

## **Neuromarketing Trends : a Bibliometric and Visualization Analysis**

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### **ABSTRACT**

Neuromarketing is a research field that combines neuroscience, behavioral economics, and social psychology to gain a deeper understanding of how the human brain responds to advertisements, brands, and marketing strategies. The primary goal of neuromarketing is to uncover aspects that are not always consciously recognized in the consumer decision-making process, such as emotions, preferences, and reactions to marketing stimuli. Bibliometric analysis has shown significant growth in neuromarketing research in recent years, reflecting strong interest from both the academic and industrial communities. These studies cover various topics, including neuroscience, behavioral economics, and social psychology, all of which play a crucial role in understanding consumer behavior in a marketing context. The results of this bibliometric analysis provide valuable insights for marketing practitioners and researchers in developing more effective marketing strategies and gaining a better understanding of consumer behavior. However, it is also important to consider ethical and privacy issues related to the collection of consumer brain data in the context of neuromarketing. Overall, neuromarketing is a rapidly evolving field with significant potential to transform how we understand and approach marketing. With a multidisciplinary approach and strong collaboration, neuromarketing will continue to be a powerful tool in addressing increasingly competitive markets.

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## INTRODUCTION

Marketing is a field that continues to develop and requires finding innovative ways to understand consumer purchasing decisions (Morin, 2011). Apart from that, marketing is also a field that is always changing rapidly, especially in the current globalized digital era. The development of technology and information has changed the conventional marketing paradigm, encouraging marketing practitioners to look for new ways to attract consumer attention, understand their preferences, and increase the effectiveness of marketing campaigns (Fortunato et al., 2014). In an effort to achieve success in an increasingly competitive marketplace, companies and marketers are trying to better approach consumers, identify factors that influence consumer preferences, and forge strong emotional connections with consumer audiences. One of the newest concepts and can be a solution for business actors is neuromarketing (Ariely & Berns, 2010).

Neuromarketing is a scientific discipline that combines knowledge from neuroscience with marketing to understand how the human brain responds to marketing stimuli and how these responses can influence purchasing decisions (Lee et al., 2007). In addition, neuromarketing is also a unique combination of neuroscience, consumer psychology, and marketing (Javor et al., 2013). Neuromarketing utilizes knowledge about how the human brain works to uncover the secrets of consumer responses to marketing stimuli (Suomala et al., 2012). In this increasingly competitive marketing world, neuromarketing works behind the scenes by understanding what is really going on in consumers' brains. A deeper understanding of what is actually happening and thinking in consumers' brains when they interact with brands and products is becoming increasingly important in order to make consumer purchasing decisions (Golnar-Nik et al., 2019).

In recent years, advances in brain scanning technologies such as fMRI (Functional Magnetic Resonance Imaging) and EEG (Electroencephalography) have provided researchers with the ability to accurately map brain activity when a person is exposed to certain marketing stimuli (Yadava et al., 2017). This opens the door to the development of more effective marketing strategies and better adaptation to consumer preferences (Slavutskaya et al., 2014). At the same time, neuromarketing has raised ethical questions around consumer privacy and the use of brain scanning technology in marketing contexts (Aldayel et al., 2020). This raises a dilemma around how companies and marketers can use knowledge about consumers' brain responses with ethics and integrity.

This research uses bibliometric analysis techniques using supporting software, namely VOSviewer. This research aims to determine (1) how scientific knowledge about neuromarketing has developed; (2) what is the geographic distribution of neuromarketing; (3) the most influential authors, journals and scientific articles; (4) intellectual structure. In recent years, interest in this method has increased in various fields of knowledge. Research on neuroscience does not remain silent, for example (Javor et al., 2013); (Kringelbach & Deco, 2020); (Hubert et al., 2009); dan (M. Mostafa, 2014). In the discussion of neuromarketing, an article by (Wilson et al., 2008) is one that explains the impact of neuroscience discoveries and methods on marketing practices related to the exercise of individual free will. Research conducted by (Zurawicki, 2010) explains that neuromarketing has produced a number of findings that challenge common stereotypes about

consumer behavior. Furthermore, (Fortunato et al., 2014) explains neuromarketing techniques and concepts that are often used in marketing. However, to the best of our knowledge, there is no research that focuses on a systematic and critical analysis of scientific production related to neuromarketing, focusing on the working system of the brain when making purchasing decisions, which is understood as new ideas or ideas that are created, which have important implications for its management.

