

Bibliometric Analysis and Scientific Mapping of Neuromarketing Research: Trends, Intellectual Structure, and Future Directions

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ABSTRACT

This study examines the neuromarketing literature through a systematic review approach based on the PRISMA guidelines. In this bibliometric study, the initial data were extracted from the Scopus citation database using the keyword "Neuromarketing" for the period from 2004 to 2026. In the first stage, a total of 1,635 documents were identified. Subsequently, to improve analytical accuracy and coherence, the screening process was conducted in several stages. In the first stage, by restricting the search to relevant subject areas, including marketing, neuroscience, consumer psychology, and management, the number of documents was reduced to 700. In the second stage, a language filter was applied and only English-language publications were retained, leaving 637 documents. In the third stage, the document type was restricted to research articles, review articles, and conference papers, resulting in 442 documents. Finally, the titles and abstracts of the documents were manually reviewed, and five irrelevant articles were excluded. The final dataset therefore consisted of 437 articles, which formed the basis for the bibliometric analyses conducted in this study.

Keywords: neuromarketing, neuroscience marketing, bibliometrics

Introduction

Neuromarketing has emerged as an interdisciplinary field situated at the intersection of marketing, consumer behavior, psychology, neuroscience, and decision science. Its development reflects a growing recognition that conventional market research methods, such as questionnaires, interviews, focus groups, and self-report scales, do not always provide complete access to the cognitive and affective mechanisms underlying consumer judgments and choices. Traditional methods are valuable for examining conscious attitudes and stated preferences, but they may be constrained by memory limitations, social desirability bias, post hoc rationalization, and consumers' limited ability to articulate the mental processes that precede behavior. Neuromarketing seeks to complement these approaches by examining physiological and neural responses that may occur before, during, or after exposure to marketing stimuli. Early conceptual discussions attempted to define the field beyond the narrow idea of using brain scanners to increase sales, emphasizing instead the scientific study of how marketing stimuli interact with neural and psychophysiological processes related to attention, emotion, memory, valuation, and choice (1, 2). Subsequent scholarship further clarified that neuromarketing should not be viewed simply as the commercialization of



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neuroscience, but as a potentially integrative framework for understanding consumer responses through the combination of behavioral, physiological, and neuroscientific evidence (3, 4). This broader conception is particularly important in management and marketing because managerial decisions concerning branding, advertising, pricing, product design, retail environments, and communication increasingly depend on understanding how consumers process information in complex and highly competitive markets. Accordingly, neuromarketing has become an important research domain for scholars seeking more direct indicators of consumers' cognitive and emotional reactions to marketplace stimuli.

The conceptual expansion of neuromarketing has been accompanied by increasing methodological diversity. The field incorporates multiple instruments that capture different dimensions of consumer response, including electroencephalography (EEG), functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS), eye-tracking, galvanic skin response (GSR), electrodermal activity, heart rate, heart rate variability, facial coding, and other psychophysiological measures. Each method provides distinct information and is associated with particular analytical strengths and limitations. EEG, for example, offers high temporal resolution and is commonly used to investigate attention, arousal, engagement, approach-withdrawal tendencies, and the temporal dynamics of stimulus processing, whereas fMRI provides comparatively high spatial resolution and can be used to examine activation patterns associated with reward, valuation, memory, and decision-related neural processes. Eye-tracking enables researchers to identify patterns of visual attention, fixations, and gaze behavior, while GSR and related electrodermal measures provide indicators of autonomic arousal. The methodological literature has therefore emphasized that neuromarketing is not based on a single technology but rather on a family of complementary techniques whose usefulness depends on the research question, experimental design, and interpretive framework (5, 6). Reviews of technological development also show that the field has progressively moved toward multimethod designs in which neural, physiological, behavioral, and self-report measures are integrated to achieve more robust interpretations of consumer responses (7, 8). This methodological diversification has contributed to the scientific maturation of neuromarketing by shifting the field away from dependence on isolated measures and toward more comprehensive assessments of the consumer decision process.

The growing methodological sophistication of neuromarketing has also enabled its application to a wide range of marketing and managerial problems. Neuromarketing tools have been used to investigate responses to advertising content, branding cues, packaging, product attributes, price information, retail stimuli, online media, and other elements of the marketing mix. From a managerial perspective, the principal value of these methods lies in their potential to reveal mechanisms that may not be fully captured through explicit consumer reports. Cognitive and emotional reactions are especially important because consumer decisions are rarely generated through purely deliberate reasoning; rather, they are shaped by interactions among attention, affect, memory, prior experience, contextual cues, and perceived value. Research examining cognitive and emotional responses to marketing stimuli has demonstrated the importance of investigating these underlying processes in order to understand why some marketing messages attract attention, produce emotional engagement, or remain memorable while others do not (9). Similarly, foundational accounts of neuromarketing have emphasized that its contribution lies in extending the analytical toolkit of marketing research rather than replacing established consumer research methods (10). More recent systematic assessments of neuromarketing applications across the marketing mix have shown that the field now encompasses product, promotion, pricing, and related managerial domains, while also identifying significant opportunities for improved methodological integration and stronger links between neuroscientific findings and

marketing theory (11). This expansion indicates that neuromarketing has evolved from a relatively specialized experimental approach into a broader research platform with implications for consumer analytics, brand management, communication strategy, and evidence-based marketing decision-making.

At the same time, the rapid expansion of neuromarketing has generated substantial theoretical and ethical debate. The use of neuroscientific knowledge in commercial contexts has raised questions regarding privacy, manipulation, autonomy, informed consent, data governance, and the boundaries of legitimate influence. Such concerns are particularly salient when physiological and neural indicators are interpreted as revealing preferences or vulnerabilities that consumers themselves may not consciously recognize. Early scholarship warned against exaggerated claims that neuromarketing could provide direct access to a consumer's "buy button," emphasizing the complexity of brain-behavior relationships and the risks associated with oversimplifying neuroscientific evidence (2). Ethical analyses have similarly argued that neuromarketing companies and researchers have responsibilities concerning transparency, participant protection, responsible data interpretation, and the avoidance of manipulative or misleading applications (12). Moreover, the relationship between neuromarketing and consumerism has stimulated discussion regarding whether neuroscientific tools primarily serve commercial optimization or can also contribute to a deeper understanding of consumer welfare, choice quality, and the consequences of persuasive environments (13). These debates demonstrate that the development of neuromarketing cannot be assessed only in terms of technological progress or publication growth. Its intellectual evolution must also be understood through the changing balance among scientific rigor, managerial relevance, ethical responsibility, and the interpretation of consumer autonomy within technologically mediated markets.

