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SCIENTOMETRIC ANALYSIS OF SCIENTIFIC LITERATURE ON NEUROMARKETING TOOLS IN ADVERTISING

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Abstract. Neuromarketing (NM) is a relatively new area of marketing that involves innovative technological changes in the marketing research process and the tools and methods used. Considering the novelty of the domain, *the subject of the study* is chosen to be articles published in scientific literature describing neuromarketing tools used in advertising. This study examined articles in the field of advertising that used neuromarketing techniques to measure consumers' neural and physiological responses to advertising, which has not yet been covered in the literature. *Methodology*. To fill the gap in the literature, the authors, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, selected relevant articles and conducted a bibliometric analysis to identify global trends and developments in the field of advertising and neuromarketing. From the Web of Science (WoS) database, 41 articles published between 2009 and 2020 were extracted and analyzed. *Purpose of the study* was to establish a background for advertising research based on the application of NM tools. *The findings* revealed that Spain was the most productive country with eleven papers published in a domain of advertising research, followed by Italy and the USA with eight and seven papers, respectively. Among academic institutions, Sapienza University Rome was recognized as the leading academic organization with three articles. As for the most productive journals, Frontiers in Psychology was the most cited journal with eight articles and 29 total citations (TC). As the highest productive author, Babiloni, F. with two papers and 68 TCs by 2020 was identified. Keyword analysis showed that "advertising" (27 occurrences and 127 total references) is the most frequently used keyword. The analysis of co-occurrence of keywords showed that NM focused on marketing research such as advertising (12 occurrences, 63 total link strength (TLS)), followed by brain processes such as attention, emotions and memory. The paper titled "Neuromarketing: The new science of consumer behavior" was the most-cited paper with 152 TCs. *Conclusion of the study.* This study presents a brief overview of the latest universal areas of neuromarketing and advertising research. The findings suggest that neuroscientific methods and techniques are extremely important for mapping consumers' neural and physiological responses to advertising.

Key words: advertising, bibliometric analysis, marketing, neuromarketing, WoS database.

JEL Classification: M00, M31, M37

1. Introduction

Self-report has been accepted as a marketing research method for a long time to assess consumer reactions to marketing stimuli such as advertising. The self-report method reflects, as expected, conscious reactions (e.g., perceptions, attitudes and opinions) to advertising (Carrington et al., 2014). On the other hand, self-report cannot measure unconscious reactions, which represent the majority of consumer reactions to stimuli. Thus, researchers and marketers have applied neuroscience tools, such as electroencephalography (EEG), to marketing to better understand consumers' unconscious reactions (Harris et al., 2018; Plassmann et al., 2012), leading to the emergence of a new field called "neuromarketing" (NM). The term NM was coined in 2002 by Smidts (2002) as an interdisciplinary field that includes psychology, marketing and neuroscience (Ahmed et al., 2020; Javor et al., 2013). In the United States, Bright House created the first neurology department equipped with functional

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magnetic resonance imaging (fMRI) for marketing purposes (Alsharif et al., 2021b; Fortunato et al., 2014).

In a hyper-competitive environment, NM is a mainstay in advertising because it has the ability to measure the areas of brain activity of consumers that respond to advertising, which is a revolutionary direction to better understand the subconscious and unconscious reactions of consumers (Alsharif et al., 2021a). According to the literature, rapid technological advances in the field of neuroscience have led to a better understanding of consumer behavior in different contexts (e.g., in advertising) (Bočková et al., 2021; Levallois et al., 2012). According to Isabella et al. (2015), NM tools have been categorized into two clusters: (1) neuro-physiological tools: EEG, magnetoencephalography (MEG), fMRI, positron emission tomography (PET) and transcranial magnetic stimulation (TMS); and (2) physiological tools such as galvanic skin responses (GSR), eye-tracking (ET), electrocardiogram (ECG), and electromyography (EMG). Neurophysiological tools record cognitive and emotional reactions (arousal, pleasure, attraction, approach and withdrawal) to advertising (Izhikevich, 2003). Physiological tools such as eye-tracking (ET) allow to track physiological reactions of consumers such as visual fixation, eye movements and saccades at the moment of purchase. Thus, it provides useful information about what the consumer likes and what not (Alsharif et al., 2022; Dimpfel, 2015).

