citations, the USA stands out as the country that has received the most attention,

demonstrating that it has a considerable impact on the neuromarketing community worldwide. The innovative work and influential research that is coming out of the country is reflected in the large number of citations that it has received, and showed in Fig. 5.

Australia and Turkey both have significant citation impacts, with 189 and 177 citations, respectively, despite having a lower number of papers available compared to other nations. This indicates that the research outputs from the mentioned nations are highly recognized throughout the field of neuromarketing (see in Fig. 6), with works that resonate with a broad audience and are beneficial to the advancement of disciplinary action.

Based on Table 5, Next in terms of publication volume, according to related authors' nations, is the United States, with 20 articles, followed closely by Spain, with 21 articles, which accounts for 6.8 % of the total publications analyzed. This massive production demonstrates the significant involvement of these nations in neuromarketing studies. Crucial to the multidisciplinary character of neuromarketing is that 53.3 % of Italian papers are multi-country publications (MCP), suggesting a strong inclination toward cooperation between nations. Both Germany and the

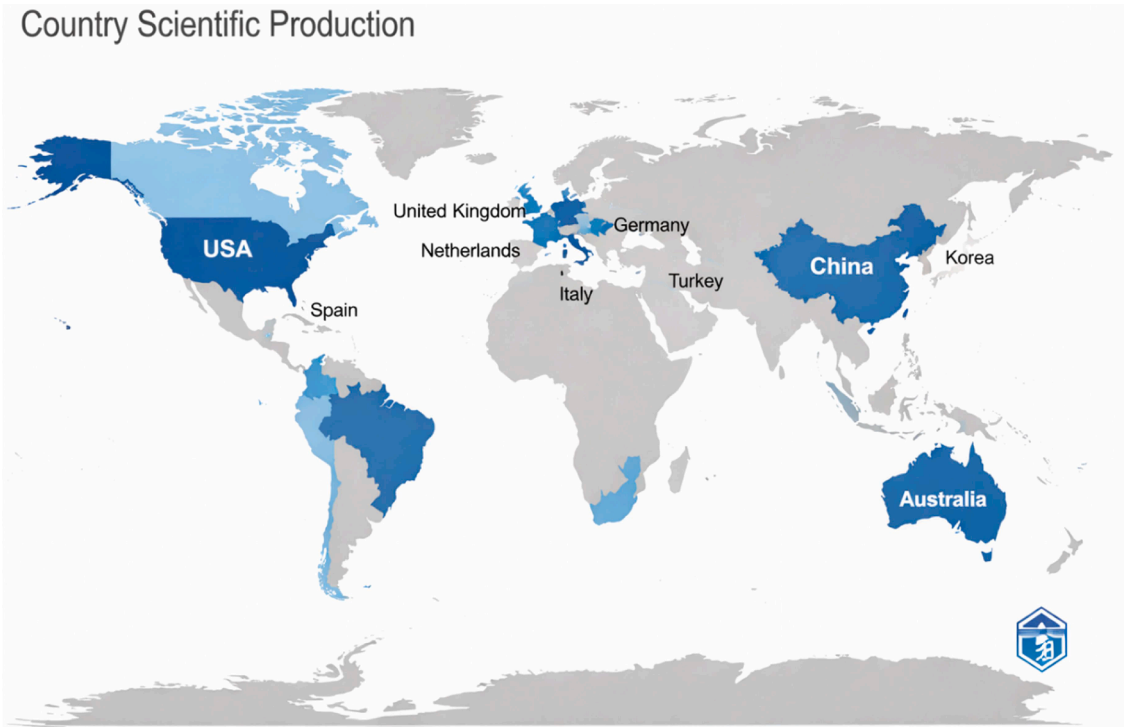


Fig. 5. Country-wise scientific production (using Biblioshiny package in RStudio)
Note: Map lines delineate study areas and do not necessarily depict accepted national boundaries.
Source: Scopus (Accessed on August 5, 2024).

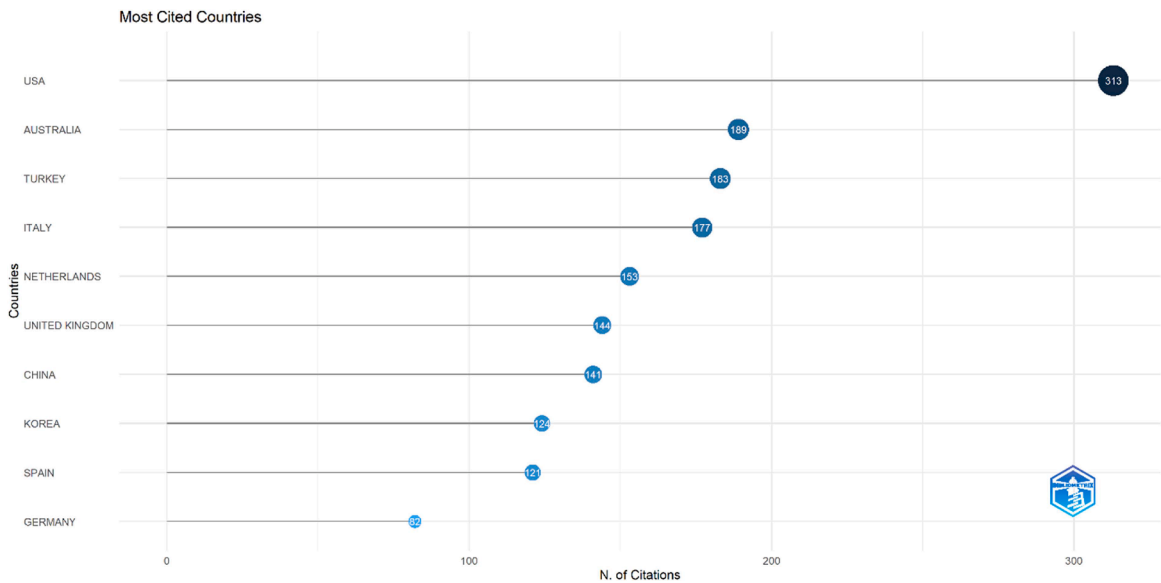


Fig. 6. Top Cited Countries (using Biblioshiny package in RStudio).
Source: Scopus (Accessed on August 5, 2024).

