



## Literature analysis on trends and scientific contributions on Neuromarketing from 2007 to 2023

## Análisis de literatura en tendencias y contribuciones científicas sobre el Neuromarketing entre 2007-2023

DOI: <https://doi.org/10.17981/econcuc.Org.6336>

Review Article

Received date: 06/03/2025

Return date: 06/05/2025

Acceptance date: 06/17/2025

Publication date: 06/25/2025

**Carlos Fernando Osorio-Andrade** 

Universidad del Valle

Buga, Valle del Cauca (Colombia)

[carlos.fernando.osorio@correounivalle.edu.co](mailto:carlos.fernando.osorio@correounivalle.edu.co)

**Juan Manuel Candelo-Viáfara** 

Universidad del Valle

Buga, Valle del Cauca (Colombia)

[juan.candelo@correounivalle.edu.co](mailto:juan.candelo@correounivalle.edu.co) 

**Edwin Arango-Espinal** 

Universidad del Valle

Buga, Valle del Cauca (Colombia)

[edwin.arango@correounivalle.edu.co](mailto:edwin.arango@correounivalle.edu.co)

To cite this article:

Osorio-Andrade, C. F., Candelo-Viáfara, J. M., & Arango-Espinal, E. (2025). Literature analysis on trends and scientific contributions on Neuromarketing from 2007 to 2023. *Económicas CUC*, 46(1), e236336. <https://doi.org/10.17981/econcuc.Org.6336>

JEL: D87, C89, M31, O30.

### Abstract

Neuromarketing, an emerging field that combines neuroscience and marketing, has experienced remarkable growth since 2007, with over 597 publications in Scopus. This growing interest drives the need to understand its evolution and areas of focus. This research analyzes the scientific literature on Neuromarketing to identify its trends, key knowledge agents, and predominant lines of research between 2007 and 2023. Bibliometrics was employed as a method, utilizing a robust approach to systematic literature review, which enabled us to analyze the internal structure of the field, its main currents, and future directions. It was found that Neuromarketing research is global, with participation from 71 countries. Europe leads the scientific production, with 52%, followed by Asia (25%) and the Americas (20%), highlighting the worldwide interest in applying neuroscience to consumer behavior. It is concluded that through the analysis of term co-occurrence, five main thematic clusters were identified, including consumer brain behavior and neuromarketing tools, which evidences the diversity and depth of research in the field. These categories reveal the current and future directions that define the cutting edge of neuromarketing.

**Keywords:** Bibliometrics; systematic literature review; consumer behavior; scientific trend analysis; co-occurrence of terms; global scientific production; thematic clusters; scientific trend analysis.

### Resumen

El Neuromarketing es un campo emergente que fusiona neurociencia y marketing, ha mostrado un notable crecimiento desde 2007, con más de 597 publicaciones en Scopus. Este interés creciente impulsa la necesidad de comprender su evolución y sus áreas de enfoque. Esta investigación analiza la literatura científica sobre Neuromarketing para identificar sus tendencias, agentes de conocimiento clave y líneas de investigación predominantes entre 2007 y 2023. Se empleó como método la bibliometría, con un enfoque robusto para la revisión sistemática de literatura, que permitió analizar la estructura interna del campo, sus corrientes principales y direcciones futuras. Se halló que la investigación en Neuromarketing es global, con participación de 71 países. Europa lidera la producción científica con el 52%, seguida por Asia (25%) y América (20%), destacando el interés mundial en la aplicación de la neurociencia al comportamiento del consumidor. Se concluye que mediante el análisis de co-ocurrencia de términos, se identificaron cinco clústeres temáticos principales, incluyendo el comportamiento cerebral del consumidor y las herramientas de neuromarketing, evidenciando la diversidad y profundidad de las investigaciones en el campo. Estas categorías revelan las direcciones actuales y futuras que definen la vanguardia del Neuromarketing.

**Palabras clave:** Bibliometría; revisión sistemática de literatura; comportamiento del consumidor; análisis de tendencias científicas; co-ocurrencia de términos; producción científica global; clústeres temáticos.

## INTRODUCTION

Neuromarketing has been established as an interdisciplinary field that integrates knowledge from neuroscience, cognitive psychology, and marketing, with the goal of enhancing the understanding of consumer behavior and the neurophysiological processes underlying decision-making. Its approach is based on analyzing brain reactions, many of which are unconscious or instinctive, to brand, advertising, and product stimuli, to generate insights to optimize commercial and communication strategies. (Javor et al., 2013; Stanton et al., 2017; Gill & Singh, 2022).

Over the last few decades, interest in this discipline has experienced remarkable growth, both in academia and in business practice. This phenomenon has been accompanied by a sustained increase in the scientific production linked to the subject. Indeed, since 2007, when the formal emergence of Neuromarketing as a subfield was recognized, until 2024, more than 597 academic publications have been identified in the Scopus database, which evidences an upward trajectory in research in this area (Alsharif et al., 2020). This dynamism has generated an expanding body of theory that demands systematization, critical analysis, and periodic updating.

Despite the growth of the field, it is possible to identify a lack of recent studies that offer an exhaustive bibliometric review, capable of mapping the evolution of knowledge in Neuromarketing in a structured way. The existing reviews, although valuable, present temporal or methodological limitations that restrict their interpretative scope. In this sense, the present article is justified by its differential contribution: it provides an updated and analytically rigorous view of the state of Neuromarketing research based on a bibliometric approach applied to the period between 2007 and 2023.

The objective of this study analyzes the scientific literature on Neuromarketing to identify its trends, key knowledge agents and predominant lines of research between 2007 and 2023, structured as follows: on the one hand, it seeks to describe the quantitative evolution of scientific production in Neuromarketing, identifying the main knowledge agents: authors, countries, academic institutions and scientific journals that have played a leading role in the development of the field. On the other hand, it aims to recognize the predominant thematic trends, emerging research focuses, and the most relevant collaboration networks. This approach will not only enable mapping of the current research ecosystem, but also facilitate the identification of theoretical gaps and future lines of research.

The importance of this work lies in its contribution to the theoretical and methodological strengthening of the field of Neuromarketing, offering the academic community updated insights that facilitate research decision-making, the design of work agendas, and the identification of opportunities for consolidating new scientific proposals. Likewise, this review provides value to marketing professionals who seek to integrate neuroscientific perspectives into their strategies, offering a more robust and empirically validated body of knowledge.

The article is structured into five sections: introduction, methodology used for the bibliometric review, including search criteria, analytical tools, and temporal delimitation. Subsequently, the general results on the evolution of scientific production are presented, followed by an analysis of the co-occurrence of terms and bibliographic coupling, which enables the identification of consolidated and emerging lines of research. Finally, conclusions are drawn. Next, an agenda with six key areas for future research is proposed. Finally, the study's conclusions and main implications for the field of Neuromarketing are presented.

## METODOLOGY

To conduct the present research, bibliometrics was employed, a promising approach for systematic literature reviews (Belter, 2016), whose applicable methods and analysis tools have been refined with the growth of scientific production (Wagner et al., 2011). Additionally, this tool enables the visualization of the internal structure of a field of study, including current and future research directions, which is why it has been widely used (Janik et al., 2020).

This tool enables the visualization of the internal structure of a field of study, including current and future research directions, which is why it has been widely used (Janik et al., 2020). In this sense, the methodological process proposed by Osorio-Andrade et al. (2020) is used, as shown in Imagen 1 below.

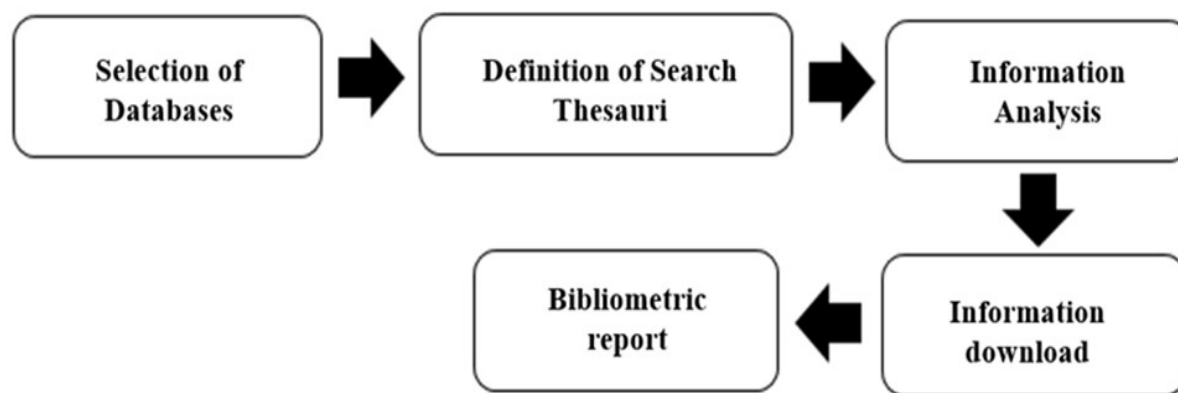


Imagen 1. Methodological process  
Source: Osorio-Andrade et al. (2020).