Another major feature of the field is its increasing integration with digital transformation and advanced computational technologies. Contemporary marketing environments generate large volumes of behavioral, physiological, visual, and interaction data, creating opportunities for the convergence of neuromarketing with artificial intelligence, machine learning, automated emotion recognition, predictive analytics, and Industry 4.0 technologies. In this context, neuromarketing tools are increasingly considered part of a broader ecosystem of data-driven consumer intelligence rather than isolated laboratory techniques. Research in Industry 4.0 contexts has highlighted the potential use of neuromarketing tools in technologically advanced business environments in which digital platforms, smart systems, automation, and real-time data collection influence both organizational processes and consumer interactions (14). Systematic reviews of technological innovation in neuromarketing also suggest a transition toward more portable, scalable, and computationally integrated methods, including wearable sensors, improved eye-tracking systems, automated signal processing, and machine-learning-based pattern recognition (8). This transition has important managerial consequences because advanced analytical methods can potentially transform raw neurophysiological signals into predictive models of attention, affective response, preference, or decision behavior. At the same time, such integration increases methodological complexity and raises new questions regarding reproducibility, algorithmic interpretation, multimodal data fusion, and the validity of predictions generated from relatively small experimental samples. Thus, the technological trajectory of neuromarketing reveals both a substantial opportunity for innovation and a need for stronger methodological standards.

Recent reviews further indicate that neuromarketing research is undergoing a process of conceptual consolidation and specialization. Studies increasingly attempt to classify the field into distinct research streams, methodological typologies, and application domains, reflecting a transition from exploratory adoption toward more structured knowledge development. Comprehensive reviews have identified heterogeneous patterns in how the

term “neuromarketing” is used, with some studies focusing narrowly on neural imaging and others incorporating wider psychophysiological and behavioral measures (15). This diversity suggests that the boundaries of the field remain somewhat fluid and that conceptual consistency is essential for cumulative knowledge development. At the same time, recent syntheses of EEG and fMRI research demonstrate that consumer decision-making has become a particularly important domain in which neuroscience-based methods are used to examine valuation, preference formation, reward processing, attention, and choice mechanisms (16). Such research illustrates the movement of the field toward more focused theoretical questions rather than the mere demonstration that marketing stimuli generate measurable neural responses. This maturation is important because the long-term scientific legitimacy of neuromarketing depends on whether it can produce replicable, theory-relevant, and managerially meaningful explanations of consumer behavior rather than simply adding technological novelty to conventional marketing experiments.

The development of neuromarketing has also stimulated efforts to evaluate the structure and growth of its scientific literature through bibliometric and scientometric methods. As the volume of publications expands, traditional narrative reviews alone become insufficient for identifying large-scale patterns in authorship, collaboration, citation impact, thematic development, and intellectual structure. Bibliometric analysis offers a quantitative means of examining these patterns through techniques such as citation analysis, co-citation analysis, bibliographic coupling, co-authorship analysis, keyword co-occurrence analysis, and scientific mapping. These methods make it possible to identify influential publications, productive journals and countries, collaboration networks, dominant research themes, and emerging topics across a field. Recent bibliometric research on neuromarketing has demonstrated notable growth in scientific output and increasing diversification of research themes, while also revealing concentration around specific technologies, consumer behavior topics, and interdisciplinary connections (17). Similarly, network-based examinations of the intellectual landscape have shown that neuromarketing has developed through interconnected clusters involving neuroscience methods, consumer decision-making, advertising, emotion, branding, and market research (18). These studies confirm that bibliometric approaches are particularly valuable for a field such as neuromarketing, where rapid technological change and disciplinary convergence continually reshape the research agenda.

Despite this growing body of review and bibliometric research, several issues justify continued systematic mapping of the neuromarketing literature. First, the field is developing rapidly, meaning that analyses based on earlier publication windows can become outdated as new technologies, journals, collaborations, and thematic streams emerge. The expansion of artificial intelligence, machine learning, systematic review research, multimodal measurement, portable sensing technologies, and advanced neuroimaging has the potential to alter the conceptual configuration of the field within only a few years. Second, different reviews have employed different databases, search strings, inclusion criteria, time periods, and analytical methods, which may produce substantially different representations of the research landscape. Third, some studies focus primarily on specific instruments or applications, whereas others address theoretical definitions, ethical issues, or broad technological developments. For example, systematic examinations of technological opportunities emphasize changes in neuromarketing instrumentation and analytical capability (7), whereas theoretically oriented studies focus on the relationship between neuromarketing and consumer behavior or market practice (19). Likewise, bibliometric work may identify influential knowledge clusters without fully integrating recent developments associated with AI-enabled analysis, multimodal data, and newer consumer neuroscience applications. These differences create a need for updated

mapping that combines publication trends, citation impact, geographical distribution, source productivity, and keyword-based conceptual analysis within a single analytical framework.

An updated bibliometric perspective is particularly relevant because the intellectual structure of neuromarketing appears to be shifting from an early emphasis on defining the field and demonstrating the utility of neuroscience tools toward more complex questions involving consumer decision-making, emotional processing, technological integration, and methodological synthesis. Earlier studies were concerned with clarifying what neuromarketing is, how it differs from conventional market research, and whether neuroscience could provide meaningful insights into consumer responses (1, 4). Later studies increasingly addressed the practical use of EEG, fMRI, eye-tracking, electrodermal measures, and related tools, along with concerns regarding their validity, applicability, and ethical implications (5, 6). More recent literature reflects an intensified focus on technological convergence, including artificial intelligence, machine learning, systematic evidence synthesis, and advanced consumer neuroscience (15, 16). In parallel, bibliometric studies have begun to document the evolution of the field as a scientific network rather than merely as a set of experimental techniques (17, 18). Therefore, a contemporary bibliometric investigation can contribute not only by quantifying publication activity but also by demonstrating how the conceptual center of neuromarketing is being reconfigured through interactions among neuroscience, consumer psychology, advertising research, management, data science, and emerging intelligent technologies.

Accordingly, a comprehensive scientific mapping of neuromarketing research can provide value for scholars, managers, and future researchers by clarifying the field's historical development, intellectual foundations, influential sources, geographical contributions, methodological emphases, and emerging research trajectories. Such an analysis can help distinguish mature research streams from emerging themes, reveal the degree of interdisciplinarity within the field, and identify topics that remain fragmented or insufficiently investigated. It can also provide a more systematic basis for developing future research agendas by demonstrating how established areas such as EEG, fMRI, eye-tracking, advertising, emotion, and consumer decision-making are becoming connected with newer themes such as artificial intelligence, machine learning, multimodal analytics, and bibliometric self-reflection. This need is reinforced by the broader movement toward a more integrated science of consumer influence and decision-making in which neuroscientific, behavioral, and managerial knowledge are combined rather than treated as isolated domains (3). Therefore, the aim of this study is to conduct a systematic bibliometric analysis and scientific mapping of neuromarketing research from 2004 to 2026 in order to identify its publication trends, influential sources and studies, geographical contributions, intellectual and thematic structure, and emerging directions for future research.