Taking into account the latter, it is necessary to create a substantial basis for continuous improvement of NM research. Thus, generalization of existing trends in advertising research conducted within the framework of NM becomes important for further improvement of applied methodologies. The scientific literature in this field still lacks general guidelines for researchers on the most prominent scholars and the most reliable articles to be taken as a basis. The current scientometric/ bibliometric analysis aims to fill the gap in the literature related to NM by focusing on the research question: what are the main trends in advertising research within NM identified in the WoS database. The purpose of the article is to create prerequisites for advertising research based on the use of NM tools.

NM research is useful for the academic and professional world to improve traditional marketing research such as advertising research (Fortunato et al., 2014). However, the understanding of universal academic trends in NM and advertising research is still unclear in the literature. To this end, this study attempts to present universal academic trends in NM and advertising research with brief conclusions. The main findings of this study can be illustrated as follows, based on the research objectives:

– to determine the annual and cumulative growth of scientific publications, the indicators of reputable journals were used;
– identify common indicators such as leading countries, authors, academic institutions, journals and most cited papers;
– identify the most prominent keywords in "neuromarketing" OR "consumer neuroscience" and "advertising*";
– to provide new benchmarks and future directions for emerging researchers and scholars in the field of NM and advertising research.

With this in mind, this paper provides an overview of NM and the current research questions. Next, the methodology and data collection methods used in this study are described (Section 2). Section 3 presents the bibliometric analysis. Discussion of the results is presented in Section 4. Section 5 provides conclusions and policy recommendations. Finally, Section 6 presents the limitations and future directions of this research.

2. Methodology

Bibliometric analysis (BA) is a statistical method of analyzing publications in the relevant field, which has been used since the 1920s (Gingras, 2016). This study aims to extract empirical articles in the field of advertising in the context of NM from the Web of Science (WoS) database to fill the gap in the literature. The first step, it has followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol of Moher et al. (2015) to select the original articles in advertising research that have used NM methods to investigate consumers' behaviour toward advertising, as depicted in Figure 1. In the second step, it has used a BA to know the current directions and developments in advertising research based on the outcomes / findings of articles such as the leading countries, academic research institutes, authors / researchers, and the total publications (TPs) and total citations (TCs), which is highly beneficial for evaluating advancement in thefield of advertising research (Ahmed et al., 2021; Alsharif et al., 2020). In addition, to present an impactful / valuable BA in a certain area such as advertising, it has followed the instructions of Block & Fisch (2020). These processes will give a complete picture of the general NM methods used in advertising research. Thus, the results obtained will be a reference point for researchers interested in the field of advertising and NM.

The study used the search query according to the title, abstract, and keywords: (("neuromarketing" OR "consumer neuroscience") AND ("adverti*")). Articles published in 2021 were excluded; thus, the total number of publications was 125 papers for