The following is a description of each of the phases included in the methodological process.

### *Database selection*

The Scopus database was selected for this study. Taking into account that this is one of the most complete and internationally recognized bibliographic databases (Lechtenberg et al., 2022), with a broad coverage of scientific journals, books,

conference proceedings and patents, covering about 240 disciplines (Elsevier, 2023), which allows a more complete view of research in the field of neuromarketing, including publications in areas such as neuroscience, psychology and marketing.

This database was selected based on a study conducted by Pranckutė (2021), who conducted a comprehensive analysis of the Scopus and Web of Science databases. He concludes that Scopus is more advantageous in practical terms, as it covers a broader range of content, offers individual profiles for all authors, institutions, and serial sources, and its impact indicators perform as well as, or even better than, WoS metrics. In addition, they are less susceptible to manipulation and are available for all serial sources across all disciplines, whereas most bibliometric studies are based on a single database.

#### *Definition of search thesauri.*

For information retrieval, the thesauri “NEUROMARKETING”, “CONSUMER NEUROSCIENCE”, “MARKETING NEUROPSYCHOLOGY” and “NEUROSCIENCE OF ADVERTISING” were used inclusively. The search was restricted to documents of the “article” type, taking into account that these documents are based on specific topics studied in depth using empirical evidence. Additionally, they are subjected to rigorous academic peer review processes, which guarantee the validity and quality of the information they contain.

The choice of the thesauri “NEUROMARKETING”, “CONSUMER NEUROSCIENCE”, “MARKETING NEUROPSYCHOLOGY” and “NEUROSCIENCE OF ADVERTISING” responds to the need to capture the semantic breadth, multidisciplinary and interdisciplinarity of the field under study. In bibliometric analyses, the strategic use of controlled terms or descriptors enables the improvement of retrieval of relevant documents, avoidance of search biases, and increased conceptual precision (Donthu et al., 2021). To understand why these thesauri were selected, it is necessary to see Table 1.

**Table 1.** *Thesauri used for information retrieval in Neuromarketing Studies*

Thesaurus	Definition and Approach	Justification for use	Source
“NEUROMARKETING”	An interdisciplinary field that applies neuroscience technologies, such as functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and eye tracking, to study consumer behavior in market contexts.	Primary descriptor and central axis of the field. Its inclusion enables the identification of empirical studies that utilize neuroscientific tools to analyze consumer reactions to commercial stimuli.	Alsharif et al. (2021)

“CONSUMER NEUROSCIENCE”	Subfield that integrates the neurobiology of consumer behavior with approaches from cognitive psychology, affective neuroscience, and decision theory.	Extends the focus to research that examines the neurological basis of consumer decision-making. Facilitates the connection between medical neuroscience and marketing studies.	Plassmann et al. (2012)
“MARKETING NEUROPSYCHOLOGY”	An emerging subdiscipline that studies mental processes, such as memory, attention, and motivation, in the face of marketing stimuli, with an emphasis on underlying psychological mechanisms rather than neurophysiological techniques.	It allows for delimiting research that explains how cognitive variables influence consumer decision-making. It is helpful to identify studies focused on marketing psychology.	Ariely & Berns (2010)
“NEUROSCIENCE OF ADVERTISING”	A field that analyzes how advertisements, brands, and advertising strategies impact emotional and brain processes using techniques such as EEG and fMRI, integrating symbolic and affective dimensions.	It ensures the recovery of research focused on the effectiveness of advertising communication from a neuroscientific perspective, considering emotional and symbolic reactions of the target audience.	Vecchiato et al (2011)

---

Source: Author elaboration

The following is the final equation, which initially yielded 597 papers on neuromarketing written in English as of April 10, 2023; these documents reflect the totality of the records contained in the database on the field under study.

Equation 1.

*(TITLE-ABS-KEY ( “neuromarketing” ) OR TITLE-ABS-KEY ( “Consumer neuroscience” ) OR TITLE-ABS-KEY ( “Marketing neuropsychology” ) OR TITLE-ABS-KEY ( “Neuroscience of advertising” )) AND ( LIMIT-TO ( DOCTYPE, ”ar” ))*

*Analysis of the information.*

For the analysis of the information, two main approaches are implemented. First, quantitative measures known as bibliometric indicators are used. Second, the bibliometric package VOSviewer (Waltman & van Eck, 2015) is used to construct bibliographic linkage and term co-occurrence networks. (See Table 2)

**Table 2.** *Approaches and tools used for the analysis of bibliometric information*

Analysis approach	Tools or techniques	Objective of the analysis	Reference
Quantitative analysis	Bibliometric indicators (citation frequency, reference analysis, output by country, journal, author, etc.)	Identify the most influential knowledge agents: authors, institutions, countries and relevant journals in the field of neuromarketing.	Waltman (2016)
Network analysis	VOSviewer - Bibliographic matching	Visualize the relationships between individual publications to determine the main research streams in neuromarketing.	Waltman & van Eck (2015)
Semantic analysis	VOSviewer - Co-occurrence of terms	Identify the most commonly used terms and explore emerging topics in the field.	Waltman & van Eck (2015)
Prospective analysis	Docking networks on recent documents	Detect future research opportunities by studying relationships in recently published papers.	Author elaboration based on Waltman & van Eck (2015)
Processing and visualization	Data export in CSV format; processing with specialized software (e.g., VOSviewer, Excel, R, etc.)	Enable automated bibliographic data processing and bibliometric report generation.	Author elaboration

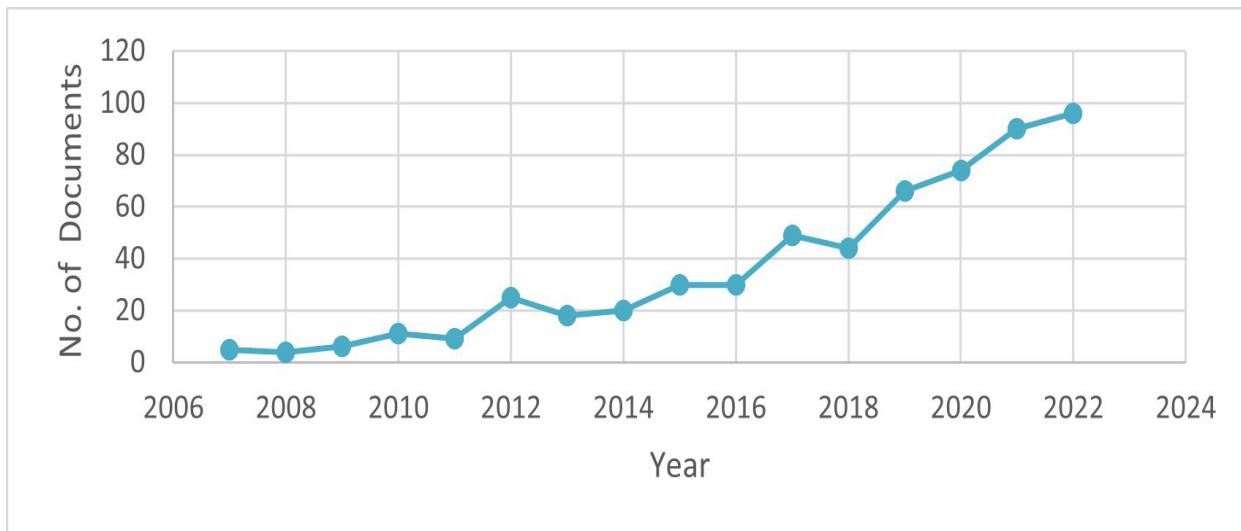
Source: Author elaboration

## RESULTS

Bibliometric indicators are quantitative tools that facilitate the analysis of scientific production and its impact within a specific area of knowledge (Calero-Medina et al., 2020). Based on the most frequently used indicators (Álvarez-García et al., 2023), the results corresponding to research in the field of neuromarketing are presented below.