This work is organized into five parts. In this first part, the topic that will be discussed is reviewed, and the research object is explained. The second relates to the theoretical framework, delimiting the concept of neuromarketing while asking research questions. Next, the methodology used in terms of obtaining references, analysis, and visualization and interpretation of results is determined. The fourth section presents the results obtained, and finally the fifth section contains discussion and conclusions of the research.

## LITERATURE REVIEW

In an ever-changing and competitive world, marketing has become a key element in business success. The success of a company in selling its various products also depends on the company's marketing strategy (Madan, 2010) Marketing is a communication channel between products and consumers that determines the end of sales. In an economy that is constantly changing with the emergence of new businesses and changes in consumer preferences, assessing consumers in a quantitative or qualitative way has become a necessity (Kumar & Singh, 2015). Newly launched products require more efficient marketing strategies to compete in a competitive market. The ability to understand consumer behavior, identify consumer preferences, and predict purchasing decisions is at the core of a successful marketing strategy (Bastiaansen et al., 2018). However, the traditional marketing paradigm, with a survey, interview and observation approach. These methods have limitations in the form of time required, high costs, and data that is not always reliable, which often results in inaccurate information. Therefore, neuromarketing can be a revolutionary solution by taking advantage of technological advances (Lim, 2018).

Neuromarketing has experienced rapid growth and is widely used in consumer research. Neuromarketing uses brain-computer interface (BCI) technology which can be used as a meeting point between neuroscience and marketing which can change the way marketing research is done (Golnar-Nik et al., 2019). Neuromarketing is a method used to understand how humans make choices about stimuli by utilizing brain function (Stasi et al., 2018). The main focus of neuromarketing is on examining and understanding consumer behavior through the study of the nervous system (Borgman, 1989). In the view of (Genco et al., 2013), marketing and neuromarketing are actually not that different. Marketing is used to influence humans to buy certain products, while neuromarketing is a way to measure the effectiveness of that marketing based on brain reactions. Neuromarketing integrates knowledge of nervous system science to better understand the subconscious processes involved in consumer purchasing decisions (Cuesta et al., 2018).

Research in the field of neuromarketing overcomes subjectivity by measuring observable brain behavior, resulting in more objective data. The basic concept behind neuromarketing is that purchasing decisions occur in a very short time in the part of the brain that controls emotions, which the individual is often not fully aware of (Lee et al., 2007). By understanding preferences, dissatisfaction, desires, fears, and levels of interest and boredom, which are reflected in the brain's response to various brand stimuli. Marketers have the opportunity to design products and communication messages that better suit unmet market needs and enable marketers to build connections and motivate purchasing activity (Morin, 2011). This is supported by research conducted by (Kumar & Singh, 2015) revealed that the brain that controls emotions can make purchasing decisions in just 2.6 seconds.

The main goal in neuromarketing is to investigate how the brain physically reacts to advertising and marketing strategies (Fisher et al., 2010). Studies in neuromarketing are very important because they are able to identify implicit and automatic decision-making processes, which are not always revealed through traditional marketing methods. This makes it possible to reveal deep insights into consumer behavior that are impossible to obtain through traditional marketing approaches (Stasi et al., 2018). The benefit gained from a deeper understanding of the brain's response to marketing is the increased effectiveness of customer segmentation. By identifying brain-related patterns of behavior and preferences, marketers can divide consumer audiences into more focused and relevant groups (Lee et al., 2007). This allows the development of more targeted marketing strategies and more effective message personalization.