Methods and Materials

The PRISMA approach was employed to examine and analyze the data.

A systematic search was conducted in the international Scopus database. The search strategy was designed using a combination of keywords and Boolean operators as follows:

“neuromarketing” OR “neuro_marketing” OR “consumer_neuro_science” AND “consumer decision making”

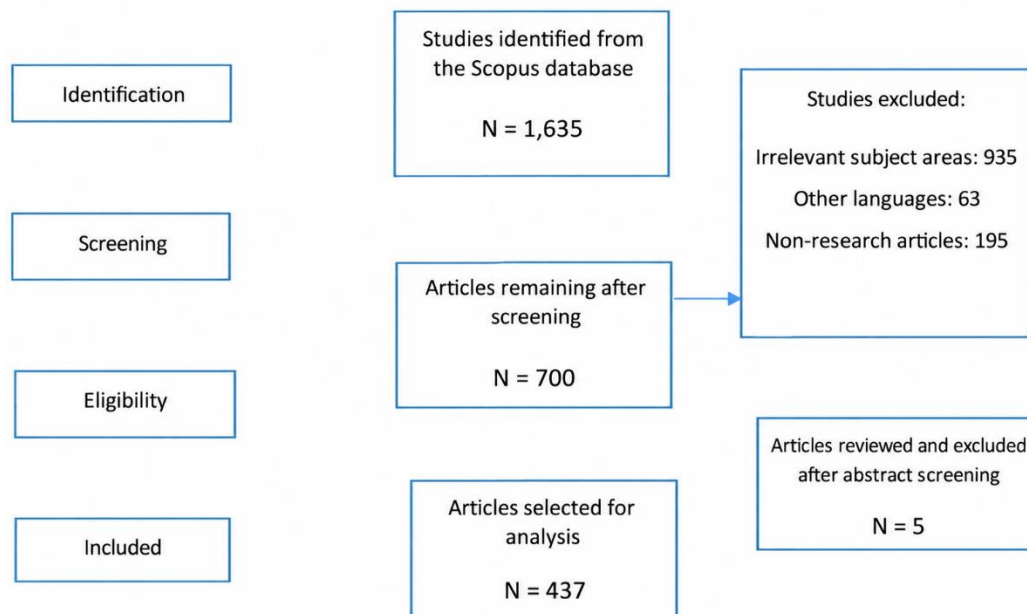


Figure 1. Article Selection Process

The objectives of bibliometric analysis in the field of neuromarketing are multifaceted. First, the analysis seeks to map the temporal development of neuromarketing research and highlight major trends and shifts in researchers' areas of focus over time. Second, by identifying the most highly cited authors and scientific journals, the analysis seeks to determine the influential scholarly contributions and publications that have played important roles in shaping and developing the field. In addition, bibliometric analysis examines scientific relationships and collaborations among researchers and countries, thereby revealing the principal research networks and centers in the field of neuromarketing. Finally, bibliometric analysis aims to identify underexplored areas and existing research gaps in the literature. Identifying these gaps can provide a foundation for future studies, enabling researchers to address neglected areas and contribute to the further development and advancement of knowledge in neuromarketing.

The bibliographic database used to conduct the bibliometric analysis of neuromarketing was Scopus, which was selected because of its extensive coverage of scholarly sources and scientific literature. The keyword "neuromarketing" was used in the search process, yielding a total of 1,635 records without applying any language restrictions.

The inclusion criteria encompassed articles published in scientific journals, conference papers, and review articles because these publication types generally contain original research, comprehensive scholarly reviews, or detailed scientific investigations. The data were subsequently refined by applying the exclusion criteria. Editorials, letters, notes, and short survey studies were excluded from the dataset.

Findings and Results

A total of 442 documents were selected for subsequent analyses. The selected documents were exported and stored in CSV format. Bibliometric analyses were performed using VOSviewer software.

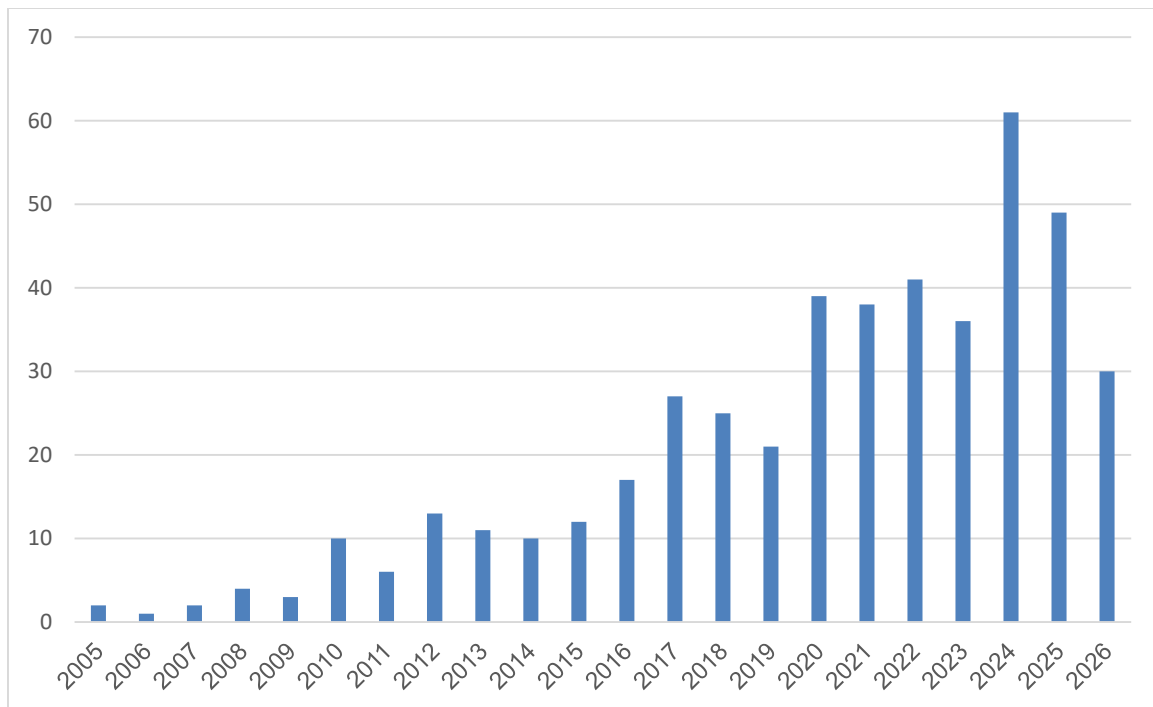


Figure 2. Annual Trend in Article Publications

The figure above illustrates the annual trend in article publications. As shown, scholarly publication in the field of neuromarketing remained negligible until 2011. This trend continued with only modest growth until 2019. A substantial increase occurred in 2020, and the highest number of articles was published in 2024, after which the publication trend declined.