Netherlands provide substantial contributions regarding the number of citations and articles; the latter has the most significant proportion of MCP at 50 %. Because of this, the Netherlands is becoming an increasingly a center for study on neuromarketing collaborations.

Our results show that the multinational neuromarketing scholarly community is active and well-connected, with the United States having the most citations and nations like Spain and Italy emerged as the most productive countries in neuromarketing research, followed by the United States and the United Kingdom. This dominance reflects strong interdisciplinary collaboration between marketing scholars,

neuroscientists, and behavioral researchers in these regions.

However, it is important to acknowledge that country-level publication dominance may also be partially influenced by Scopus indexing patterns and English-language publication bias. Databases such as Scopus provide broader coverage of European institutions and English-language journals, which may elevate the visibility of research outputs from Spain and Italy relative to equally active but less-indexed regions. Therefore, observed dominance should be interpreted cautiously as a reflection of both research intensity and database coverage characteristics. Based on the data on the nations of corresponding authors, these

Table 5

Countries of corresponding authors and amount of scientific output.

Country	Articles	Articles %	SCP	MCP	MCP %
Spain	21	6.8	14	7	33.3
USA	20	6.5	17	3	15
Germany	15	4.9	12	3	20
Italy	15	4.9	7	8	53.3
Netherlands	8	2.6	4	4	50
Turkey	8	2.6	8	0	0
China	7	2.3	6	1	14.3
India	7	2.3	5	2	28.6
Romania	7	2.3	7	0	0
Brazil	6	2	4	2	33.3

contributions highlight how important it is for the neuromarketing field to have various worldwide perspectives and work together.

4.7. Author's keywords

As shown in the Fig. 7, the document, coupling and keyword trend evaluations, the context of the neuromarketing investigation is vividly formed by its core theme keywords. This is the case because these keywords are the most important. Several terms, including "neuromarketing," "consumer behaviour," "marketing," and "electroencephalography," have been recognised as being particularly noteworthy. These keywords are indicative of the multidisciplinary nature of the topic. The terms "neuromarketing" and "consumer behaviour" are particularly prevalent, and each of them was cited with a hundred per cent credibility in our clustering analysis, highlighting their vital significance in neuromarketing research.

The cloud of words graphic further emphasizes the prominence of terms such as "decision making," "advertising," and "sales," in addition to "neuromarketing" and "marketing." This indicates a strong focus on comprehending customers' reactions and measuring marketing efficacy through neuroscientific approaches. The fact that these terms are used so frequently draws attention to the relevance of the topic as well as the breadth of study that is being conducted on it.

Over time, the trending analysis of keywords demonstrates that there has been a substantial rise in the utilisation of terms such as "neuromarketing," "consumer behaviour," and "electroencephalography." As an illustration, the term "neuromarketing" has demonstrated a discernible

increase in terms of frequency between the years 2015 and 2024 (see Fig. 8). This trend reflects a rising curiosity in integrating brain research into marketing, both in academics and practical settings. In addition, there has been a consistent rise in the number of conversations on "consumer behavior," which is in line with the broadening of the scope of consumer research within the field of neuromarketing.

With the help of clustering by document coupling, these themes are further classified into four unique groups, each with a different level of significance and influence. The recognised clusters comprise crucial domains such as "neuromarketing" and "consumer behaviour," which are at the discipline's core (see Fig. 9). On the other hand, "tourism development" and "travel behaviour" manifest as specialisations with a significant thematic significance but a lower centralisation in the neuromarketing domains.

This keyword analysis aims to provide a comprehensive framework for understanding the development and focus of neuromarketing research. It does so by identifying the established cores and developing trends within the discipline. Neuromarketing is a correction experiencing dynamic expansion, as seen by a steady rise in key phrases. This growth reflects the developing significance of neuromarketing in understanding the intricate relationship that links marketing techniques and consumers' brain responses.

4.8. Key word co-occurrence

The relation between terms necessary for the study of neuromarketing is highlighted by the network map, showing the co-occurrence of terms. This group includes "neuromarketing," "consumer behavior," and "marketing"—concepts that are incredibly related to each other. Demonstrating the close correlation among these themes, this cluster frames the crucial roles of them in the context of neuroscience research for marketing. The graphic illustrates the link between "consumer neuroscience" and "consumer behavior" and the integration of neuroscience insights in more effective marketing practices and understanding of how consumers relate to each other.