### *Evolution of scientific production on neuromarketing*

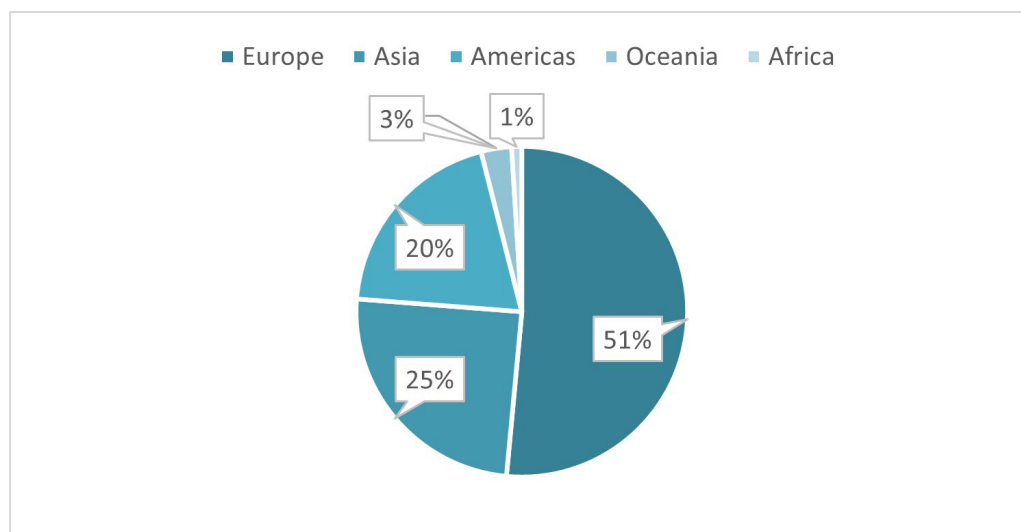
Neuromarketing is a relatively recent field of study, a fact that is evidenced by the search carried out in the Scopus database, where it is found that the first text on this discipline was published in 2007. This text, entitled “Careers in Neuromarketing”, written by Mark Caldwell (2007), highlights the relevance of neuroscience applied to marketing in the study of consumer psychology in business. Furthermore, as can be seen in Graph 1, research in neuromarketing has experienced sustained growth since its first publication, reaching its peak in 2022 with the publication of 96 papers on this field of study. Even for the current year, up to the cut-off date of this research on April 10, 2023, about 20 articles related to the topic are registered in the database.



**Graph 1.** Evolution of scientific production on Neuromarketing.  
Source: Author elaboration based on Scopus (2023).

### *Countries with the highest number of publications on Neuromarketing*

Regarding the countries with the most significant number of documents related to the study of Neuromarketing, it can be seen that this topic has captured the interest of academics worldwide. Specifically, approximately 71 countries from different continents have been involved, as shown in **Graph 2**.



**Graph 2.** Countries with publications on Neuromarketing.  
Source: Author elaboration

**Table 3** shows the 30 countries with the highest number of publications in the field of Neuromarketing. Spain tops the list with 100 published papers, followed by the United States with 88 and Italy in third place with 47 publications. These countries account for 29% of the total research in Neuromarketing. Additionally, in Latin America, three countries, including Colombia, have contributed to the study of this field of knowledge, with a total of 36 published documents.

**Table 3.** *Countries with the highest number of published papers on Neuromarketing*

Country	No. of Documents	Most productive institutions per country	Citations	Country	No. of Documents	Most productive institutions per country	Citations
Spain	100	Universidad Complutense de Madrid, Universidad de Granada y Universidad Rey Juan Carlos	1180	South Korea	16	Sungkyunkwan University	276
United States	88	University of Pennsylvania, University of Southern California, and Temple University	4870	Romania	15	Bucharest University of Economic Studies	180
Italy	47	Sapienza Università di Roma, Università IULM, Università Cattolica del Sacro Cuore	1099	Denmark	14	Copenhagen Business School	1096
United Kingdom	44	Imperial College London, University of Oxford, Aston Business School	1442	Iran	14	Ferdowsi University of Mashhad	146
China	41	Zhejiang University, Hangzhou Dianzi University	753	Turkey	14	Erciyes Üniversitesi	366
Germany	36	Universität Düsseldorf, Universität Göttingen	1167	Austria	12	WU Vienna University of Economics and Business	404
Malaysia	23	Universiti Teknologi Malaysia, Azman Hashim International Business School	535	Lithuania	12	Vytautas Magnus University	141
Netherlands	23	Erasmus Universiteit Rotterdam, Tilburg University	915	Portugal	12	Iscte – Instituto Universitário de Lisboa	104
Australia	20	Curtin University, University of Newcastle	911	Russia	11	HSE University	39
India	19	Indian Institute of Technology Roorkee, Vellore Institute of Technology	265	Saudi Arabia	11	Islamic University	207
Japan	19	Toyama Prefectural University, Tokai University	112	Colombia	10	Universidad Nacional de Colombia Medellin	44
Slovakia	18	Slovak University of Agriculture in Nitra	131	Poland	10	Uniwersytet im. Adama Mickiewicza w Poznaniu	502
Brazil	17	Universidade de São Paulo	787	Taiwan	10	National Kaohsiung University of Hospitality and Tourism	342
Canada	16	Université McGill	875	Peru	9	Universidad ESAN	69
France	16	INSEAD, Europe	898	Switzerland	9	University of St. Gallen	164

Source: Author elaboration based on Scopus

*Most important journals in the field of Neuromarketing*

From the bibliographic search performed in the Scopus database, a ranking of the most relevant journals in the field of Neuromarketing was obtained, determined by the number of publications in this area of knowledge. (See **Table 4**)

**Table 4.** *Journals with the highest number of publications in the field of Neuromarketing.*

No.	Journal	No. of Papers	Citations received	SJR Index	No.	Journal	No. of Papers	Citations received	SJR Index
1	Frontiers in Psychology	32	342	Q1	6	Journal of Neuroscience, Psychology and Economics	10	299	Q2
2	Frontiers in Human Neuroscience	14	252	Q2	7	Psychology & Marketing	9	172	Q1
3	Frontiers in Neuroscience	14	364	Q2	8	European Journal of Marketing	8	278	Q1
4	Integration and Process Optimization for Sustainability	11	98	Q2	9	Journal of Retailing and Consumer Services	7	200	Q1
5	Journal of Business Research	10	397	Q1	10	Asia Pacific Journal of Marketing and Logistics	6	73	Q1

Source: Author elaboration based on Scopus

*Most influential authors in the field of Neuromarketing*

**Table 5** below presents the ranking of the 10 most influential authors in neuroscience research applied to marketing, as determined by the Scopus database.

**Table 5.** *Most influential authors in the field of Neuromarketing.*

No.	Author	No. of Papers	Total citations	No.	Author	No. of Papers	Total citations
1	Babiloni F.	12	623	6	Smidts A.	8	603
2	Ma Q.	12	312	7	Vecchiato G.	8	478
3	Berčík J.	11	79	8	Crespo-Pereira V.	6	46
4	Cherubino P.	8	282	9	Kenning P.	6	303
5	Reimann M.	8	603	10	Lee E.J.	6	163

Source: Author elaboration based on Scopus

### *Universities with the highest number of publications in the field of Neuromarketing*

Based on the results obtained in the Scopus search, **Table 6** below has been prepared. **Table 6** lists the 10 universities with the highest number of publications in the field of Neuromarketing.

**Table 6.** *Universities with the highest number of publications on Neuromarketing.*

No.	University	Country	No. of Papers	No.	University	Country	No. of Papers
1	Complutense University of Madrid	Spain	22	6	Slovak University of Agriculture in Nitra	Slovakia	12
2	Zhejiang University	China	15	7	Bucharest University of Economic Studies	Romania	10
3	University of Granada	Spain	15	8	IULM University	Italy	9
4	Sapienza University of Rome	Italy	14	9	Catholic University of the Sacred Heart	Italy	9
5	School of Management, Zhejiang University	China	14	10	University of Valencia	Spain	8

Source: Author elaboration based on Scopus

### *Most cited texts in the field of Neuromarketing*

To identify the most influential texts in the field of neuromarketing, a citation analysis was conducted using data retrieved from Scopus. **Table 7** presents the 10 most cited papers from 2007 to 2023, including their main contributions to the advancement of the field, the number of citations recorded, and the methodological or theoretical approaches addressed. This information provides evidence of the most consolidated lines within the area.

**Table 7.** *Most cited texts in the field of Neuromarketing.*

Nº	Short title	Citation	Nº of citations	Main contribution
1	Facial expression recognition with CNN	<b>Lopes et al. (2017)</b>	544	Methodology for facial expression recognition using neural networks and image preprocessing.
2	What is 'Neuromarketing'?	<b>Lee et al. (2007)</b>	406	Conceptual definition of neuromarketing and proposed agenda for future research.
3	Consumer neuroscience with EEG and eye tracking	<b>Khushaba et al. (2013)</b>	291	Evaluation of consumer behavior with EEG and eye tracking to determine product attributes.
4	Aesthetic package design	<b>Reimann et al. (2010)</b>	288	Study on how packaging design influences purchase decisions from neurological and psychological approaches.
5	Branding the brain	<b>Plassmann et al. (2012)</b>	285	Review of the state of the art in branding and neuroscience; identifies future lines of research.