Table 1. Ten Most Highly Cited Articles in the Field of Neuromarketing

Article Title	Journal	Publication Year	Total Citations
Neuromarketing: The Hope and Hype of Neuroimaging in Business	<i>Nature Reviews Neuroscience</i>	2010	776
Branding the Brain: A Critical Review and Outlook	<i>Journal of Consumer Psychology</i>	2012	438
Aesthetic Package Design: A Behavioral, Neural, and Psychological Investigation	<i>Journal of Consumer Psychology</i>	2010	431
From Neural Responses to Population Behavior: Neural Focus Group Predicts Population-Level Media Effects	<i>Psychological Science</i>	2012	283
Brain Responses to Movie Trailers Predict Individual Preferences for Movies and Their Population-Wide Commercial Success	<i>Journal of Marketing Research</i>	2015	275
A Neural Predictor of Cultural Popularity	<i>Journal of Consumer Psychology, 22(1)</i>	2012	241
Analysis of Neurophysiological Reactions to Advertising Stimuli by Means of EEG and Galvanic Skin Response Measures	<i>Journal of Neuroscience, Psychology, and Economics, 2(1)</i>	2009	209
Demystifying Neuromarketing	<i>Journal of Business Research, 91</i>	2018	208
Neuromarketing: A Layman's Look at Neuroscience and Its Potential Application to Marketing Practice	<i>Journal of Consumer Marketing, 24(7)</i>	2007	208
Application of Frontal EEG Asymmetry to Advertising Research	<i>Journal of Economic Psychology, 31(5)</i>	2010	214

In terms of the most influential journals and scientific sources in neuromarketing based on the number of published articles, *Frontiers in Psychology* ranks first with 31 articles, indicating its substantial role in disseminating neuromarketing research. It is followed by *Springer Proceedings in Business and Economics*, with 21 publications,

Scientometric analyses conducted to assess the contributions of different countries indicate that the United States has produced the largest number of publications and ranks first, followed by Spain, Italy, India, China, and the United Kingdom.

Table 2. Number of Neuromarketing Publications by Country

Country	Number of Publications	Country	Number of Publications
United States	73	India	39
Spain	62	China	37
Italy	43	United Kingdom	36

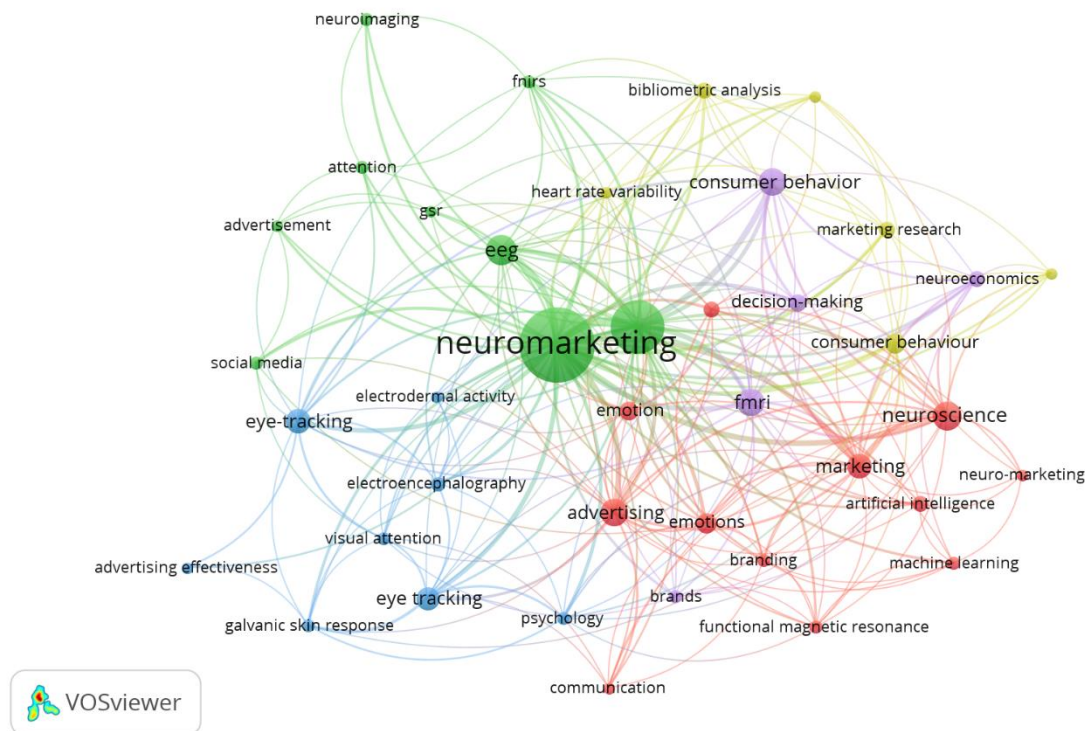


Figure 3. Thematic Clustering Map of Keywords

The green cluster is the largest and most prominent cluster in the map and is positioned at the center of the network, with “neuromarketing” constituting its largest node. It is accompanied by concepts such as heart rate variability, GSR, attention, advertising, social media, neuroimaging, EEG, and fNIRS.

The central location of neuromarketing and its extensive connections with almost all other clusters indicate that this concept constitutes the conceptual core of the entire research network. The presence of EEG, fNIRS, GSR, and heart rate variability in this cluster indicates that a substantial portion of the neuromarketing literature focuses on measuring consumers' neural and physiological responses. Accordingly, this cluster can conceptually be labeled **“Neural and Physiological Methods in Neuromarketing.”**

Blue Cluster: Eye-Tracking, Attention, and Advertising Effectiveness

The blue cluster is located in the lower-left section of the map. Its most important concepts include eye-tracking, visual attention, electroencephalography, skin response, advertising effectiveness, and psychology.