Terms in Cluster 1 also include "neuroethics" and "social media," suggesting that the field of neuromarketing is considering questions of ethics and is employing new media platforms. The second cluster links 'electroencephalography', 'information management' and 'sustainable development', thus demonstrating convergence across neuromarketing

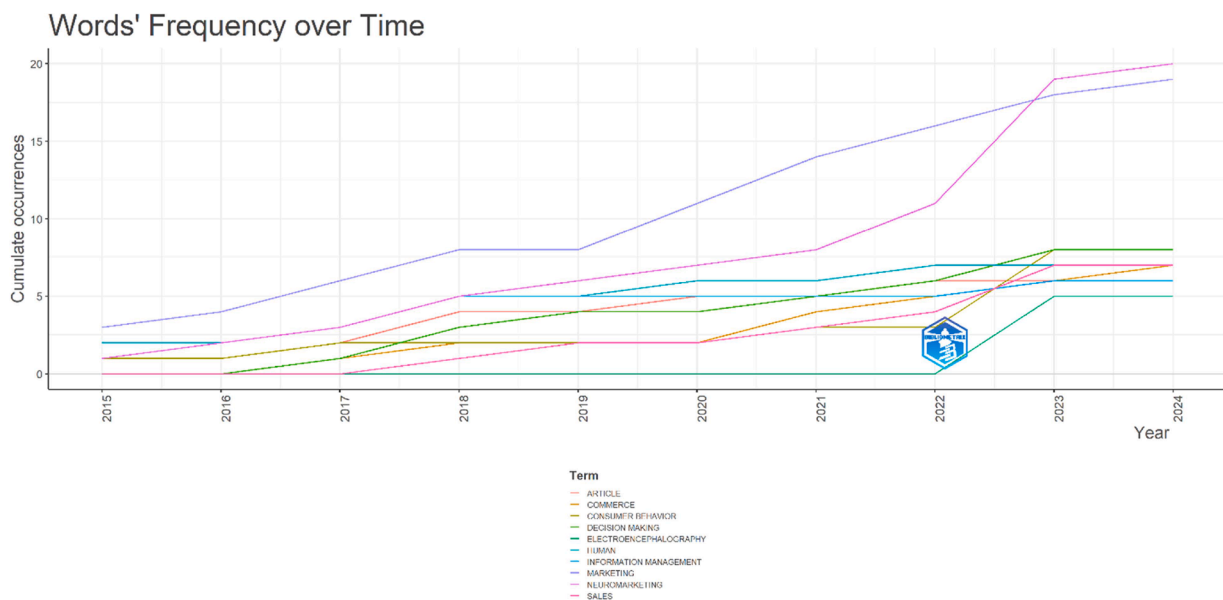


Fig. 7. Word frequency over time (usning Biblioshiny package in RStudio).
Source: Scopus (Accessed on August 5, 2024).



Fig. 8. Keyword word map (using RStudio). Source: Scopus (accessed on August 5, 2024).

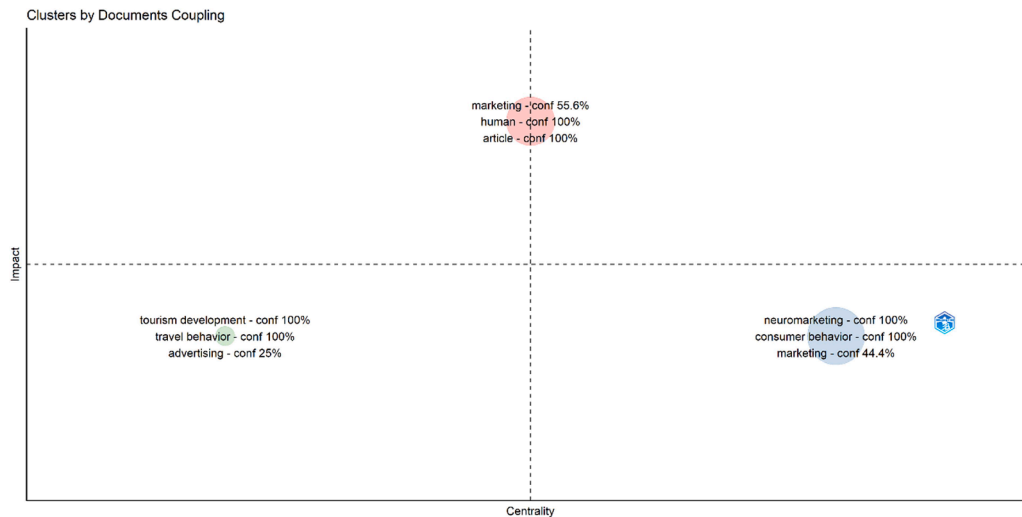


Fig. 9. Cluster coupling is assessed using author keywords (using RStudio). Source: Scopus (accessed on August 5, 2024).

applications and data stewardship, and the ramifications that these methodologies have on sustainable practices (see Fig. 10).

The significance of fundamental ideas such as "neuromarketing" and "consumer behavior" in the continued development of neuro-marketing methodologies and tactics is essential to comprehend, and this in-depth examination is essential for achieving this knowledge.

Furthermore, the above figure shows four main groups, each colored to indicate a different theme focus. The following table shows the number of terms for each cluster, showing that there is a lot of academic interest in each field (see [Table 6](#)). The clustering of these terms shows how often they appear together and how cohesive they are thematically, which mirrors current trends in neuromarketing research.

Key neuromarketing phrases have been evolving dynamically over the past few years, as seen by the patterns in keyword frequency from 2015 to 2024. Words like "neuromarketing," "consumer behavior," and "eye tracking" are appearing more often, which shows that people are increasingly interested in and using these concepts. These tendencies are crucial to determining the long-term and short-term goals of neuromarketing studies (see [Fig. 11](#)).