Neuromarketing opens the door to a deeper understanding of consumers' subconscious and provides valuable insights into how consumers respond to products and advertising (Nyoni & Bonga, n.d.). A deeper understanding of the brain's response to advertising and marketing strategies helps companies design more targeted campaigns and detail more effective messages (Sebastian, 2014). Ultimately, this can encourage improved product marketing quality and increase sales levels significantly. As such, neuromarketing is becoming an important tool in companies' efforts to compete in an ever-expanding and changing marketplace. According to (Genco et al., 2013), the basis of neuromarketing comes from the combination of several brain disciplines which include:

a. Neurosains

Neuroscience is a field of study that focuses on the human nervous system and understanding the brain. In this science, research revolves around brain organs, such as brain anatomy, brain function, and the nervous system controlled by the brain. Neuroscience is used to explore understanding of the brain and its physiological responses to stimuli provided by brands and products.

b. Economic Behavior

Behavioral economics focuses on the way humans make decisions in an economic context. This helps in understanding how situational factors influence consumer choices and behavior in the economic world.

c. Social Psychology

Social psychology is a branch of science that studies how humans think and behave when interacting with other people, both in real situations and in imaginative contexts. In recent years, social psychology has placed increasing emphasis on the influence of unconscious processes. This is relevant in understanding how the brain works, both consciously and unconsciously, in decision making and consumer behavior.

By combining insights from these three disciplines, neuromarketing becomes a powerful tool to aid the understanding of consumer behavior and response to product and brand marketing. There are several definitions of neuromarketing which have the common characteristic of placing neuroscience as a basis for development in understanding consumer mindsets to improve marketing. Several definitions of neuromarketing are in accordance with Table 1 as follows.

Table 1

Definition of Neuromarketing	
Author	Definition
(Lee et al., 2007)	Neuromarketing is the application of neuroscience methods to consumer analysis to understand consumer

	behavior related to the influence of marketing on consumers or customers, consumer behavior, or the purchasing process.
(Hubert et al., 2009)	Neuromarketing is a part of neuroeconomics that solves marketing problems through knowledge and brain research methods.
(Javor et al., 2013)	Neuromarketing is a scientific discipline that uses neuroscience methods to study consumer behavior and purchasing decisions, to better understand psychological processes and the role of emotions in decision making, and to improve the effectiveness of marketing communications through neurobiological analysis.
(Marci, 2008)	Neuromarketing is considered an attempt to use neuroscientific understanding of the brain and emotions for marketing purposes.

Given the importance and implications of all these issues for destination management, this study aims to evaluate the scope and importance of neuromarketing by answering the following research questions:

RQ1 : How is scientific knowledge about neuromarketing developing?

RQ2: What is the geographic distribution?

RQ3: What authors, journals and scientific articles are the most influential?

RQ4: What is the intellectual structure?

## METHODS

### Bibliometric Data

To identify relevant references, a systematic review was conducted in Scopus by applying the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement guidelines (Moher et al., n.d.). Following (Pelagio Rodriguez & Hechanova, 2014), the term “neuromarketing” becomes the basis of the search strategy, which in this case is combined with “trend”. To expand and complete the search equation, other more specific terms related to smart technology were added.

Additionally, studies had to meet a series of inclusion and exclusion criteria to be eligible (Aguinis et al., 2018);(Sterne et al., 2019): (1) no time range was specified, and publications were indexed to September 22, 2021, the date the consultation took place is included; (2) only peer-reviewed articles published in scientific journals were included because they are considered “certified knowledge,” subject to critical review and approval by other researchers (Ramos-Rodríguez & Ruíz-Navarro, 2004); (3) no thematic area filter was applied due to the transversal nature of tourism; and (4) only articles in English were considered, because the natural language processing (NLP) algorithm used by the software used for the analysis does not support other languages (Table 2).

Table 2

### Bibliometric Reference Search Methodology

<b>Search terms</b>	Neuromarketing
<b>Search field</b>	Article Title (Scopus)
<b>Query string</b>	("Marketing") and ("Neuromarketing")
<b>Period time</b>	All
<b>Document type</b>	Journal article
<b>Thematic area</b>	All
<b>Language</b>	Indonesia
<b>Search date</b>	September 2023

After these criteria were applied, a search carried out in Scopus produced 417 results. Of note, a single bibliographic database was compiled in Excel to identify and eliminate duplicates (via digital object identifiers (DOIs) and bibliographic reference titles). Scopus duplicate records were prioritized for the final database because Web of Science only includes the first author of each cited document and, therefore, does not consider other co-authors for co-citation analysis.