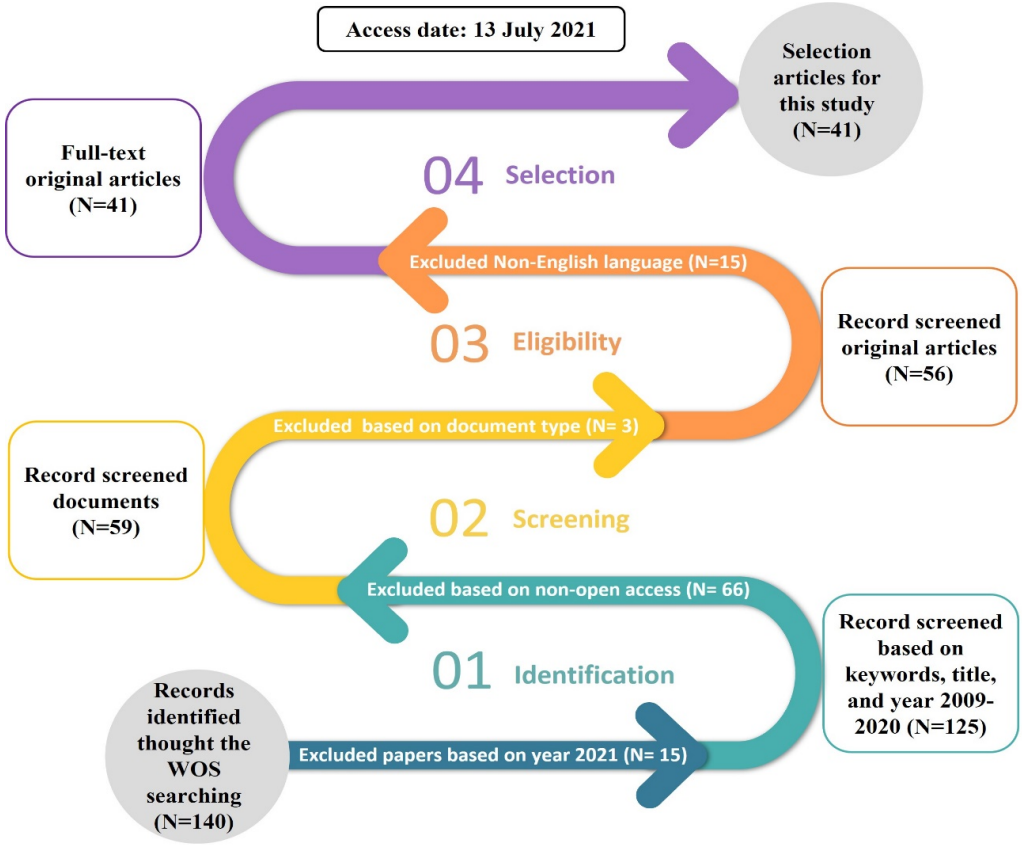

Figure 1. Flow chart process for selecting relevant articles

the period 2009–2020. Finally, forty-one original articles were selected from the Web of Science (WoS) database. Figure 1 illustrates the process of selecting relevant articles for this study, which meets the following characteristics:

– Publication year: 2009–2020.
– Methods: neurophysiological and physiological techniques.
– Language: English.
– Document type: Original articles.

To analyze the articles selected for this study, the authors used VOSviewer software, which is a proven tool for creating a view/map visualization based on the area of interest. VOSviewer is widely used in bibliometric research (for example, in neuromarketing) (Ahmed et al., 2022a; Alsharif et al., 2021c); service quality and health-care (Ali et al., 2021a, 2021b); social media (Abbas et al., 2021; Abbas et al., 2022)). Figure 2 shows the methods that were used in the analytical framework of this study. It also shows the organization of this study, the structure, indicators and methods that were used.

3. Results

Figure 3 provides a brief overview of selected articles on advertising research based on NM methods. There were also studies that used more than one method in one experiment or study.

There were 41 articles published in journals included in the WoS database related to advertising, in which NM tools were used. From 2009 to 2020, there was a fluctuation in the number of published articles on advertising. In 2020, there was the highest number of annual publications – thirteen articles, as shown in Table 1.

Table 1
The number of annual and cumulative publications by year

Year	Annual publications	Cumulative publications
2009	1	1
2010	1	2
2011	2	4
2012	1	5
2013	1	6
2014	1	7
2015	2	9
2016	2	11
2017	10	21
2018	3	24
2019	4	28
2020	13	41