This cluster demonstrates that one of the major streams of neuromarketing research concerns visual attention and consumers' responses to advertising. The simultaneous presence of eye-tracking, attention, and advertising effectiveness is particularly meaningful because it indicates that researchers use eye-movement tracking to examine which parts of an advertisement attract consumers' attention, what consumers visually process, and how such attention may be associated with advertising effectiveness. Accordingly, this cluster can be labeled "Visual Attention and Advertising Effectiveness."

Red Cluster: Marketing, Emotion, and Intelligent Technologies

The red cluster is located in the lower-right section of the map. The main concepts within this cluster include marketing, neuroscience, emotions, advertising, branding, artificial intelligence, machine learning, functional magnetic resonance imaging, communication, and neuromarketing.

This cluster is particularly important in relation to recent developments in the field because it combines traditional marketing concepts with emerging technologies. In particular, the simultaneous presence of artificial intelligence, machine learning, emotion, and neuroscience indicates that neuromarketing research is increasingly moving toward the intelligent analysis of neural and emotional data. From this perspective, this cluster can be labeled "Convergence of Neuroscience, Artificial Intelligence, and Marketing." This area is likely to represent one of the most important directions for future research.

Purple Cluster: Consumer Behavior and Decision-Making

The purple cluster is located in the upper central-right area of the map and encompasses important concepts such as consumer behavior, decision-making, and fMRI.

This cluster is theoretically significant because the research focus shifts from merely "measuring brain activity" toward explaining consumer behavior and decision-making. The relationships among fMRI, consumer behavior, and decision-making indicate that a segment of the neuromarketing literature seeks to answer the following question: How can neural activity explain consumer decision-making processes and actual consumer behavior? Accordingly, an appropriate label for this cluster is "Neuroscience of Consumer Decision-Making and Behavior."

Yellow Cluster: Scientific Analysis, Marketing, and Neuroeconomics

The yellow cluster is located in the upper-right section of the map. Its prominent concepts include bibliometric analysis, marketing research, and neuroeconomics.

This cluster differs from the other clusters because part of it concerns the methodology used to study the scientific field itself. The presence of bibliometric analysis indicates that a portion of the studies in the dataset is devoted to examining the structure, trends, and evolution of the neuromarketing literature. At the same time, the presence of neuroeconomics reflects the connection between neuromarketing and the broader field of neuroeconomics, particularly research on economic decision-making. This cluster can therefore be labeled "Scientific Analysis and the Link Between Neuromarketing and Neuroeconomics."

Relationships Among Clusters: More Important Than the Colors Themselves

One of the most important characteristics of the map is that the clusters are not isolated from one another. The numerous links among them demonstrate the highly interdisciplinary nature of neuromarketing.

Green Cluster → Blue Cluster

The relationships between neuromarketing and EEG on the one hand and eye-tracking and visual attention on the other indicate that researchers combine neural measurement techniques with attention-tracking methods to investigate consumer responses.

Green Cluster → Purple Cluster

The relationships of EEG and neuroimaging with consumer behavior and decision-making demonstrate that measurements of brain activity are used to explain consumer behavior and decision processes.

Red Cluster → Purple Cluster

The relationships of emotion, neuroscience, and marketing with consumer behavior and decision-making indicate a close connection among emotional processes, neural activity, and consumer decision-making.

Red Cluster → Technology

The positioning of artificial intelligence and machine learning alongside neuroscience and emotion demonstrates that the field is moving toward advanced analytical approaches for neural and emotional data.

Node size is also highly important in this map. The largest node is neuromarketing, reflecting the very high frequency of this keyword and its central role within the network. Other concepts with substantial prominence include consumer behavior, EEG, neuroscience, eye-tracking, marketing, advertising, emotions, and fMRI.

Accordingly, the overall structure of the literature can be described as originating from a central core—neuromarketing—around which four major dimensions have developed:

Neural and physiological methods → Attention and advertising → Behavior and decision-making → Technology and intelligent analytics

The keyword co-occurrence network analysis reveals the multidimensional conceptual structure of the neuromarketing field. As shown in the figure, the keyword “neuromarketing” constitutes the largest and most central node in the network and is connected to a broad range of neural, physiological, marketing, and behavioral concepts. The network colors indicate the formation of distinct conceptual clusters. The green cluster predominantly focuses on neural and physiological methods, including EEG, fNIRS, GSR, and heart rate variability. The blue cluster is more closely associated with eye-tracking, visual attention, and advertising effectiveness. The purple cluster emphasizes consumer behavior, decision-making, and the application of fMRI to the investigation of consumer processes. By contrast, the red cluster represents the intersection of neuroscience, marketing, emotions, advertising, branding, and emerging technologies such as artificial intelligence and machine learning. The yellow cluster is associated with concepts such as bibliometric analysis, marketing research, and neuroeconomics.

Overall, the network structure indicates that neuromarketing has progressed beyond being a field concerned solely with measuring brain activity and is increasingly moving toward the integration of neuroscience with consumer behavior, decision-making, advertising, emotions, and advanced computational technologies. The dense interconnections among the clusters further confirm the interdisciplinary nature of this field. In particular, the links among artificial intelligence, machine learning, emotion recognition, eye-tracking, and neural indicators may indicate the emergence of new research trajectories in neuromarketing.