### **Bibliometric Analysis**

Bibliometrics is a part of scientometrics that applies mathematical and statistical methods to scientific literature and the authors who produce it, with the aim of studying and analyzing their activities (Pritchard, 1969). Bibliometric methods are classified as evaluative or relational (Borgman, 1989); (Benckendorff & Zehrer, 2013); (Koseoglu et al., 2016). Evaluative techniques focus on the impact of academic studies that evaluate performance with measures of productivity, impact, and hybrid metrics (Michael Hall, 2011). Citations are a fundamental impact metric, and their main goal is to identify the most influential publications, authors, and documents in a particular research field (Zupic & Čater, 2015).

Relational techniques explore relationships in research, such as the structure of the research field, the emergence of new topics and methods, and national and international patterns of author collaboration (Benckendorff & Zehrer, 2013). In this work, two techniques of this type are used: co-citation and co-word analysis.

Co-citation is a co-occurrence relationship that occurs when two items from existing literature are cited together by a third party (Small, 1973); (Miguel et al., 2007), in this case, one author citing two others (White & Griffith, 1981); (McCain, 1990). This type of analysis assumes that there is a thematic affinity between two or more co-cited authors and that the greater the frequency of co-citations, the greater the similarity between them. The aim is to determine the central researcher of a particular scientific discipline based on citations with others.

### **Visualization of results**

References made by some authors to others, whether between journals or other types of documents, can be represented by graphs with a network structure (Spinak, 1996) consisting of two fundamental elements: nodes, which represent articles, authors, keywords, etc., and links, also called edges, that connect one or more nodes to each other. To avoid duplication in notes and to correct inconsistencies, it is necessary to develop a thesaurus for writers and to normalize keywords (singular and plural, in American and British English, etc.).

To build, visualize and explore author co-citation networks, the software VOSviewer, developed

at Leiden University, was used (Waltman et al., 2010). This program provides visualization of bibliometric networks through distance-based maps such that the distance between two nodes reflects the strength of the relationship between them. Based on bibliometric databases, VOSviewer performs cluster analysis, grouping each node according to proximity or distance patterns (Waltman et al., 2010), obtaining groups or clusters of similar nodes as a result, differentiated by color.

## RESULT AND DISCUSSION

### The Evolution of Literature

Figure 1 shows the annual frequency of publications, which uses graphs to analyze the evolution of the literature. The time period used to see the annual evolution is twenty years, between 2004 and 2023. From 2004 to 2010 there were still very few documents using neuromarketing. Then, from 2011 to 2014, documents discussing neuromarketing increased slightly. New neuromarketing variables will be widely used from 2015 to 2023. Since 2018, the production of scientific papers has continued to increase, although not significantly. The largest number of documents regarding neuromarketing variables occurred in 2022, namely 76 documents.

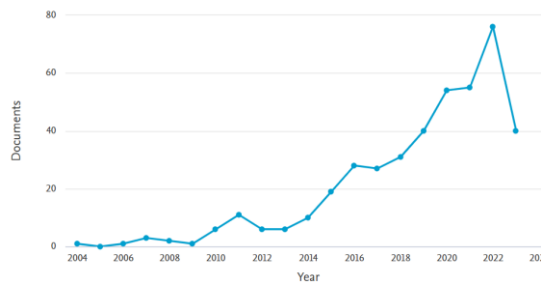


Figure 1

### Publications by year

Source: analyze search scopus

Table 3 shows the distribution of the number of documents by country or region. This provides an overview of neuromarketing documents distributed geographically. These works come from various different countries. The country with the most documents regarding neuromarketing is Spain with 40 documents cited 244 times. Next, even though it has fewer documents, the United States has greater citations, namely 1,787 with 47 documents. The next rank is occupied by India with a total of 39 documents and cited 222 times. Furthermore, Italy has a total of 346 citations from 30 documents. Meanwhile, Turkey only has 219 citations, even though it has more documents than the United Kingdom, Malaysia, Romania, Germany and China. Documents regarding neuromarketing in the United Kingdom have quite a lot of citations, namely 846 from 25 documents. Malaysia topped Germany, Romania and China with 24 documents and was cited 384 times. Romania and China have a much higher number of citations than Germany which only has 90 citations with 14 documents.