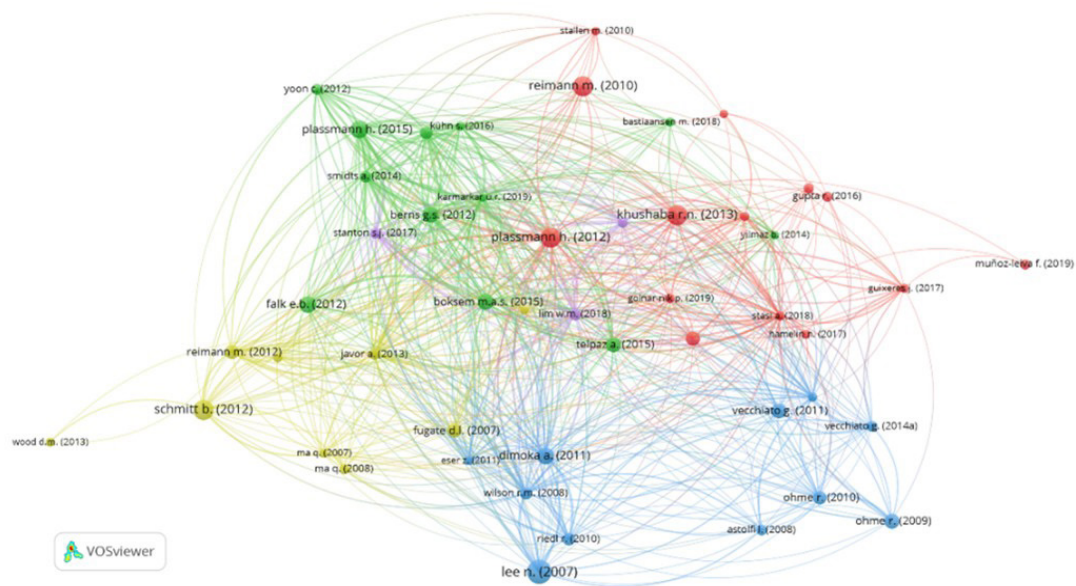
6	The consumer psychology of brands	Schmitt (2012)	282	A comprehensive model on how brands psychologically impact consumer behavior.
7	Consumer neuroscience: applications and challenges	Plassmann et al. (2015)	226	Applications and challenges of neuromarketing: proposes solutions and gaps for disciplinary development.
8	Neural focus group and media effects	Falk et al. (2012)	196	Prediction of population behavior about campaigns through brain responses of focus groups.
9	NeuroIS	Dimoka et al. (2011)	196	Application of cognitive neuroscience to the study of information systems (NeuroIS).
10	Brain responses to movie trailers	Boksem & Smidts (2015)	182	Use of brain activations to predict the commercial success of films and individual preferences.

Source: Author elaboration based on Scopus

### *Bibliographic docking*

Bibliographic linking is a literature analysis technique used to identify relationships between individual scientific papers through the bibliographic references they share (Chen et al., 2010). This technique enables the establishment of knowledge networks in a specific research area and the identification of relationships between scientific papers and the research communities that produce them.

Taking the above into account and using the bibliometric package VOSviewer, the bibliographic coupling network shown in Fig 1 was constructed, based on the results obtained from the Scopus database.



**Fig 1.** Bibliographic linkage network.

Source: Author elaboration in VOSviewer based on Scopus results.

The bibliographic linkage analysis carried out made it possible to identify the main thematic areas that structure the field of neuromarketing between 2007 and 2023. In total, five thematic clusters, composed of publications sharing co-citation

of authors, key terms, and common semantic relationships, were detected. Figure 1 presents the visualization of the bibliographic linkage network, where each node represents a document and the colors group the detected clusters according to their thematic affinity.

Subsequently, the documents in each cluster were classified according to their focus, predominant methodological techniques, and main lines of application. This information is summarized in [Table 8](#).

**Table 8.** *Thematic clusters identified in the neuromarketing literature (2007-2023)*

Cluster	Cluster name	Main thematic axis	Main techniques or tools	Main applications	Representations authors
1	Neuroscience applied to marketing	Applying neuroscience to understand consumer behavior	EEG, eye-tracking, fMRI	Measurement of emotions, attention, recall, advertising effectiveness, and product design.	Plassmann et al. (2012); Stasi et al. (2018); Chew et al. (2016); Yadava et al. (2017)
2	Applications and challenges of neuroscience in marketing	Links between neural processes and consumer decisions	fMRI, ERP, EEG	Cognitive process mapping, decision prediction, social campaigns, and exploration of new methodologies	Boksem & Smidts (2015). Falk et al. (2012); Kühn et al. (2016); Smidts et al. (2014)
3	Impact of neuromarketing on marketing research	Use of neuroscience to deepen marketing research	fMRI, EEG, frontal cortex analysis	Reaction to advertising, marketing diagnostics, interaction between IT and cognitive processes, and ethical dilemmas	Ohme et al. (2009); Vecchiato et al. (2011); Dimoka et al. (2011); Wilson et al. (2008)
4	The science behind consumer decision making	Studying underlying mental processes and their impact on marketing	EEG (P300, N270 waves), neuropsychology, emotional analysis	Brand psychology, trust, product design, children's behavior, packaging, and pricing	Schmitt (2012); Reimann et al. (2012); Javor et al., (2013); Bruce et al. (2014)
5	Potential and ethical concerns of neuromarketing	Critical reflection on risks and ethics in the application of neural tools	Neuroeconomics, critical review, interdisciplinary approaches	Privacy, consent, ethical regulation, future role of neuroscience in marketing	Stanton et al. (2017); Lim (2018)

Source: Author elaboration in VOSviewer based on Scopus results



### *Future lines*

To identify research gaps for future studies in neuroscience applied to marketing, a bibliographic linkage network (Fig 3) is constructed from documents published in Scopus between January 2022 and April 13, 2023, to consider the contributions and suggestions of the most recent research. The VOSviewer software was again used for its construction (Waltman & van Eck, 2015).

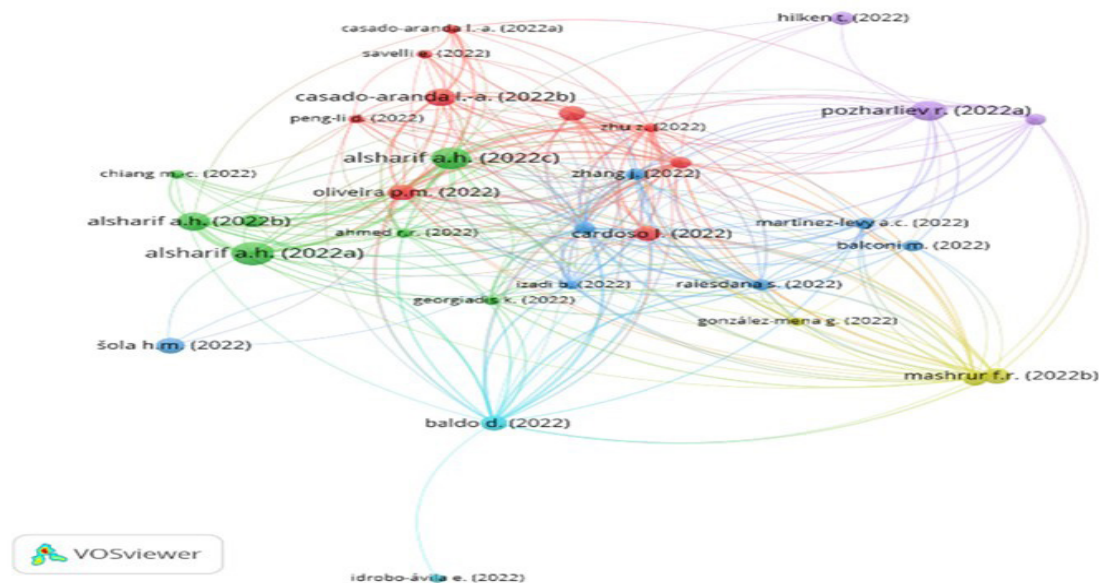


Fig 3. Bibliographic linkage network documents published between 2022 and 2023.  
Source: Author elaboration in VOSviewer based on Scopus results.

The identification of these clusters enables the mapping of the most recent and promising topics in neuromarketing, highlighting a constantly expanding field where neuroscience, digital marketing, ethics, and smart technology converge. These lines provide a clear guide for future research aimed at a better understanding of the consumer from a multidisciplinary perspective. The emerging thematic clusters are presented below, along with their main approaches and identified gaps (see Table 10).