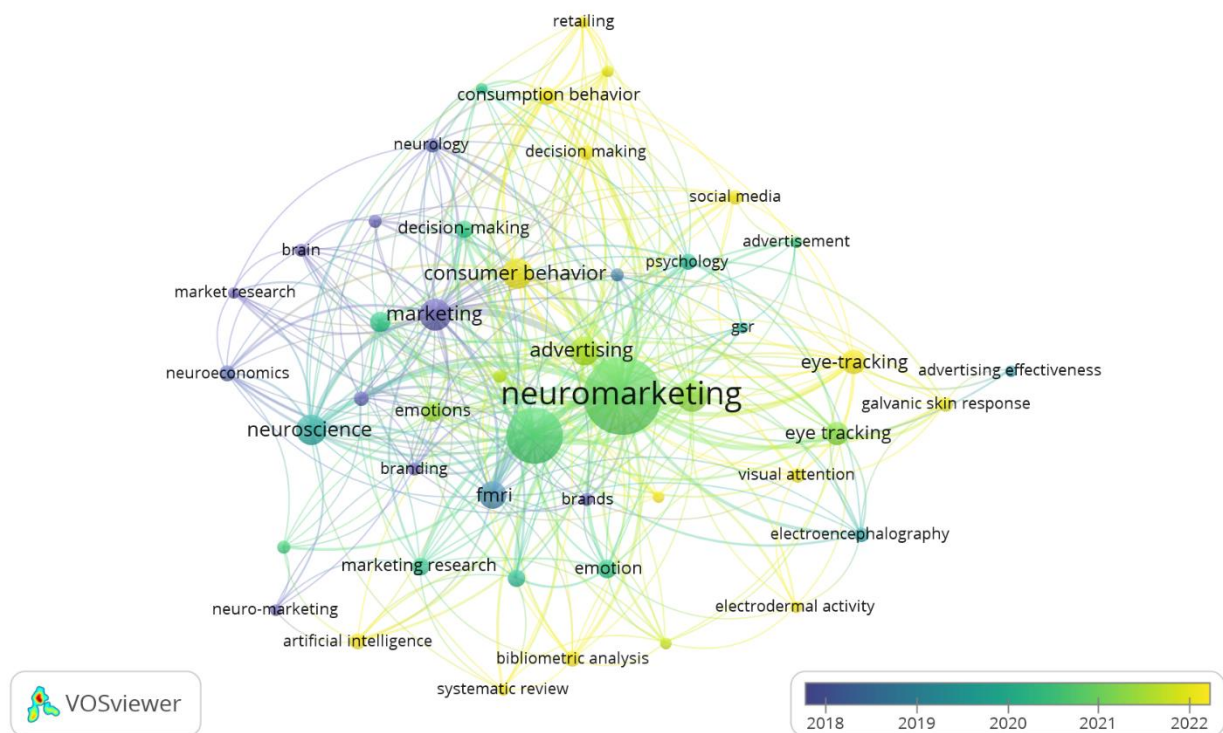


Figure 4. Keyword Co-Occurrence Map in VOSviewer Using Overlay Visualization

This figure presents the keyword co-occurrence map generated in VOSviewer using the Overlay Visualization mode. The map illustrates which concepts have been used together most frequently in neuromarketing studies and how the temporal patterns of their emergence or increasing prominence have evolved.

The figure above presents the keyword co-occurrence map of neuromarketing research based on temporal overlay analysis. As shown, the keyword “neuromarketing” represents the largest and most central node in the network and is closely connected with concepts such as marketing, advertising, consumer behavior, neuroscience, and decision-making. This pattern indicates that the core of neuromarketing research has focused on consumer behavior, decision-making, advertising, and the application of neuroscience to marketing.

In the older section of the map, keywords such as brain, neurology, neuroeconomics, and market research are primarily located within the blue and purple portions of the color spectrum, whereas concepts such as neuroscience, emotions, branding, and fMRI became more prominent during the intermediate period of research development. In contrast, keywords such as artificial intelligence, bibliometric analysis, systematic review, eye-tracking, advertising effectiveness, and electrodermal activity appear in light green and yellow, indicating the emergence or increasing prominence of these topics during the later years of the period examined.

Furthermore, the close relationships among eye-tracking, visual attention, galvanic skin response, electrodermal activity, and electroencephalography indicate that a substantial proportion of recent research has focused on the objective measurement of consumers’ attention, emotional arousal, and physiological responses when exposed to advertising stimuli. Overall, the map indicates that neuromarketing has evolved from an initial emphasis on neural foundations and decision-making toward the integration of analytical technologies, artificial intelligence, multimodal methods, and assessments of advertising effectiveness.



Figure 5. Keyword Density Visualization in VOSviewer

This figure presents the keyword Density Visualization generated in VOSviewer for the field of neuromarketing. Unlike the preceding network visualization, the principal objective here is to identify the degree of research concentration around different concepts. Areas represented by warmer colors, particularly yellow, indicate greater keyword density and frequency, whereas green and blue areas indicate moderate and lower levels of density, respectively.

The figure above presents the density map of frequently occurring concepts in the neuromarketing literature. As shown, the highest research density is located in the central area surrounding the keyword “neuromarketing,” reflecting the central position of this concept within the thematic structure of the field. Around this core, concepts such as EEG, consumer behavior, eye-tracking, fMRI, neuroscience, emotion, and decision-making also exhibit considerable density, demonstrating that research has concentrated on measuring neural and physiological responses, consumer attention and perception, decision-making processes, and consumer behavior. In contrast, concepts such as artificial intelligence, machine learning, neuroeconomics, and bibliometric analysis exhibit relatively lower density, potentially reflecting their emerging or more specialized status within the neuromarketing literature. In particular, the emergence of artificial intelligence and machine learning alongside neural and emotional concepts indicates the gradual movement of the field toward the application of advanced computational methods for analyzing consumer responses. Overall, the density map indicates that although neuromarketing research continues to maintain a strong emphasis on conventional neuroscience methods, the field is gradually evolving toward explaining consumer behavior and decision-making and integrating intelligent technologies with neural and physiological data.

Discussion and Conclusion

The present bibliometric analysis provides a comprehensive overview of the development, intellectual structure, and emerging trajectories of neuromarketing research between 2004 and 2026. The findings indicate that the field has experienced substantial growth, particularly after 2020, following a relatively limited publication output during its early stages and only gradual expansion up to 2019. The marked increase in publications after 2020 suggests that neuromarketing has moved beyond an exploratory phase and entered a period of greater scientific consolidation, methodological diversification, and interdisciplinary integration. This trajectory is consistent with the broader evolution of neuromarketing from an initially controversial and narrowly defined application of neuroscience to marketing toward a more mature research domain incorporating consumer behavior, cognitive neuroscience, psychophysiology, artificial intelligence, and advanced analytics. Earlier discussions of the field emphasized conceptual clarification and the need to distinguish neuromarketing from overly simplistic claims about identifying hidden consumer preferences through direct access to the brain (1, 2). Subsequent studies progressively expanded this conceptualization by framing neuromarketing as a research domain capable of integrating neuroscientific and behavioral perspectives to explain consumer responses to marketing stimuli (3, 4). The publication growth observed in the present study therefore reflects not only increased popularity but also the growing acceptance of neuromarketing as a legitimate interdisciplinary field with relevance to marketing science and managerial decision-making.

The annual publication trend also demonstrates that 2024 represented the peak of scientific output in the dataset, followed by a decline in subsequent years. This pattern should not necessarily be interpreted as a weakening of scholarly interest in neuromarketing. Because the most recent years may be affected by incomplete indexing, publication delays, or the timing of database extraction, the apparent decline may partly reflect bibliographic coverage rather than an actual contraction in research activity. More importantly, the strong growth preceding the peak corresponds with the expansion of technological applications in neuromarketing. Recent literature has highlighted increasing access to portable EEG systems, eye-tracking devices, electrodermal sensors, computational signal-processing methods, and artificial intelligence-based analytical techniques (7, 8). These technological developments have reduced some of the barriers associated with earlier neuroimaging-based research and have allowed neuromarketing methods to be applied in a wider range of experimental and managerial settings. The increasing availability of such tools may therefore explain the acceleration in publication output observed during the later period of the analysis. The findings are also consistent with bibliometric evidence demonstrating a gradual but persistent expansion of the intellectual landscape of neuromarketing and a shift from isolated methodological studies toward more interconnected research networks (17, 18).