4.9. Neuromarketing research with cross-disciplinary links

In cognitive marketing research, the three-field plot is a precise representation of the dense web of interconnections between significant authors, notable works, and focal keywords. Cherubino, Trettel, and Babiloni are just a few of the researchers whose work has been crucial in laying the groundwork for neuromarketing, especially around the junction of neurophysiology and marketing. This visualization illustrates the contributions that these researchers have made to the field. These ground-breaking investigations are necessary to define an environment that governs how neuromarketing progressively develops.

Additionally, the plot illustrates how other notable academics, such as Cartocci and Di Flumeri, use neuromarketing tactics to eliminate the divide between psychological insights into how customers make choices and the practical use of these strategies. This exemplifies a developing trend in which scientific perspectives on human mental and emotional processes are increasingly influencing conventional marketing techniques.

In addition, the visualization sheds light on the linkages between the utilization of cutting-edge technologies such as fMRI and eye-tracking and an investigation focused on the behavior and engagement of consumers. This highlights the fact that the field relies heavily on

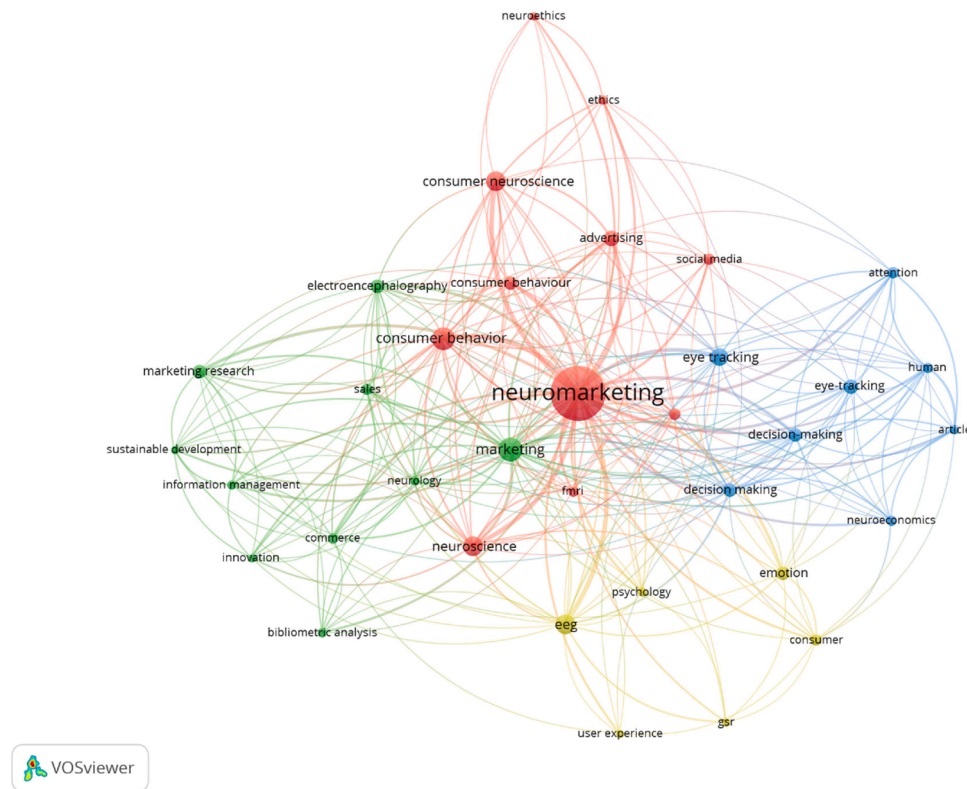


Fig. 10. Co-occurrence of Keywords (using Vosviewer). Source: Scopus (accessed on August 5, 2024).

Table 6
Clusters of keywords.

Cluster	Number of Key Words	Keywords
Cluster 1	11	advertising, consumer behavior, consumer behavior, consumer neuroscience, emotions, ethics, fMRI, neuroethics, social media
Cluster 2	10	bibliometric analysis, commerce, electroencephalography, information management, innovation, marketing, marketing research, neurology, sales, sustainable development
Cluster 3	8	article, attention, decision making, decision-making, eye tracking, eye-tracking, human, neuroeconomics
Cluster 4	6	consumer, EEG, emotion, GSR, psychology, user experience

sophisticated techniques to gain greater knowledge of how consumers react to what is being marketed to them. Furthermore, the links across distinct publications and terms such as "advertising" and "neurophysiology" highlight the variety of research approaches that are utilized and point to areas that are intriguing for individual researchers working within the respective discipline (see Fig. 12).

In highlighting the researchers' individual and collaborative efforts, the three-field plot sheds light on the quantitative and thematic convergences that define modern neuromarketing research by mapping these complex relationships. It shows how neuromarketing brings together several fields to create a better knowledge of consumer behavior by combining neuroscience, economics, psychology, and modern data analysis.

5. Discussion

The findings of this bibliometric analysis draw a panoramic picture of the changing landscape of neuromarketing over the 2015–2024

decade, reflecting the continuously increasing interdisciplinary character of the field and the growing sophistication of the technologies employed. The progression in the use of neuroimaging tools like fMRI and EEG, combined with the emergence of AI, VR, AR, and multisensory simulation platforms, has not only expanded conceptual understanding but also generated new methodological possibilities in neuromarketing research. For instance, AI-driven classifiers now enable real-time interpretation of EEG and fNIRS signals, allowing researchers to model affective engagement with unprecedented temporal resolution. VR studies increasingly incorporate immersive 360° retail environments to examine spatial decision-making, eye-tracking patterns, and embodied cognition—an advancement over traditional screen-based experiments. Multisensory integration prototypes (e.g., synchronized scent diffusion, haptic feedback surfaces, binaural audio manipulation) facilitate controlled manipulation of sensory cues, enabling researchers to test theoretically rich questions such as how cross-modal congruence shapes brand preference, memory encoding, and emotional valence.