Table 10. *Clústeres temáticos emergentes en neuromarketing (2022–2023)*

Nº	Thematic cluster	Main focus	Research gaps identified	Key authors (year)
1	Neuromarketing and ethical concerns	Consumer neuroscience, brand memory, and willingness to buy.	Explore links between neural processes and consumer attitudes (impulsivity, personality); ethical dilemmas and skepticism in the face of positive messages.	Casado-Aranda et al. (2022a, 2022b); Herrando et al. (2022); Savelli et al. (2022); Li et al. (2022); Oliveira et al. (2022)

2	Brain analysis and marketing	EEG strategy evaluation, neuroscience in pricing and discounting, and fMRI.	Validate EEG tools; apply artificial neural networks for prediction; study perception in the face of brand dissonance and sustainability in decisions.	Georgiadis et al. (2022); Alsharif et al. (2022a, 2022b, 2023); Ahmed et al. (2022); Kokthi et al. (2022); Chiang et al. (2022)
3	Consumer neuroscience	Decision-making, emotions, and behavior, as well as EEG and fMRI techniques.	Analyze unconscious responses; measure emotional influence in social networks; and risk perception in contexts such as pandemics.	McInnes et al. (2023); Raiesdana & Mousakhani (2022); Izadi et al. (2022); Zhang & Lee (2022); Šola et al. (2022); Martínez-Levy et al. (2022); Balconi et al. (2022)
4	Intelligent neuromarketing systems	Decision prediction using EEG signals; digital user experience.	Optimize intelligent prediction systems by linking facial expressions to web design, thereby improving digital interaction and the consumer experience.	Mashrur et al. (2022a, 2022b); González-Mena et al. (2022)
5	Technological innovations in advertising	Neuroscience applied to social networks, augmented and virtual reality in communication.	Study the effectiveness of advertising in digital environments; explore the potential of immersive technologies for personalized service.	Pozharliev et al. (2022a, 2022b); Hilken et al. (2022)
6	Physiological measurements and advertising	Use of physiological variables (heart rate, emotions) in marketing and advertising effectiveness.	Evaluate the relationship between emotions, memory, and brain activity in response to advertisements; complement metrics with physiological recordings.	Idrobo-Ávila et al. (2022). Baldo et al. (2022)

Source: Author elaboration in VOSviewer based on Scopus results

## ANALYSIS AND DISCUSSION OF RESULTS

### *Trends in the evolution of the field*

The temporal evolution of scientific production in neuromarketing (Figure 1) reveals an upward trajectory since 2007, with a peak in 2022. This sustained growth is evidence of the consolidation of neuromarketing as an emerging scientific discipline that has transcended its interdisciplinary origins, integrating neuroscience, marketing, and consumer psychology.

This behavior aligns with the global trend toward the adoption of empirical and neuroscientific approaches to understanding consumer decision-making processes. Methodological consolidation through the use of technologies such as EEG and fMRI has been key to this growth (Plassmann et al. (2012); Lee et al., 2007).

### *Geographical distribution and academic concentration*

Europe leads the field, accounting for 52% of the publications, with Spain standing out as the country with the highest number of papers (n = 100). The United States (n = 88) and Italy (n = 47) follow in importance. Latin America still has a low but growing participation in terms of the number of publications, with Colombia, Brazil, and Peru among the most active.

The concentration of publications in European countries can likely be attributed to the strong institutional support and funding for applied neuroscience research. The presence of universities such as the Complutense University of Madrid or Sapienza di Roma reflects neuralgic centers of knowledge production (Table 6). In contrast, the low participation of regions such as Africa and Latin America reveals a structural gap in access to neuroscience technologies.

### *Influence of journals and authors*

Frontiers in Psychology leads in volume (n=32) of articles in the areas reviewed. However, other journals, such as the Journal of Business Research or Psychology & Marketing, have the same impact index (Q1). In the case of the Journal of Business Research, it also has a higher number of citations. In the case of the most cited authors, such as Babiloni, F., Reimann, M., and Smidts, A., they have generated nuclei of influence that mark the research agenda of the field. In this regard, thematic consolidation is evident in psychology, neuroscience, and marketing journals. On the other hand, the recurrence of authors such as Schmitt and Reimann et al. reveals a dominant academic corpus that articulates neuroscience with phenomena of branding, packaging, and decision making. This also points to a risk of thematic concentration that could limit alternative approaches or emerging ethical critiques.

### *Consolidated thematic areas (2007-2023)*

From the bibliographic linkage analysis conducted on scientific production between 2007 and 2023, five thematic clusters were identified that structure the field of neuromarketing (see Figure 1 and Table 8). Each cluster groups documents that share standard references and thematic affinities, which allows for highlighting the consolidated areas of research. Table 11 presents these clusters, describing their central focus, recurrent themes, and main findings that characterize each group.

**Table 11.** *Consolidated thematic clusters in the neuromarketing literature (2007-2023)*

Cluster	Key finding	Critical discussion
Neuroscience applied to marketing	Use of EEG and eye-tracking to measure emotions and attention.	Validates the usefulness of neuromarketing in advertising scenarios, but raises doubts about its applicability to complex and cultural behaviors.
Applications and challenges	Decision prediction, campaign design, and new methodologies.	Solid methodological advances, but with little discussion on replicability and ecological validity.
Market research	Advertising diagnostics and IT-cognition link.	Interesting articulation with information systems, although it requires greater integration with consumer theories.
Consumer decision	Mental processes, trust, emotions, and packaging.	Allows deep understanding of purchase motivations, although with a predominance of positivist methodologies.
Ethics and risks	Privacy, consent, and regulation.	Puts on the table an urgent discussion on neurocognitive manipulation and the need for international ethical frameworks.

Source: Author elaboration

### *Conceptual nuclei by co-occurrence of terms*

The analysis of co-occurrence of key terms (see [Fig 2](#)) made it possible to identify five conceptual clusters that reflect the dominant concerns and the most recurrent research foci in the field of neuromarketing. These clusters are constructed from the frequency and semantic association of terms in the titles, abstracts, and keywords of the documents analyzed, which enables a finer understanding of the semantic axes of the field.

The five conceptual cores identified are: (1) consumer brain behavior, (2) neuromarketing technological tools, (3) emotion measurement, (4) brain preferences, and (5) marketing research methodologies. These cores are explained in [Table 12](#).

**Table 12.** *Conceptual cores in neuromarketing according to term co-occurrence analysis (2007-2023)*

Conceptual core	Associated key terms	Interpretation
Consumer brain behavior	brain activity, decision-making, prefrontal cortex, cognitive processing	Focus on neural processes linked to decision-making, memory, and brand identification.
Technological tools	EEG, fMRI, eye tracking, GSR	Predominance of studies using neurophysiological technologies to capture subconscious consumer responses.
Emotion measurement	emotion, arousal, valence, facial expression analysis	Emphasis on quantifying emotional responses to marketing stimuli and brand experiences.
Brain preferences	brand preference, neural correlates, implicit memory, consumer attitude	Analysis of brain patterns that explain attitudes, preferences, and loyalty to brands and products.

Methodologies for market research	experimental design, data analysis, neuroscience methods, consumer insights	Consolidation of methodological approaches that integrate neuroscience and marketing to obtain more accurate diagnoses.
-----------------------------------	---	---

Source: Author elaboration based on co-occurrence analysis (Fig 2).

These thematic nuclei not only allow mapping the areas of most excellent research density, but also show the progressive theoretical-methodological sophistication of the field. Likewise, the analysis reveals a balance between technical development and conceptual concerns, positioning neuromarketing as a space of interdisciplinary convergence with potential for expansion into ethical, cultural, and social agendas.

#### Emerging lines in neuromarketing research (2022-2023)

The analysis of the most recent thematic clusters (Table 10) enables us to identify not only consolidated lines but also emerging lines that reflect a critical evolution in the field of neuromarketing. These lines are characterized by integrating ethical, technological, psychological, and social concerns, thereby expanding the traditional boundaries of advertising and sensory neuromarketing into more complex environments, such as artificial intelligence, responsible consumption, and emotional health.

**Table 13** articulates these emerging lines as an interpretive synthesis of the identified clusters, connecting them with the main contributions, developing approaches, and gaps to be explored:

**Table 13.** *Emerging lines derived from the thematic analysis of the neuromarketing literature (2022-2023).*

Emerging line	Relationship with clusters (Table 10)	Analytical description	Projections and gaps
Neuroethics and neural data governance	Cluster 1: Neuromarketing and Ethical Concerns	A critical line on the ethical use of brain stimulation and measurement technologies is consolidated, addressing issues such as consent, privacy, and manipulation.	There is a lack of coherent global regulation. Studies on consumer perception of these practices are required.
Neurotechnologies and artificial intelligence	Cluster 2 and 4: Brain analysis and marketing; Intelligent neuromarketing systems	Advances in integrating AI, predictive algorithms, and EEG/fMRI to analyze decision patterns and optimize marketing personalization.	Gaps in algorithmic transparency and ethical evaluation of intelligent systems.
Neuromarketing for sustainability	Cluster 2 and 3: Brain Analysis and Marketing; Consumer Neuroscience	Emerging interest in applying neuromarketing to responsible consumption and environmental sustainability campaigns.	Empirical studies on the effectiveness of pro-environmental messages from unconscious processing are required.

Emotional design and user experience (UX)	Cluster 4 and 5: Intelligent Systems; Technological Innovations in Advertising	Growing use of biometrics to adjust interfaces, immersive experiences, and web design, seeking to optimize the user's affective response.	Need to validate neurophysiological metrics in real browsing and digital shopping contexts.
Neurointerventions for wellness	Cluster 3 and 6: Consumer Neuroscience; Physiological Measurements and Advertising	Recent line that applies neuromarketing in contexts related to health, emotional well-being, and trust in products for self-care.	Requires a robust bioethical framework and differentiation from traditional persuasion strategies.