Table 3

### Geographic Distribution by Country

Rank	Country	Document	Citation	Average citations
1	Spain	49	244	4,98
2	Amerika Serikat	47	1.787	38,02
3	India	39	222	5,69

4	Itali	30	346	11,53
5	Turkey	25	219	8,76
6	Britania Raya	25	846	33,84
7	Malaysia	24	384	16
8	Romania	20	190	9,5
9	Jerman	14	90	6,43
10	Cina	13	219	16,85

*Source: analyze search scopus*

Furthermore, Sapienza Università di Roma from Italy and Universidad Complutense de Madrid from Spain are the institutions with the highest number of documents discussing neuromarketing, namely 12 documents. Universiti Teknologi Malaysia from Malaysia is in third place with the highest number of documents with 11 documents. The last institution with the highest number of documents is IRCCS Fondazione Santa Lucia from Italy with 5 documents. However, it can be seen that IRCCS Fondazione Santa Lucia in Italy is ranked first in average citations and ranked second in number of citations below Sapienza Università di Roma from Italy which has a number of citations of 200. There are several universities that have a small number of citations even though they have documents more such as Universidad Complutense de Madrid from Spain, Chitkara University from India and Universidade da Coruña from Spain.

Table 4

**Distribusi Geografis Berdasarkan Institusi**

Rank	Institution	Document	Citation	Average citations
1	Sapienza Università Roma, Italia	12	200	16,67
2	Universidad Complutense de Madrid, Spanyol	12	78	6,50
3	Universiti Teknologi Malaysia, Malaysia	11	145	13,18
4	Bucharest University of Economic Studies, Romania	10	100	10,00
5	Chitkara University, Punjab, India	10	19	1,90
6	Azman Hashim International Business School, Malaysia	7	140	20,00
7	Universidade da Coruña, Spanyol	6	24	4,00
8	United International University, India	6	52	8,67
9	Università IULM, Italia	5	87	17,4
10	IRCCS Fondazione Santa Lucia, Italia	5	162	32,4

*Source: analyze search scopus*

**Author with the most extensive and influential documents**

The author is the creator of a scientific work or article. The author with the most quotes and works can determine or compare who is an expert in that field. A total of 169 authors of works on neuromarketing have been identified. After analysis, there were 10 authors with the most documents regarding neuromarketing. Babiloni, F. from the Facoltà di Farmacia e Medicina is the author with the most documents, with 11 documents. The next order is Alsharif, A.H. from Universiti Teknologi Malaysia with 9 documents. The next author, Salleh, N.Z.M. from Azman Hashim International Business School with a total of 7 documents. Authors Rahman, K.M., Sarker, F., and Vecchiato, G. each created 6 neuromarketing article documents. Then, Anwar, S.F., Baharun, R., Chamberlain, L.,



and Cherubino, P. each created 5 documents. Furthermore, the most influential documents can be seen from the number of times they are cited. Therefore, the author with the greatest influence regarding neuromarketing is Chamberlain, L. from Warwick Business School, Coventry in the United Kingdom with 642 citations.

Table 5  
Influential Writers

Rank	Author	Institution	Document	Citation	Average citations
1	Babiloni, F.	Facoltà di Farmacia e Medicina, Rome, Italy	11	200	18,18
2	Alsharif, A.H.	Universiti Teknologi Malaysia, Johor Bahru, Malaysia	9	121	13,44
3	Salleh, N.Z.M.	Azman Hashim International Business School, Kuala Lumpur, Malaysia	7	90	12,85
4	Rahman, K.M.	United International University, Dhaka, Bangladesh	6	52	8,67
5	Sarker, F.	University of Liberal Arts Bangladesh, Dhaka, Bangladesh	6	52	8,67
6	Vecchiato, G.	Consiglio Nazionale delle Ricerche, Rome, Italy	6	162	27,00
7	Anwar, S.F.	University of Dhaka, Dhaka, Bangladesh	5	52	10,40
8	Baharun, R.	Azman Hashim International Business School, Kuala Lumpur, Malaysia	5	82	16,40
9	Chamberlain, L.	Warwick Business School, Coventry, United Kingdom	5	642	128,4
10	Cherubino, P.	BrainSigns Srl, Rome, Italy	5	33	6,60