Importantly, these clusters increasingly intersect with emerging technologies such as artificial AI, VR, AR, and immersive metaverse environments. In the consumer neuroscience cluster, AI-driven machine learning algorithms are now widely used to analyze EEG, eye-tracking, and biometric datasets, enabling real-time prediction of consumer responses. Within the marketing innovation cluster, VR and AR environments are being employed to simulate immersive retail experiences, allowing researchers to capture neurophysiological responses in controlled yet realistic contexts. Ethical issues are amplified in AI-integrated neuromarketing systems, particularly when automated emotional recognition tools process sensitive neural or biometric data. Similarly, decision-making research increasingly integrates computational modeling and AI-based pattern recognition to enhance predictive accuracy. Thus, emerging digital technologies act as integrative mechanisms linking all four clusters, accelerating methodological sophistication while simultaneously intensifying ethical considerations.

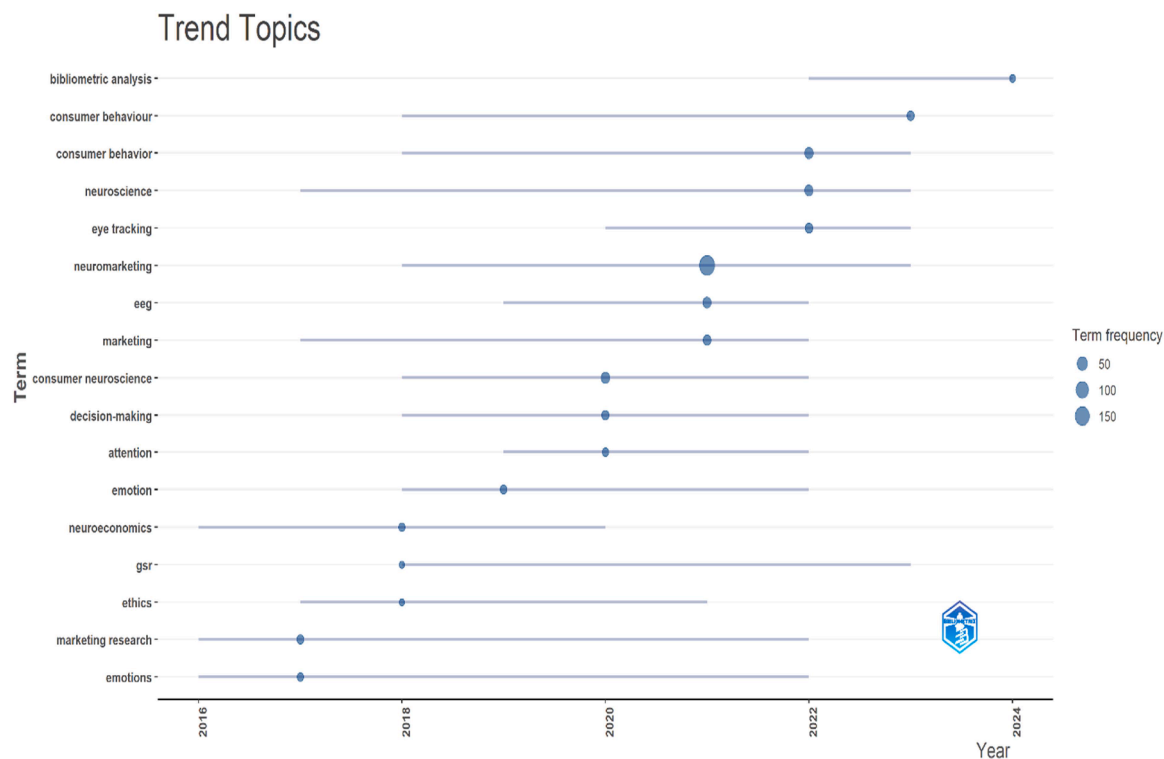


Fig. 11. Trending Topics in the Neuromarketing Research Area (using Biblioshiny package in RStudio). Source: Scopus (accessed on August 5, 2024).