The citation analysis further reveals that highly influential studies have played a foundational role in shaping the field. The most highly cited publications are concentrated around several major themes, including the scientific legitimacy of neuromarketing, the application of neuroimaging to business and consumer research, neural prediction of consumer and population-level behavior, advertising effectiveness, branding, packaging, and methodological evaluation. The prominence of these publications suggests that the intellectual foundations of neuromarketing were built not only around the introduction of neuroscientific technologies but also around debates regarding their interpretive value and practical applicability. This observation is consistent with foundational research emphasizing that neuromarketing should be understood as more than a technological novelty and should

instead contribute theoretically meaningful explanations of consumer cognition and behavior (10, 19). The high citation impact of studies addressing neuroimaging, advertising, and consumer prediction also indicates that researchers have consistently been interested in whether neural and physiological measures can provide explanatory or predictive information beyond conventional self-report methods. This orientation has become increasingly prominent in recent research, especially in studies applying EEG and fMRI to consumer decision-making and examining how neural activation relates to preference formation, valuation, attention, and choice (16). Thus, the citation structure identified in the present study reflects the gradual movement of neuromarketing from methodological experimentation toward theoretically informed applications with predictive and managerial relevance.

The analysis of journals and scientific sources shows that *Frontiers in Psychology* is the most productive outlet in the dataset, followed by *Springer Proceedings in Business and Economics* and *Frontiers in Human Neuroscience*, while the *Journal of Consumer Behaviour* and *Journal of Business Research* also occupy notable positions. This distribution reinforces the interdisciplinary character of neuromarketing. The presence of journals from psychology, neuroscience, business, and consumer research demonstrates that the field cannot be confined to a single disciplinary tradition. Instead, its development depends on interactions among experimental neuroscience, cognitive psychology, marketing theory, consumer behavior, and managerial science. This finding is strongly aligned with previous research characterizing neuromarketing as an inherently interdisciplinary field that requires integration across scientific domains (3, 4). It is also consistent with systematic reviews showing that neuromarketing tools are increasingly applied across multiple elements of the marketing mix, including advertising, branding, product design, pricing, and consumer engagement (11). The prominence of interdisciplinary journals further suggests that future advances in the field are likely to arise from collaborative research teams capable of combining neuroscientific measurement with marketing theory and advanced quantitative analysis.

The geographical analysis indicates that the United States has the largest number of publications, followed by Spain, Italy, India, China, and the United Kingdom. This distribution suggests that neuromarketing research has developed most strongly in countries with relatively established research infrastructures in neuroscience, psychology, marketing, and digital technologies. The leadership of the United States is unsurprising given its longstanding role in consumer research, cognitive neuroscience, and advanced experimental methodologies. However, the strong presence of Spain and Italy demonstrates that neuromarketing has also developed considerably within European research networks, while the growing contribution of India and China indicates increasing geographical diversification. This finding is relevant because the cultural generalizability of neuromarketing findings remains an important issue. Consumer responses to advertising, brands, emotional stimuli, and decision contexts are shaped not only by neurophysiological mechanisms but also by cultural and social environments. Therefore, the increased participation of different countries can strengthen the field by providing more diverse samples and facilitating cross-cultural comparisons. Previous research has likewise emphasized the need to move beyond narrow experimental settings and develop neuromarketing applications in different institutional, cultural, and industrial contexts (13, 14). The geographical expansion observed here may therefore be interpreted as an indicator of the field's transition toward broader international relevance.

The keyword co-occurrence analysis revealed several conceptually distinct but strongly interconnected clusters. The green cluster, centered on neuromarketing and encompassing EEG, fNIRS, GSR, heart rate variability, attention, advertising, social media, and neuroimaging, represents the methodological core of the field. The

prominence of these terms indicates that a substantial proportion of neuromarketing research remains focused on the measurement of neural and physiological responses. This result is consistent with previous reviews identifying EEG, fMRI, eye-tracking, and electrodermal measures among the most widely used neuromarketing instruments (5, 6). It also aligns with the broader technological review literature showing that the development of neuromarketing has been strongly influenced by improvements in measurement devices, signal processing, and multimodal integration (7). The centrality of these methodological keywords confirms that measurement technology remains fundamental to the identity of the field. At the same time, the wide range of connections extending from this cluster indicates that these tools are increasingly used not as ends in themselves but as mechanisms for investigating broader behavioral and managerial questions.

The blue and purple clusters further demonstrate this shift from measurement toward explanation. The blue cluster, characterized by eye-tracking, visual attention, electroencephalography, skin response, advertising effectiveness, and psychology, highlights the importance of attention-based research in advertising. Eye-tracking is particularly useful because it provides direct evidence of visual fixation and gaze patterns, allowing researchers to examine which elements of advertisements, packaging, websites, or brand communications attract consumer attention. When combined with EEG or electrodermal responses, eye-tracking can offer a more comprehensive view of both perceptual attention and emotional arousal. The present findings therefore support earlier research emphasizing the importance of combining cognitive and emotional measures when evaluating consumer responses to marketing stimuli (9). The purple cluster, centered on consumer behavior, decision-making, and fMRI, represents a theoretically deeper dimension of neuromarketing research in which neural activity is examined in relation to actual consumer choice. This finding closely aligns with recent systematic research showing that EEG and fMRI studies increasingly focus on consumer valuation, reward, preference, and decision mechanisms rather than merely documenting stimulus-related brain activation (16). Together, the blue and purple clusters indicate that the field is progressively moving toward explaining how measurable neurophysiological responses translate into attention, judgment, and consumer behavior.

The red cluster is particularly important because it contains marketing, neuroscience, emotion, advertising, branding, artificial intelligence, machine learning, fMRI, and communication. This configuration provides strong evidence that neuromarketing is entering a new phase characterized by the convergence of neuroscience and intelligent computational technologies. Artificial intelligence and machine learning can enhance neuromarketing by enabling the analysis of complex, high-dimensional, and multimodal datasets that may include EEG signals, gaze patterns, facial expressions, electrodermal responses, and behavioral indicators. The emergence of these technologies within the same cluster as emotion and neuroscience suggests a shift toward predictive and automated consumer analytics. This interpretation is consistent with recent reviews showing that technological innovation is increasingly reshaping the methods and applications of neuromarketing (8). It also accords with research positioning neuromarketing within broader Industry 4.0 environments, where smart technologies, digital platforms, and advanced data analytics are becoming integral to consumer research (14). More recent conceptual reviews have similarly identified increasing methodological diversification and the emergence of new typologies that extend beyond traditional neuroimaging toward integrated analytical systems (15). Therefore, the red cluster may represent one of the most strategically important areas for future development of the field.