Source: analyze search scopus

There are 208 journal articles identified and several journals have multiple discussion subjects. Among all the existing journals regarding neuromarketing, the journal discussing management, business and accounting stands out compared to other journals with a total of 153 documents and 1,607 citations. Next in line are journals on computer science and financial economics, each with 122 documents with 826 citations and 82 documents with 609 citations. There are several fields that have a higher number of citations with fewer documents, such as neuroscience which is cited 1,543 times with only 46 documents, health which is cited 902 times with 38 documents. Apart from that, there are also journals in other fields such as social sciences, psychology, mathematics and others.

Table 6  
Based on Journal Theme

Rank	Journal	Document	Citation	Average citations
1	Business, Management and Accounting	153	1.607	10,51
2	Computer Science	122	826	6,77

3	Economics, Econometrics and Finance	82	609	7,43
4	Social Sciences	81	944	11,65
5	Engineering	75	414	5,52
6	Neuroscience	49	1.543	31,49
7	Medicine	38	902	23,75
8	Decision Sciences	36	145	4,03
9	Psychology	35	808	23,08
10	Mathematics	29	274	9,44

*Source: analyze search scopus*

Document analysis and citations applied to articles can be used to determine recommended journals or articles based on the number of citations. In this case, the article written by (Ariely & Berns, 2010) explains the reasons why neuromarketing strategies have become popular in marketing. Furthermore, the work of (Lee et al., 2007) describes an attempt to broaden the scope of neuromarketing beyond the application of commercial brands and consumer behavior, to encompass a broader conceptualization of marketing science. Next, (Morin, 2011) explains the potential of the emerging field of neuromarketing and shows that this field has the potential to significantly increase the effectiveness of commercial advertising messages and goal-related advertising messages throughout the world. (Yadava et al., 2017) explains predictive modeling with a neuromarketing strategy to understand consumer choices for E-commerce products in terms of "likes" and "dislikes" by analyzing EEG signals. Apart from that, there are still several authors who have articles or journals that can be used as references or recommended according to Table 7 below.

Table 7

<b>Based on Influential Journal</b>			
<b>Rank</b>	<b>Author</b>	<b>Title</b>	<b>Citation</b>
1	(Ariely & Berns, 2010)	Neuromarketing: The hope and hype of neuroimaging in business	558
2	(Lee et al., 2007)	What is 'neuromarketing'? A discussion and agenda for future research	425
3	(Morin, 2011)	Neuromarketing: The New Science of Consumer Behavior	279
4	(Yadava et al., 2017)	Analysis of EEG signals and its application to neuromarketing	150
5	(Zurawicki, 2010)	Neuromarketing: Exploring the brain of the consumer	150
6	(Fugate, 2007)	Neuromarketing: A layman's look at neuroscience and its potential application to marketing practice	149
7	(Fisher et al., 2010)	Defining neuromarketing: Practices and professional challenges	129
8	(Vecchiato et al., 2011)	On the Use of EEG or MEG brain imaging tools in neuromarketing research	121
9	(Lim, 2018)	Demystifying neuromarketing	117
10	(Wilson et al., 2008)	Neuromarketing and consumer free will	99

*Source: analyze search scopus*

## Intellectual Structure

In order to understand the intellectual structure of literature on perceived innovation, an analysis of neuromarketing written by the author was carried out using VOSviewer software. This tool has checked the document characteristics provided by the bibliography of each document. VOSviewer has identified 417 documents contained in Scopus so that it can map authors who produce works on neuromarketing, obtaining 31 items which are divided into 4 clusters. The items or topics of an article related to neuromarketing are appropriate (Figure 2a). The nodes in Figure 2a are the topics most often used by writers or researchers. The path that connects the nodes explains the relationship between the topics discussed in journals and articles.