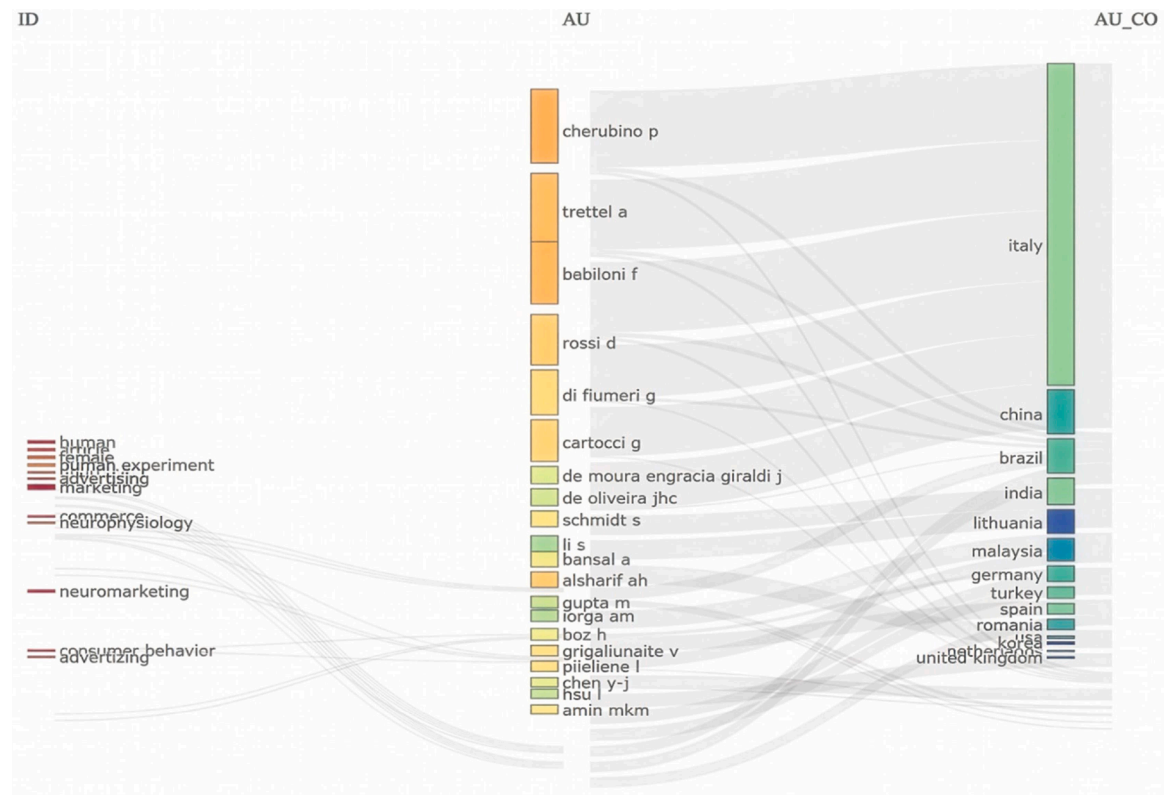


Fig. 12. Three Field Plot based on Keyword Plus and Countries (using Biblioshiny package in RStudio). Source: Scopus (accessed on August 5, 2024).

The new wave of publications post-2018 indicates the increased interest from academia, with leading authors and affiliations contributing to promoting neuromarketing. At the head of this research, we find institutions such as Sapienza University of Rome and universities from

Spain, the USA, and Malaysia [68]. Nevertheless, some gaps are evident from the literature, especially in the form of cross-cultural research and the use of new technologies such as the metaverse and AI. These are promising areas for future research, in particular with regard to the potential of combining neuroscience with cultural insights, and designing marketing approaches that are not only more personal but also more ethically mindful. Illustratively, recent scholarship discusses how Chilean courts and policymakers have begun testing whether existing personal-data rules are sufficient for protecting neurodata, reinforcing calls for explicit neurodata governance and consent procedures in non-clinical applications.

On a practical level, neuromarketing offers rich insights into consumers' desires that survey data cannot capture. Rising penetration of immersion, data-driven marketing could potentially lead to better customer engagement and brand loyalty. Beyond broad concerns about manipulation, neuromarketing raises specific challenges regarding informed consent (e.g., whether participants can fully understand the implications of sharing neural signatures), data privacy (given that biometric and neural data are potentially identifiable and may reveal sensitive psychological traits), and data governance. For example, Chile has adopted neurorights-oriented constitutional reforms and enacted Law aimed at safeguarding brain data and mental privacy, reflecting growing international efforts to recognize cognitive liberty and neurodata protection as emerging legal concerns [69,70]. In parallel, courts and policymakers in several jurisdictions have begun evaluating whether existing personal data protection frameworks sufficiently cover neural and biometric information, illustrating the real-world regulatory challenges surrounding neurotechnology governance [71]. These developments suggest that neuromarketing research must integrate ethical-by-design frameworks, ensuring transparent consent procedures, data minimization strategies, and responsible AI governance [72]. These developments suggest that neuromarketing research must integrate ethical-by-design frameworks, ensuring transparent consent procedures, data minimization strategies, and responsible AI governance and these ethical pressures are likely to shape not only research practices but also corporate adoption of neuromarketing technologies [73].

Together, although the progress of neuromarketing has been significant, primarily driven by the incorporation of new techniques and technologies, there is still much more to be developed. Additionally, the ethical, cultural, and psychological aspects of neuromarketing require investigation, and new boundaries of immersive consumerism need to be established. In doing so, the discipline can further develop into a more sophisticated, responsible, and effective instrument of consumer understanding and influence.

6. Theoretical and practical implications

The present work has significant theoretical contributions that make this field of research rich and considerably wide in terms of intellectual structure. Through a methodical exploration of the development of the area in the past decade, it reveals the way the complex interaction between neuroscience, psychology, and marketing has allowed us to improve our current understanding of subconscious consumer behavior. First at the core of this transformation is the infiltration of advanced neuroimaging and multisensory interpretations that together bring to light the underlying motives behind the consumer choices. In addition to the description of publication trends, the study identifies strong themes organized into clusters particularly relevant to our day and age, including consumer neuroscience, decision-making about uncertainty and ethical controversies. These results serve beyond historical tracing, but adjust existing theories by drawing attention to the emerging dialectical significance of multisensory integration, as well as artificial intelligence, as an engine of consumer activity. These insights leave researchers with the contrast of reproductive (causes and consequences) models of human cognition and a dynamic relationship that is intertwined with cognition. The study shows how subconscious drives

overlap with emotional triggers and cultural relational context so as to promote a more enveloping paradigm that does not treat consumers as independent rational beings but rather as interconnected meaning-making creatures. Furthermore, the analysis points to the interdisciplinary nature of neuromarketing implying a new conceptual change in the field of isolated cognitive models toward a conceptualized view that embraces the aspects of ethical, social, and technological aspects. This denser theoretical canvas warrants academics to investigate the way that emerging technologies, such as virtual reality, to machine learning, transform not only the decision-making process but also the way consumers feel, recollect, and connect. Conclusively, these suggestions provide fertile soil where theorists can work to develop a construct of brand loyalty, emotional resonance, and consumer trust in the era when marketing is more frequently corroding into the most private niches of the mind.