Source: Author elaboration based on thematic cluster analysis (Table 10) and literature 2022-2023 in Scopus.

These emerging lines show how neuromarketing is moving from an instrumental stage to a reflexive and interdisciplinary phase. It is no longer limited to describing neural reactions to advertisements. However, it seeks to understand how brain data can contribute to (or jeopardize) informed decision-making processes, ethical consumption, and human welfare. This epistemological shift poses new methodological challenges, such as replicability of experiments, algorithmic transparency, and equity in access to neurocognitive technologies.

Furthermore, these lines open up the possibility of a critical research agenda that not only refines techniques but also interrogates the ethical, political, and social assumptions of contemporary neuromarketing.

The analysis of neuromarketing literature between 2007 and 2023 reveals a significant evolution in both volume and thematic complexity. Initially focused on advertising and sensory applications, the field has undergone an expansion towards interdisciplinary approaches that integrate neuroscience, artificial intelligence, ethics, digital experience design, and sustainability. This thematic-methodological diversification is evident in the most recent emerging clusters (2022-2023), where concerns about the ethical use of neural data, the development of intelligent behavior prediction systems, and the growing attention to consumer well-being and complex social and emotional contexts stand out.

In addition, emerging lines are identified that reflect not only technological advances, but also a shift in research questions: from “what stimuli generate the greatest impact?” to “how does neuromarketing impact consumer decisions, values, and rights?”. These lines enable us to outline a future research agenda that necessitates mixed approaches, more robust ethical frameworks, and increased attention to the social and cultural implications of neuroscientific technology use in marketing.

Taken together, the results enable us to conclude that neuromarketing is no longer a complementary tool, but a strategic field in marketing research, whose growth will be determined by both technical innovation and its capacity for self-regulation and ethical adaptation.

## CONCLUSIONS

Based on the results of the present bibliometric study, it can be concluded that the application of neuroscience to marketing is a relatively recent field of knowledge, yet one that has garnered growing interest among scientific communities worldwide. Since the publication of Caldwell's (2007) text, the production of literature has steadily increased, reaching its peak in 2022, with a total of 597 papers indexed in the Scopus database over the 15-year period.

Using bibliographic linking in the VOSviewer bibliometric software, a network was constructed to identify five research trends around neuromarketing: (1) neuroscience applied to marketing, (2) how does neuroscience improve marketing? applications and challenges, (3) the impact of neuromarketing on market research, (4) neuromarketing: the science behind consumer decision making, and (5) neuromarketing's potential and ethical concerns. These lines reflect the evolution of the field from an instrumental orientation to more reflective and critical approaches.

Also, attending to the importance of co-occurrence in defining relationships between key terms in scientific articles (Castriotta et al., 2019; Donthu et al., 2021), five clusters were identified that reveal the predominant approaches: (1) consumer brain behavior, (2) neuromarketing tools, (3) emotions and prediction, (4) brain preferences, and (5) market research. These findings enable the mapping of the conceptual structures that have guided scientific production in the area.

To identify research gaps that will serve as a basis for future studies, a bibliographic linkage network was constructed using papers published between January 2022 and April 2023. From this, six emerging lines with high potential for academic development were identified: (1) neuromarketing and ethical concerns, (2) brain analysis and marketing, (3) consumer neuroscience, (4) intelligent neuromarketing systems, (5) technological innovations to improve advertising, and (6) physiological measurements and advertising. These lines not only broaden the theoretical horizon of the field but also open up new possibilities for methodological and applied exploration.

In summary, neuromarketing has been the subject of growing interest in the global scientific community over the last fifteen years, driving a steady expansion of the literature and consolidating new ways of understanding the relationship between brain, emotion, and consumer behavior. This trend is expected to continue to rise, enabling the refinement of neuroscientific applications in marketing, as well as further reflection on their ethical implications.

At the academic level, this article examines advances in understanding consumer behavior through a comprehensive review of scientific production related to the application of neuroscience to marketing. In doing so, it significantly contributes to the construction of a more robust theoretical framework on the mechanisms that influence purchase decision-making. The identification of five emerging trends also provides a clear guide for future research, highlighting the value of neuroscience in understanding consumer emotions, preferences, and decisions.

This study also highlights the importance of interdisciplinary collaboration among neuroscience, marketing, and psychology, which facilitates the integration of diverse methods and enhances the empirical understanding of the field. This interaction fosters the development of a more comprehensive framework for analyzing consumer behavior from a neuroscientific perspective.

In terms of practical implications, it highlights the usefulness of neuromarketing in designing more effective strategies, improving the customer experience by identifying critical points of frustration or desire, and making decisions based on scientific evidence. Additionally, the study offers valuable insights into academic training in neuromarketing, which may be beneficial for designing educational programs to enhance the competencies of future professionals in this field.

Among the study's limitations, the exclusive use of a single database (Scopus) is acknowledged, which may restrict the review's scope. Therefore, further research could incorporate additional platforms such as Web of Science or Google Scholar to contrast and enrich the results obtained. Also, given the evolving nature of neuromarketing, further bibliometric studies are recommended to help consolidate the state of the art, map recent advances, and promote a critical and responsible research agenda.

### **CREDIT AUTHORSHIP CONTRIBUTION STATEMENT**

Osorio-Andrade: Conceptualization, Methodology, Validation, Formal analysis, Supervision. Candelo-Viáfara: Writing - Original draft, Writing - Review and editing, Data curation, Visualization. Arango-Espinal: Resources, Project management, Obtaining funding, Supervision

### **FUNDING**

This article is derived from the homonymous academic research project developed by the authors. It did not receive external funding from public, private or international cooperation institutions. All expenses related to the study's development were covered by the authors themselves.

### **DECLARATION OF COMPETING INTEREST**

The authors declare that there are no conflicts of interest that may have influenced the research, authorship, or publication of this article.

### **ACKNOWLEDGMENTS**

The authors express their sincere gratitude for the support received during the development of this research. They also acknowledge that the translation of the original manuscript from Spanish to English was assisted by artificial intelligence tools, which facilitated the writing process in a second language and contributed to improving clarity in scientific communication.

## REFERENCES

- Ahmed, R. R., Streimikiene, D., Channar, Z. A., Soomro, H. A., Streimikis, J., & Kyriakopoulos, G. L. (2022). The Neuromarketing Concept in Artificial Neural Networks: A Case of Forecasting and Simulation from the Advertising Industry. *Sustainability*, 14(14), <https://doi.org/10.3390/su14148546>
- Alsharif, A. H., Salleh, N. Z. M., & Baharun, R. (2020). Research trends of neuromarketing: A bibliometric analysis. *Journal of Theoretical and Applied Information Technology*, 98(15), <https://doi.org/10.26441/RC21.1-2022-a1>
- Alsharif, A. H., Salleh, N. Z. M., & Baharun, R. (2021). A bibliometric analysis of neuromarketing: Current status, development and future directions. *International Journal of Innovation, Creativity and Change*, 11(3), 828–847. <http://dx.doi.org/10.6007/IJARAFMS/v11-i3/11673>
- Alsharif, A. H., Salleh, N. Z. M., Abdullah, M., Khraiwish, A., & Ashaari, A. (2023). Neuromarketing Tools Used in the Marketing Mix: A Systematic Literature and Future Research Agenda. *SAGE Open*, 13(1). <https://doi.org/10.1177/21582440231156563>.
- Alsharif, A. H., Salleh, N. Z. M., Baharun, R., Abuhassna, H., & Hashem E, A. R. (2022a). Tendencias globales de investigación en neuromarketing: 2015-2020. *Revista De Comunicación*, 21(1), 15–32. <https://doi.org/10.26441/RC21.1-2022-A1>.
- Alsharif, A., Md Salleh, N. Z., Pilelienė, L., Abbas, A. F. & Ali, J. (2022b). Current Trends in the Application of EEG in Neuromarketing: A Bibliometric Analysis. *Scientific Annals of Economics and Business*, 69(3), 393–415. <https://doi.org/10.47743/saeb-2022-0020>
- Álvarez-García, J.; Durán-Sánchez, A.; Montalván-Burbano, N.; del Río-Rama. (2023) M.d.l.C. Spanish Journal of Finance and Accounting (SJFA): Mapping of Knowledge over the Last 25 Years. *Publications*, 11(1), 11. <https://doi.org/10.3390/publications11010011>
- Ariely, D., & Berns, G. S. (2010). Neuromarketing: The hope and hype of neuroimaging in business. *Nature Reviews Neuroscience*, 11(4), 284–292. <https://doi.org/10.1038/nrn2795>
- Balconi M, Sansone M and Angioletti L (2022) Consumers in the Face of COVID-19-Related Advertising: Threat or Boost Effect? *Front. Psychol*, 13, 834426. <https://doi.org/10.3389/fpsyg.2022.834426>
- Baldo, D., Viswanathan, V. S., Timpone, R. J., & Venkatraman, V. (2022). The heart, brain, and body of marketing: complementary roles of neurophysiological measures in tracking emotions, memory, and ad effectiveness. *Psychology & Marketing*, 39(10), 1979-1991, <http://dx.doi.org/10.1002/mar.21697>