Furthermore, VOSviewer has also identified the relationship of neuromarketing with other relevant topics (Figure 2b). Neuromarketing is connected to 30 research links divided into 4 clusters. Some of the strongest links to neuromarketing are communications, market research, advertising strategy, and consumer neuroscience. The nodes in Figure 2b represent the strength of the relationship of other topics or items to neuromarketing with the VOSviewer results. The density display mode in Figure 2c shows that the most research related to neuromarketing is advertising, neuroscience, marketing, attention, and emotion. This is marked with a bright yellow color in Figure 2c. The brighter the color, the more research and documents there will be. Vice versa, the fainter the color, it means there is still little research and documents on that topic.

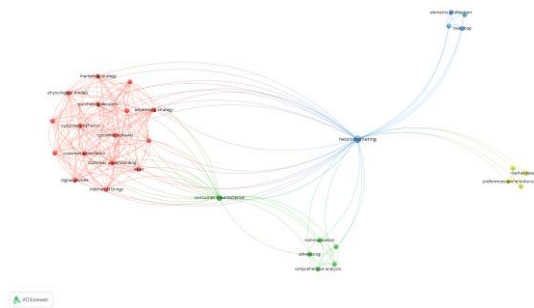


Figure 2a. Network visualization

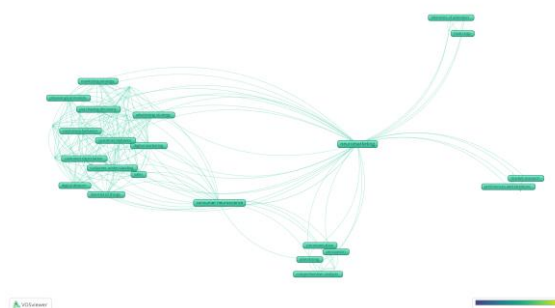


Figure 2b. Overlay visualization

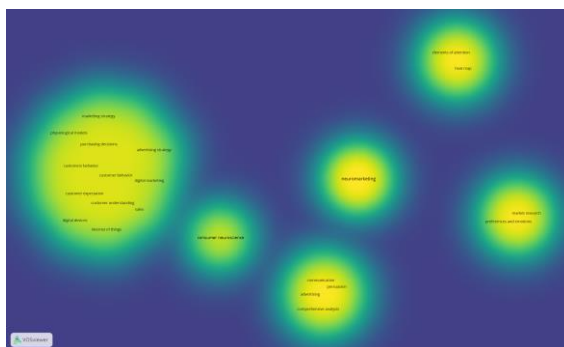


Figure 2c. Density visualization

## DISCUSSION AND CONCLUSION

Neuromarketing is a method used to reveal how humans make choices about stimuli by utilizing brain function through brain-computer interface technology (Golnar-Nik et al., 2019). By utilizing neuromarketing, various challenges commonly faced in the marketing domain, such as understanding consumer behavior, identifying consumer preferences, and predicting purchasing decisions, can be addressed more efficiently. The main goal of neuromarketing is to investigate how the brain physically responds to advertising and marketing strategies (Miguel et al., 2007). Additionally, neuromarketing opens the door to a deeper understanding of consumers' subconscious and provides valuable insights into how consumers respond to products and advertising. With this, it becomes possible to develop more targeted marketing strategies and increase effectiveness in delivering personalized messages.

This work uses evaluative and relational bibliometric analysis techniques to analyze 417 articles about neuromarketing contained in Scopus from 2004 to mid-2023. Based on the research conducted, the evolution of marketing knowledge regarding neuromarketing began in 2004, but this variable has only just begun to become more frequent, used in 2016 and has a fairly large growth trend with a peak in 2022 of almost 80 documents and articles. This is supported by the increasing interest in using neuromarketing methods in marketing (Shin et al., 2017).