As a practitioner, the findings provide a guide on how it is possible to move forward and make sense of the changing landscape of neuromarketing. By incorporating sophisticated methods such as fMRI, EEG, and eye-tracking into the design of the campaign, as the study reveals, marketers will achieve an ability to look beyond what people say they like, and to get a sense of what really attracts attention and recall attention. The benefit of this evidence-based strategy is that it assists brands to create emotionally appealing stories that make their message reach the unconscious mind—a strategy that is very important in a market that has lots of close substitutes. Moreover, the listed increase in multisensory research leads to an executable avenue: the development of brand attachment by the use of sight, sound, touch, and even smell in creating experiences. Marketers can exploit this know-how to develop immersive retail experiences, interactive advertising, and product packaging that combines sensory accountability with preferred emotional reaction, increasing differentiation and loyalty. Ethical observations that were made in the study are practical as well. The logic of transparency in how data are used and protection of consumer privacy, are not only becoming compliance challenges but ways to distinguish an organization as it faces a new age of consumer skepticism. As neuromarketing adopts more invasive or high-resolution tools—such as multimodal biosignal fusion, machine-learning-based trait inference, and immersive VR exposure—the theoretical implications intersect increasingly with ethical and regulatory concerns. The capability to infer attitudes or preferences that individuals may not consciously endorse raises questions about autonomy, cognitive liberty, and the boundaries of persuasive communication. Future theoretical models must therefore incorporate constraints related to cognitive privacy and ethical design, ensuring that neuromarketing frameworks evolve in tandem with emerging legal norms.

7. Limitations and directions for future studies

While this study provides a comprehensive overview of neuromarketing scholarship, several limitations must be acknowledged. First, reliance on Scopus as the sole database may exclude relevant publications indexed in Web of Science, PubMed, or regional databases, potentially leading to coverage bias. Because Scopus disproportionately indexes English-language and Western European journals, the prominence of Spanish and Italian institutions—and, to an extent, U.S. contributors—may reflect publication channel availability rather than absolute research output. Similarly, regions with robust neuromarketing activity but strong local-language publishing norms (e.g., Latin America, China, Francophone countries) may be underrepresented in both publication counts and thematic clusters. This indexing bias may also skew keyword co-occurrence patterns toward concepts favored in Anglo-European scholarship, such as decision-making and consumer neuroscience, while undervaluing culturally grounded or industry-oriented neuromarketing studies common in non-English contexts.

Second, by restricting the search to English-language and indexed journals, important regional and non-indexed contributions may have

been omitted, which could skew geographic and thematic interpretations toward developed economies. This approach risks underrepresenting novel theoretical contributions, non-mainstream discussions, or qualitative studies, which may offer innovative perspectives but have not yet garnered substantial citations. Furthermore, the focus on citation-based metrics might inadvertently prioritize popularity over scientific merit, limiting the consideration of emerging or less-cited works that could bring fresh ideas to the field.

Third, the current studies (2015–2024) risk missing the latest research, particularly in-press manuscripts, unpublished research, and conference presentations that often precede new concepts before publication. This time delay implies areas of current trends, such as what neuromarketing can do in the metaverse or what AI will do to our personalisation, are currently not explored to their full potential. Also, restrictions based on language impose a language bias where other large advances in theory may be lost due to the analysis of English-language publications. This puts the cultural axis of understanding neuromarketing in jeopardy. The exclusion of preprints and conference materials also may omit emergent but unpublished research that often anticipates new methodological trends.

Fourth, thematically, the Scopus-only and English-only constraints may elevate technologically intensive studies (e.g., EEG, fMRI) while overlooking practitioner-level or qualitative neuromarketing research prevalent in emerging markets. As a result, clusters emphasizing AI and neuroimaging may appear more central than they would in a more globally inclusive corpus.

Finally, the use of citation-based metrics may privilege highly cited, popular papers over those that are theoretically innovative but less visible. These constraints highlight the need for future research integrating multilingual and multi-database approaches to provide a more inclusive global map of neuromarketing scholarship.

Through such findings, there are certain paths that lead to potential future research opportunities that can continue to develop neuromarketing as a science and practice. Methodological direction is one, and the combination of qualitative content analysis with bibliometrics has the possibility of revealing subtle theoretical discussions and emerging terms that might not be identified through citations. In the same way, the diversification of Scopus to the Web of Science, PubMed, and local databases has the promise to provide a more detailed and internationally representable map of the neuromarketing discourse. There is also ethical consideration which could use more studying. Since such technologies as predictive analytics powered by AI or real-time neurofeedback are becoming common, researchers are expected to explore the possible consequences on consumer autonomy and mental health. In that regard, the discussion of regulatory systems that could ensure a balance between innovation and ethically friendly practice would be beneficial. The other open ground is cross-cultural neuromarketing studies. The exploration of the crossover between cultural values and norms on altering subconscious responses might end up giving brands some more culturally appropriate approaches, which make campaigns more inclusive globally. These and other technological frontiers, such as the metaverse, VR and AR, raise new questions concerning the impact of immersive worlds on attention, memory, and emotional arousal. Such knowledge gaps can be covered with longitudinal surveys analysing how using such interventions influences brand loyalty and consumer trust over the long term. Lastly, due to the complexity of consumer cognition, multi-methods seeking to integrate neuroscience and behavioral experimentation with big data and qualitative reflections are some of the areas that future research may adopt. This kind of integration holds prospects of a more profound, morally informed, and practically habitable interpretation of everything that enacts what consumers decide, in a digitalized environment that keeps changing.