- Belter, C. W. (2016). Citation analysis as a literature search method for systematic reviews. *Journal of the Association for Information Science and Technology*, 67(11), 2766–2777.
- Boksem, M. A. S., & Smidts, A. (2015). Brain Responses to Movie Trailers Predict Individual Preferences for Movies and Their Population-Wide Commercial Success. *Journal of Marketing Research*, 52(4), 482–492. <https://doi.org/10.1509/jmr.13.0572>
- Bruce, A. S., Bruce, J. M., Black, W. R., Lepping, R. J., Henry, J. M., Cherry, J. B. C., Martin, L. E., Papa, V. B., Davis, A. M., & Brooks, W. M. (2014). Branding and a child’s brain: An fMRI study of neural responses to logos. *Social Cognitive and Affective Neuroscience*, 9(1), 118–122. <https://doi.org/10.1093/scan/nss109>
- Caldwell, M. (2007). Neuromarketing Careers. *Science*, 316(5827), 1060-1061. <https://doi.org/10.1126/science.316.5827.1060a>
- Calero-Medina, C., Arroyo-Machado, A., & García-Sánchez, J. A. (2020). Bibliometrics and analysis of social networks as research tools. *Journal of Research in Higher Education*, 8(15), 15-28.
- Casado-Aranda, L. A., & Sanchez-Fernandez, J. (2022a). Advances in neuroscience and marketing: analyzing tool possibilities and research opportunities. *Spanish Journal of Marketing-ESIC*, <http://dx.doi.org/10.1108/SJME-10-2021-0196>
- Casado-Aranda, L. A., Sanchez-Fernandez, J., & Ibanez-Zapata, J. A. (2022b). It is all about our impulsiveness—How consumer impulsiveness modulates neural evaluation of hedonic and utilitarian banners. *Journal of Retailing and Consumer Services*, 67, 102997. <https://doi.org/10.1016/j.jretconser.2022.102997>
- Castriotta, M., Loi, M., Marku, E., & Salvemini, S. (2019). Mapping the evolution of scientific research on open innovation: A bibliometric analysis. *Technological Forecasting and Social Change*, 146, 706–732.
- Chen, C., Ibekwe-SanJuan, F., & Hou, J. (2010). The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. *Journal of the American Society for Information Science and Technology*, 61(7), 1386-1409. <https://doi.org/10.1002/asi.21309>
- Chew, L. H., Teo, J., & Mountstephens, J. (2016). Aesthetic preference recognition of 3D shapes using EEG. *Cognitive neurodynamics*, 10, 165-173, <https://doi.org/10.1007%2Fs11571-015-9363-z>
- Chiang, M. C., Yen, C., & Chen, H. L. (2022). Does Age Matter? Using Neuroscience Approaches to Understand Consumers’ Behavior towards Purchasing the Sustainable Product Online. *Sustainability*, 14(18), <https://doi.org/10.3390/su141811352>
- Dimoka, A., Pavlou, P. A., & Davis, F. D. (2011). Research commentary—NeuroIS: The potential of cognitive neuroscience for information systems research.

- Information Systems Research*, 22(4), 687-702. <http://dx.doi.org/10.1287/isre.1100.0284>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines *Journal of Business Research*, 133, 285-296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Elsevier. (2023). Scopus content. <https://goo.su/csSMW>
- Falk, E. B., Berkman, E. T., & Lieberman, M. D. (2012). From Neural Responses to Population Behavior: Neural Focus Group Predicts Population-Level Media Effects. *Psychological Science*, 23(5), 439-445. <https://doi.org/10.1177/0956797611434964>
- Georgiadis, K., Kalaganis, F. P., Oikonomou, V. P., Nikolopoulos, S., Laskaris, N. A., & Kompatsiaris, I. (2022). Rneumark: A Riemannian EEG analysis framework for neuromarketing. *Brain Informatics*, 9(1), 22. <https://doi.org/10.1186/s40708-022-00171-7>
- Gill, R., & Singh, J. (2022). A study of neuromarketing techniques for proposing a cost-effective information-driven framework for decision making. *Materials Today: Proceedings*, 49, 2969-2981. <https://doi.org/10.1016/j.matpr.2020.08.730>
- González-Mena, G., Del-Valle-Soto, C., Corona, V., & Rodríguez, J. (2022). Neuromarketing in the Digital Age: The Direct Relation between Facial Expressions and Website Design. *Applied Sciences*, 12(16), 8186. <https://doi.org/10.3390/app12168186>
- Herrando, C., Jiménez-Martínez, J., Martín-De Hoyos, M. J., & Constantinides, E. (2022). Emotional contagion triggered by online consumer reviews: Evidence from a neuroscience study. *Journal of Retailing and Consumer Services*, 67, 102973. <https://doi.org/10.1016/j.jretconser.2022.102973>
- Hilken, T., Chylinski, M., de Ruyter, K., Heller, J., & Keeling, D. I. (2022). Exploring the frontiers in reality-enhanced service communication: from augmented and virtual reality to neuro-enhanced reality. *Journal of Service Management*, 33(4/5), 657-674. <http://dx.doi.org/10.1108/JOSM-11-2021-0439>
- Idrobo-Ávila, E., Loaiza-Correa, H., Muñoz-Bolaños, F., van Noorden, L., & Vargas-Cañas, R. (2022). Development of a biofeedback system using harmonic musical intervals to control heart rate variability with a generative adversarial network. *Biomedical Signal Processing and Control*, 71, 103095. <https://doi.org/10.1016/j.bspc.2021.103095>
- Izadi, B., Ghaedi, A., & Ghasemian, M. (2022). Neuropsychological responses of consumers to promotion strategies and the decision to buy sports products. *Asia Pacific Journal of Marketing and Logistics*, 34(6), 1203-1221. <https://doi.org/10.1108/APJML-01-2021-0026>

- Janik, A., Ryszko, A., & Szafraniec, M. (2020). Scientific landscape of smart and sustainable cities literature: A bibliometric analysis. *Sustainability*, 12(3), 779. <https://doi.org/10.3390/su12030779>
- Javor, A., Koller, M., Lee, N., Chamberlain, L., & Ransmayr, G. (2013). Neuromarketing and consumer neuroscience: contributions to neurology. *BMC neurology*, 13(1), 13. <https://doi.org/10.1186/1471-2377-13-13>
- Khushaba, R. N., Wise, C., Kodagoda, S., Louviere, J., Kahn, B. E., & Townsend, C. (2013). Consumer neuroscience: Assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking. *Expert systems with applications*, 40(9), 3803-3812. <https://doi.org/10.1016/j.eswa.2012.12.095>
- Kokthi, E., Thoma, L., Saary, R., & Kelemen-Erdos, A. (2022). Disconfirmation of taste as a measure of trust in brands: An Experimental Study on Mineral Water. *Foods*, 11(9), 1276. <https://doi.org/10.3390/foods11091276>
- Kühn, S., StreLOW, E., & Gallinat, J. (2016). Multiple “buy buttons” in the brain: Forecasting chocolate sales at point-of-sale based on functional brain activation using fMRI. *NeuroImage*, 136, 122-128. <https://doi.org/10.1016/j.neuroimage.2016.05.021>
- Lechtenberg, F., Farreres, J., Galvan-Cara, A. L., Somoza-Tornos, A., España, A., & Graells, M. (2022). Information retrieval from scientific abstract and citation databases: A query-by-documents approach based on Monte-Carlo sampling. *Expert Systems with Applications*, 199, 116967. <https://doi.org/10.1016/j.eswa.2022.116967>
- Lee, N., Broderick, A. J., & Chamberlain, L. (2007). What is ‘neuromarketing’? A discussion and agenda for future research. *International journal of psychophysiology*, 63(2), 199-204. <https://doi.org/10.1016/j.ijpsycho.2006.03.007>
- Li, S., Lyu, T., Chen, M., & Zhang, P. (2022). The prospects of using EEG in tourism and hospitality research. *Journal of Hospitality & Tourism Research*, 46(1), 189-211. <https://doi.org/10.1177/1096348021996439>
- Lim, W. M. (2018). Demystifying neuromarketing. *Journal of business research*, 91, 205-220. <https://doi.org/10.1016/j.jbusres.2018.05.036>
- Lopes, A. T., De Aguiar, E., De Souza, A. F., & Oliveira-Santos, T. (2017). Facial expression recognition with convolutional neural networks: coping with few data and the training sample order. *Pattern recognition*, 61, 610-628. <https://doi.org/10.1016/j.patcog.2016.07.026>
- Martínez-Levy, A. C., Rossi, D., Cartocci, G., Mancini, M., Di Flumeri, G., Trettel, A., ... & Cherubino, P. (2022). Message framing, non-conscious perception, and effectiveness in non-profit advertising. Contribution by neuromarketing research. *International Review on Public and Nonprofit Marketing*, 19(1), 53-75. <https://doi.org/10.1007/s12208-021-00289-0>