The yellow cluster, which includes bibliometric analysis, marketing research, and neuroeconomics, reflects a different but equally important dimension of the literature. The presence of bibliometric analysis indicates that

neuromarketing has reached a level of maturity at which researchers are increasingly studying the development of the field itself. Such reflexive scholarship is characteristic of an expanding discipline because it allows researchers to assess cumulative knowledge, detect research concentrations, identify influential authors and journals, and reveal emerging themes. Previous bibliometric studies have already demonstrated the value of this approach by mapping citation structures, collaboration patterns, and thematic clusters within neuromarketing research (17, 18). The association with neuroeconomics is also noteworthy, as it indicates an intellectual link between neuromarketing and broader research on the neural mechanisms of valuation, reward, risk, and economic decision-making. This relationship supports the view that neuromarketing is increasingly embedded within a larger interdisciplinary science of decision behavior rather than operating as an isolated marketing technique.

The overlay visualization and density analysis provide further insight into the temporal evolution of the field. Older terms such as brain, neurology, neuroeconomics, and market research were more prominent in the earlier stages, while neuroscience, emotions, branding, and fMRI gained importance in the intermediate period. More recent topics include artificial intelligence, bibliometric analysis, systematic review, eye-tracking, advertising effectiveness, and electrodermal activity. This temporal shift indicates a clear transition from defining the neurological basis of marketing responses toward applying increasingly sophisticated technologies to practical consumer and advertising problems. The emergence of systematic reviews and bibliometric analysis also suggests that the field is moving toward evidence synthesis and methodological self-evaluation. This development is consistent with the increasing number of review studies attempting to clarify the theoretical boundaries, research typologies, and technological opportunities of neuromarketing (7, 11, 15). The density visualization complements this result by showing that conventional concepts such as neuromarketing, EEG, consumer behavior, eye-tracking, fMRI, neuroscience, emotion, and decision-making remain the most established research areas, whereas artificial intelligence, machine learning, neuroeconomics, and bibliometric analysis exhibit lower density and can therefore be considered comparatively emerging or specialized topics.

Overall, the findings demonstrate that neuromarketing has evolved from an early emphasis on defining the field and introducing neuroscientific measurement into marketing toward a more complex and integrated research domain. Its contemporary structure includes established methodological foundations, theoretically oriented investigations of consumer behavior and decision-making, applied research on advertising and branding, and emerging computational approaches based on artificial intelligence and machine learning. The dense links among the identified clusters confirm that these developments are not occurring independently. Instead, the field is increasingly characterized by multimethod integration, in which neural signals, physiological responses, behavioral indicators, and computational analytics are combined to explain consumer cognition and behavior. This pattern supports the argument that neuromarketing should be understood as an integrated science of consumer influence rather than as a narrow set of neuroimaging techniques (3). At the same time, this expansion reinforces the importance of maintaining scientific and ethical standards. As neuromarketing tools become more powerful and potentially more predictive, concerns regarding interpretation, privacy, consumer autonomy, informed consent, and responsible application remain highly relevant (2, 12). The future credibility of neuromarketing will therefore depend on balancing technological innovation and managerial relevance with methodological rigor, theoretical clarity, and ethical responsibility.

This study has several limitations that should be considered when interpreting its findings. First, the analysis was based exclusively on documents indexed in the Scopus database; consequently, relevant publications available

only in Web of Science, PubMed, Google Scholar, Dimensions, or other specialized databases may not have been included. Second, the search strategy centered on the term “neuromarketing” and closely related expressions, which may have excluded studies conducted under labels such as consumer neuroscience, neuroeconomics, decision neuroscience, affective computing, or physiological consumer research even when their substantive focus overlapped with neuromarketing. Third, the analysis was limited to English-language publications and selected document types, potentially reducing representation of regional research published in other languages or publication formats. Fourth, citation-based indicators inherently favor older publications because they have had more time to accumulate citations, whereas recent studies may have substantial scientific relevance but relatively low citation counts. Fifth, bibliometric clustering and keyword co-occurrence depend on author-assigned terminology and database indexing practices, which may introduce inconsistencies caused by synonyms, spelling differences, or variation in keyword selection. Finally, the most recent publication years may be incompletely indexed, which could partially explain the apparent decline in publication output after the observed peak.

Future studies should extend the present analysis by integrating multiple bibliographic databases and harmonizing records across sources to obtain broader and more representative coverage of the neuromarketing literature. Longitudinal bibliometric analyses should examine how thematic clusters change over shorter time intervals and should distinguish mature, declining, and emerging research fronts. Greater attention should also be given to artificial intelligence, machine learning, multimodal signal integration, portable neurotechnology, emotion recognition, virtual reality, augmented reality, social media environments, and real-time digital consumer analytics. Future research should compare countries and cultural regions to determine whether the conceptual and methodological development of neuromarketing differs across institutional and cultural contexts. More studies are also needed to investigate the predictive validity of neuromarketing measures by linking laboratory responses to subsequent real-world consumer behavior, purchasing, brand loyalty, and market outcomes. Researchers should prioritize larger samples, preregistered designs, replication studies, open datasets, standardized reporting protocols, and direct comparisons between neuroscientific measures and conventional marketing research methods. Finally, future bibliometric investigations could incorporate thematic evolution analysis, citation burst detection, co-citation structures, bibliographic coupling, and collaboration networks to provide a more dynamic account of how the field is developing.

For practitioners, the findings indicate that neuromarketing should be used as a complementary decision-support approach rather than as a substitute for established market research. Managers can obtain greater value by integrating eye-tracking, EEG, electrodermal measures, physiological indicators, behavioral data, and conventional surveys according to the specific marketing problem being examined. Advertising and brand managers can use these methods to identify elements that attract attention, generate emotional engagement, and influence memory, while product and packaging teams can apply them to optimize visual design and consumer experience. Organizations adopting artificial intelligence and machine-learning techniques should ensure that automated models are validated against meaningful behavioral outcomes rather than relying solely on predictive accuracy within experimental datasets. Firms should also establish clear ethical protocols for informed consent, privacy protection, data storage, interpretation of neural and physiological information, and communication of findings to clients or consumers. Most importantly, neuromarketing results should be translated into managerial decisions cautiously, recognizing that consumer responses are context-dependent and that no single neural or physiological indicator can provide a complete explanation of preference or purchasing behavior.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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