8. Conclusion

This bibliometric review gives an in-depth study of the research done on neuromarketing in the last seven years (2015–2024), and the way the research field has grown over time by the adoption of modern technology and multisensory research. These results of the analysis of the performance and scientific mapping do not simply summarise the amount of work that was done, but the thematic and methodological development of the area. It is important to note that a growing emphasis on identifying consumer responses at the subconscious level as accurately as possible can be seen through the further use of such neuroimaging tools as fMRI and EEG in line with other physiological measures such as eye-tracking. We have found that interest in neuromarketing has increased steadily, reaching its peak in approximately 2022. However, recent years have seen a slight downtrend in output, which can be attributed to shifts in research priorities or other disruptions in the academic community. Significant articles, authors, and organizations have contributed to the field essential in developing the field. The control of institutions like Sapienza University of Rome and the birth of global contributions of countries like Spain, the USA, and Malaysia emphasize a diversified and collaborative research process. The two sets of keywords and keyword clusters show that the theme of the meta-analysis of the studies on consumer behavior, decision-making, and neuroethics remains academic, whereas such emerging concepts as multisensory integration and artificial intelligence mean the widening of horizons. The bibliometric data proves that neuromarketing is no longer a smallfield but an interdisciplinary field which is becoming popular in business, technology as well as psychological sciences.

The bibliometric evidence indicates that neuromarketing has evolved from its formative stage into a more structured interdisciplinary field, integrating technological, psychological, and ethical dimensions. However, the field remains developing rather than fully mature, with continuing debates on ethical use, cultural inclusivity, and integration of new technologies such as virtual and augmented reality. The present review, therefore, offers an empirically grounded overview rather than a normative claim of disciplinary completion.

Looking ahead, several specific research gaps warrant prioritization to advance neuromarketing as a rigorous interdisciplinary field. First, there is a need for standardized multimodal protocols integrating EEG, fNIRS, eye-tracking, and physiological sensors to improve cross-study comparability. Second, culturally comparative neuromarketing research should be systematically expanded to examine how cultural norms, cognitive styles, and sensory expectations shape neural responses to marketing stimuli. Third, VR- and metaverse-based neuromarketing experiments require validated methodological frameworks that address ecological validity while respecting privacy and data-ownership boundaries. Fourth, the development of ethical-by-design neuromarketing methodologies—incorporating cognitive privacy safeguards, consent transparency, and data minimization—should become a cornerstone of future empirical work. Finally, computational models powered by explainable AI (XAI) offer a promising route for linking neural signals with behavioral outcomes in a transparent, ethically aligned manner.

Future research should move beyond descriptive expansion toward methodological innovation and standardization. First, the development of multimodal reporting checklists for neuromarketing experiments would improve replicability and comparability across studies. Second, shared benchmark datasets and open analytical pipelines could enhance transparency and facilitate cumulative knowledge building. Third, pre-registration of experimental protocols, particularly for neurophysiological outcome measures, would reduce reporting bias and strengthen empirical robustness. Finally, the adoption of privacy-preserving analytics—such as secure data enclaves, federated learning architectures, and strict data minimization protocols—can ensure responsible handling of sensitive neural and biometric data while enabling scientific advancement. By integrating technological sophistication with ethical

accountability and methodological rigor, neuromarketing can evolve into a more mature and socially responsible research domain.

Neuromarketing's maturation depends on addressing several critical research gaps through standardized multimodal protocols integrating EEG, fNIRS, eye-tracking, and physiological measures to enhance reproducibility. Immersive VR, AR, and metaverse-based research must advance from exploratory use to validated paradigms capable of testing spatial cognition and affective engagement under realistic conditions. Cross-cultural studies require culturally calibrated stimuli and comparative designs to distinguish universal from culture-specific neural responses. As AI increasingly drives analysis, explainable models (XAI) are essential for transparency. Ethical-by-design practices—including cognitive-privacy protections, tailored consent, and data minimization—must also be embedded, providing a structured roadmap for a rigorous, responsible, and technologically advanced field.

Declarations

The disclosure of AI usage

The authors declare they have used AI services for grammar correction and to increase the readability of the manuscript. The author carefully reviewed all suggestions from these services to ensure the original meaning and factual accuracy were preserved.

CRediT authorship contribution statement

Md. Abu Issa Gazi: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Funding acquisition. **Md. Mustaqim Roshid:** Writing – review & editing, Validation, Software, Resources, Investigation, Formal analysis, Data curation, Conceptualization. **Abdul Waaje:** Writing – review & editing, Validation, Software, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Md. Bony Yeamin:** Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Data curation. **Rejaul Karim:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Methodology, Investigation. **Mohammad Bin Amin:** Writing – review & editing, Validation, Supervision, Resources, Funding acquisition, Data curation. **Abdul Rahman bin S Senathirajah:** Writing – review & editing, Visualization, Validation, Investigation, Funding acquisition. **Judit Oláh:** Writing – review & editing, Visualization, Validation, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was supported by the University of Debrecen Program for Scientific Publication and the INTI International University, Malaysia.

Data availability

Data will be made available on request.

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