In this analysis, there is a correlation between research topics as seen in Figure 2a. A group of nodes connected by edges explains the relationships or interrelationships between research topics in the neuromarketing domain. Bibliometric analysis based on this research topic focuses on two things, namely neuromarketing and customer neuroscience (Javor et al., 2013); (Kringelbach & Deco, 2020); (Hubert et al., 2009); and (M. Mostafa, 2014). The lines or edges in the image indicate a relationship or collaboration between the research topics discussed. For example, the edge connects "communication" with five other research topics, namely customer neuroscience, advertising, persuasion, comprehensive analysis, and neuromarketing (Bastiaansen et al., 2018); (Lim, 2018); (Spanjaard et al., 2014); and (Fisher et al., 2010).

The overlay visualization results are depicted according to Figure 2b which identifies the researcher's research history in the neuromarketing domain. This mapping is characterized by nodes that have various colors and edges that connect one researcher to another. Nodes in dark colors indicate research that has been carried out in the past, with the darkest color (purple) representing the year 2004 and the lightest color (yellow) representing the year (Bhardwaj et al., 2023). In Figure 2b, almost all nodes have a similar color, namely yellowish green, because most of the research analyzed comes from 2022 (Alsharif et al., 2022), according to the publication graph in Figure

Furthermore, the density visualization results seen in Figure 2c identify the level of density or emphasis on nodes which indicate that the research topic groups studied are related to each other. The

degree of node density in a density visualization reflects the extent to which research uses or cites other research as a form of collaboration in the field of neuromarketing. For example, nodes with the highest levels of density, reflected in the brightest colors, are the topic of neuromarketing research (Ariely & Berns, 2010). This indicates that this topic involves a lot of research collaboration with other research topics in the neuromarketing domain.

Exploration of author patterns using VOSviewer has explained the intellectual structure of literature. By using this tool, you can see the mapping of research topics that produce scientific works on neuromarketing from 417 works contained in Scopus. In addition, this tool has also checked the document characteristics provided by the bibliography of each document. VOSviewer has also identified interrelationships between variables. Also obtained were variable results that were widely discussed, namely the development of neuroscience (Morin, 2011); (Kringelbach & Deco, 2020); (Javor et al., 2013); and (Hubert et al., 2009) in other fields such as economic, social and health (Stasi et al., 2018); (Fisher et al., 2010); dan (Cuesta et al., 2018).

In a bibliometric analysis of neuromarketing, it can be seen that this field has experienced rapid development over the last few years. The number of scientific publications related to neuromarketing has increased significantly, indicating strong interest in this field from researchers around the world (Nyoni & Bonga, n.d.).

These studies cover a wide range of topics, including neuroscience (Javor et al., 2013); (Hubert et al., 2009); (Marci, 2008); and (Morin, 2011), behavioral economics (Spanjaard et al., 2014), and social psychology (social psychology) (Spanjaard et al., 2014), all of which have an important role in understanding consumer behavior in the marketing context. Interconnections and collaboration between these topics are also apparent, reflecting a multidisciplinary approach in neuromarketing.

Bibliometric analysis also describes historical trends in neuromarketing research and highlights the increasing number of publications over time (Ariely & Berns, 2010). It is also apparent that many studies cite other studies, indicating the existence of relationships and collaborations between these studies. Apart from that, it appears that there are several topics that receive special attention in neuromarketing research, such as customer neuroscience, advertising, persuasion, comprehensive analysis, and the main topic, neuromarketing itself.

Overall, neuromarketing bibliometric analysis represents a positive development in the field and highlights the importance of multidisciplinary approaches and collaboration in better understanding consumer behavior in the marketing context. This promises to continue to influence marketing practice and research in the future. However, it should be noted that the type of bibliometric analysis carried out does not have special limitations, because this method is quantitative and analyzes data from articles that have been obtained from Scopus. Even though the search method is carried out carefully, there may still be documents or journals that are outside the scope of the study, which can act as outlier data (Zupic & Čater, 2015). Therefore, it is necessary to filter out irrelevant documents, so the author decided to limit the article titles used. It is important to remember that a major limitation in this research is the focus on areas of study related to neuromarketing variables. Most publications discuss the application of neuromarketing in various fields, allowing comparison with previous research (Miguel et al., 2007). Future research may provide deeper insights and a broader understanding of neuromarketing.

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