- Mashrur, F. R., Rahman, K. M., Miya, M. T. I., Vaidyanathan, R., Anwar, S. F., Sarker, F., & Mamun, K. A. (2022a). An intelligent neuromarketing system for predicting consumers' future choices from electroencephalography signals. *Physiology & behavior*, 253, 113847. <https://doi.org/10.1016/j.physbeh.2022.113847>
- Mashrur, F. R., Rahman, K. M., Miya, M. T. I., Vaidyanathan, R., Anwar, S. F., Sarker, F., & Mamun, K. A. (2022b). BCI-based Consumers' choice prediction from EEG signals: an intelligent Neuromarketing framework. *Frontiers in human neuroscience*, 16, 861270. <https://doi.org/10.3389/fnhum.2022.861270>
- McInnes, A. N., Sung, B., & Hooshmand, R. (2023). A practical review of electroencephalography's value to consumer research. *International Journal of Market Research*, 65(1), 52-82. <http://dx.doi.org/10.1177/14707853221112622>
- Ohme, R., Reykowska, D., Wiener, D., & Choromanska, A. (2009). Analysis of neurophysiological reactions to advertising stimuli by means of EEG and galvanic skin response measures. *Journal of Neuroscience, Psychology, and Economics*, 2(1), 21–31, <https://psycnet.apa.org/doi/10.1037/a0015462>
- Oliveira, P. M., Guerreiro, J., & Rita, P. (2022). Neuroscience research in consumer behavior: A review and future research agenda. *International Journal of Consumer Studies*, 46(5), 2041-2067. <https://doi.org/10.1111/ijcs.12800>
- Osorio-Andrade, C. F., Murcia-Zorrilla, C. P., & Arango-Espinal, E. (2020). City marketing research: a bibliometric analysis. *Revista EAN*, (89), 113-130. <https://doi.org/10.21158/01208160.n89.2020.2838>
- Plassmann, H., Ramsøy, T. Z., & Milosavljevic, M. (2012). Branding the brain: A critical review and outlook. *Journal of consumer psychology*, 22(1), 18-36, <http://dx.doi.org/10.1016/j.jcps.2011.11.010>
- Plassmann, H., Venkatraman, V., Huettel, S., & Yoon, C. (2015). Consumer neuroscience: applications, challenges, and possible solutions. *Journal of marketing research*, 52(4), 427-435. <https://doi.org/10.1509/jmr.14.0048>
- Pozharliev, R., Rossi, D., & De Angelis, M. (2022a). Consumers' self-reported and brain responses to advertising post on Instagram: the effect of number of followers and argument quality. *European Journal of Marketing*, 56(3), 922-948. <https://doi.org/10.1108/EJM-09-2020-0719>
- Pozharliev, R., Rossi, D., & De Angelis, M. (2022b). A picture says more than a thousand words: Using consumer neuroscience to study instagram users' responses to influencer advertising. *Psychology & Marketing*, 39(7), 1336-1349. <http://dx.doi.org/10.1002/mar.21659>
- Pranckutė, R. (2021). Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World. *Publications*, 9(1), 12. <https://doi.org/10.3390/publications9010012>

- Raiesdana, S., & Mousakhani, M. (2022). An EEG-Based Neuromarketing Approach for Analyzing the Preference of an Electric Car. *Computational intelligence and neuroscience*, 2022(1), 9002101. <https://doi.org/10.1155/2022/9002101>
- Reimann, M., Castaño, R., Zaichkowsky, J., & Bechara, A. (2012). How we relate to brands: Psychological and neurophysiological insights into consumer–brand relationships. *Journal of Consumer Psychology*, 22(1), 128-142. <https://doi.org/10.1016/j.jcps.2011.11.003>
- Reimann, M., Zaichkowsky, J., Neuhaus, C., Bender, T., & Weber, B. (2010). Aesthetic package design: A behavioral, neural, and psychological investigation. *Journal of consumer psychology*, 20(4), 431-441. <https://doi.org/10.1016/j.jcps.2010.06.009>
- Savelli, E., Gregory-Smith, D., Murmura, F., & Pencarelli, T. (2022). How to communicate typical–local foods to improve food tourism attractiveness. *Psychology & Marketing*, 39(7), 1350-1369. <https://doi.org/10.1002/mar.21668>
- Schmitt, B. (2012). The consumer psychology of brands. *Journal of consumer Psychology*, 22(1), 7-17. <https://doi.org/10.1016/j.jcps.2011.09.005>
- Smidts, A., Hsu, M., Sanfey, A. G., Boksem, M. A., Ebstein, R. B., Huettel, S. A., ... & Yoon, C. (2014). Advancing consumer neuroscience. *Marketing Letters*, 25(3), 257-267. <https://doi.org/10.1007/s11002-014-9306-1>
- Šola, H. M., Mikac, M., & Rončević, I. (2022). Tracking unconscious response to visual stimuli to better understand a pattern of human behavior on a Facebook page. *Journal of innovation & knowledge*, 7(1), 100166. <https://doi.org/10.1016/j.jik.2022.100166>
- Stanton, S. J., Sinnott-Armstrong, W., & Huettel, S. A. (2017). Neuromarketing: Ethical implications of its use and potential misuse. *Journal of business ethics*, 144(4), 799-811. <https://doi.org/10.1007/s10551-016-3059-0>
- Stasi, A., Songa, G., Mauri, M., Ciceri, A., Diotallevi, F., Nardone, G., & Russo, V. (2018). Neuromarketing empirical approaches and food choice: A systematic review. *Food research international*, 108, 650-664. <https://doi.org/10.1016/j.foodres.2017.11.049>
- Vecchiato, G., Toppi, J., Astolfi, L., De Vico Fallani, F., Cincotti, F., Mattia, D., ... & Babiloni, F. (2011). Spectral EEG frontal asymmetries correlate with the experienced pleasantness of TV commercial advertisements. *Medical & biological engineering & computing*, 49(5), 579-583. <https://doi.org/10.1007/s11517-011-0747-x>
- Wagner, C. S., Roessner, J. D., Bobb, K., Klein, J. T., Boyack, K. W., Keyton, J., ... & Börner, K. (2011). Approaches to understanding and measuring interdisciplinary scientific research (IDR): A review of the literature. *Journal of informetrics*, 5(1), 14-26. <https://doi.org/10.1016/j.joi.2010.06.004>

- Waltman, L. (2016). A review of the literature on citation impact indicators. *Journal of informetrics*, 10(2), 365-391. <https://doi.org/10.1016/j.joi.2016.02.007>
- Waltman, L., & van Eck, N. J. (2015). Field-normalized citation impact indicators and the choice of an appropriate counting method. *Journal of Informetrics*, 9(4), 872-894. <https://doi.org/10.1016/j.joi.2015.08.001>
- Wilson, R. M., Gaines, J., & Hill, R. P. (2008). Neuromarketing and consumer free will. *Journal of consumer affairs*, 42(3), 389–410. <https://doi.org/10.1111/j.1745-6606.2008.00114.x>
- Yadava, M., Kumar, P., Saini, R., Roy, P. P., & Prosad Dogra, D. (2017). Analysis of EEG Signals and Their Application to Neuromarketing. *Multimedia Tools and Applications*, 76(18), 19087-19111. <https://doi.org/10.1007/s11042-017-4580-6>
- Zhang, J., & Lee, E. J. (2022). “Two Rivers” brain map for social media marketing: Reward and information value drivers of SNS consumer engagement. *Journal of Business Research*, 149, 494-505. <https://doi.org/10.1016/j.jbusres.2022.04.022>

## BIODATA

**Carlos Fernando Osorio-Andrade** is a Professor and researcher at Universidad del Valle and a researcher at INTEP, with 8 years of teaching experience at both undergraduate and graduate levels. Consultant in market research and online marketing strategies (SEO and SEM). Author of more than 20 scientific articles on digital consumer behavior, tourism, and advanced statistical models. ORCID: <https://orcid.org/0000-0002-5095-4991>

**Juan Manuel Candelo-Viáfara** is an Administrator from Universidad del Valle (Cali, Colombia). He holds a Master’s degree in Applied Economics and a PhD in Management with emphasis in Quantitative Finance from the same institution. His research interests include energy economics, time series analysis, volatility transmission and applied econometrics. He is a professor and researcher at Universidad del Valle, Seccional Buga. ORCID: <https://orcid.org/0000-0002-4152-5597>

**Edwin Arango-Espinal** is professor and director at Universidad del Valle, Caicedonia/Sevilla. Researcher in technological innovation, governance and marketing, with publications in high impact journals. Prominent in bibliometric analysis and data modeling. Leader in educational innovation projects, combining academic rigor with practical approaches. He has experience as the CEO of non-profit organizations, as well as serving as a coordinator of educational projects and a senior executive in technology and higher education. ORCID: <https://orcid.org/0000-0002-2231-3513>