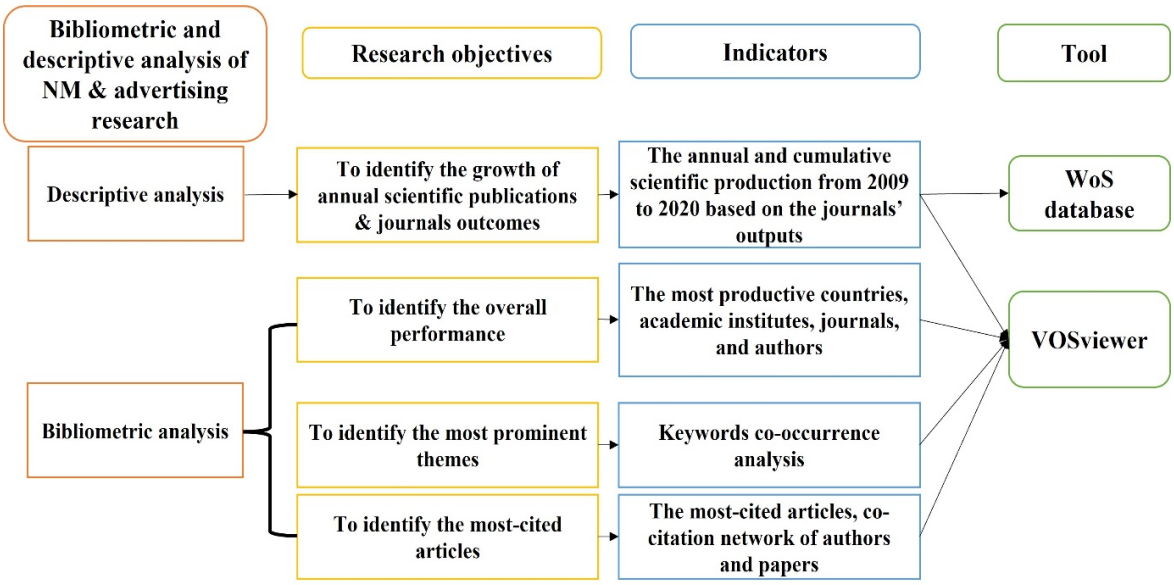

Figure 2. Analytical structure of the study

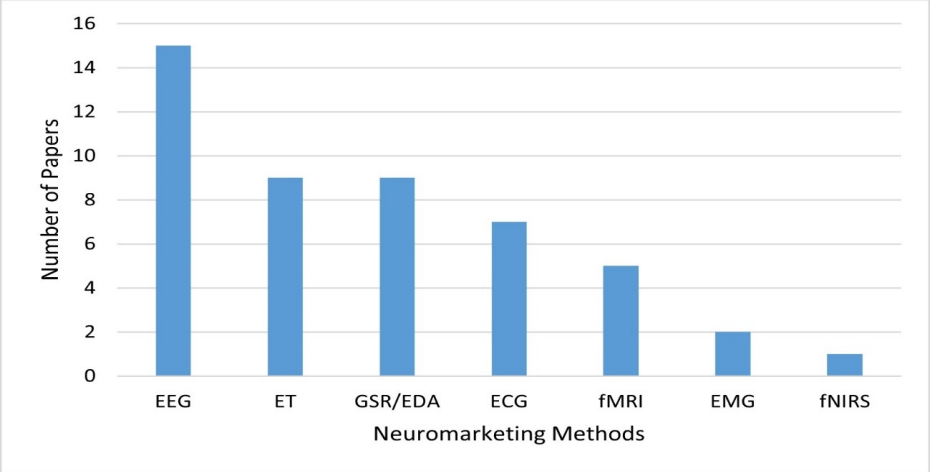

Figure 3. The number of selected papers according to NM methods

The results showed that eight publishers belong to six countries that published at least two articles in advertising and NM, as shown in Table 2. For example, Swiss publishers such as Frontiers Media Sa and MDPI are the leading players in the field of NM and promotional publications with fourteen articles, representing 34% of the total number of articles, followed by Spanish publishers such as Grupo Comunicar and University Complutense Madrid with six articles (14.6% of the total number of articles). Although Hindawi Ltd published only two articles (4.9% of the total number of articles) in Advertising and NM, it published the most cited article with 57 citations by Vecchiato et al. (2011). This is followed by the Netherlands, which also published two articles (4.9% of the total number of articles) and the second most cited article with thirty-eight references Stallen et al. (2010).

The authors analyzed 41 papers from the WoS database. Table 3 shows that three countries are key players in NM advertising research, namely Spain, Italy and the United States, with these countries accounting for almost more than 60% of the total number of publications, suggesting that these countries play a significant role in strengthening NM advertising research. In addition, Spain is the country producing the largest number of documents – 11 documents (approximately 26.83% of the total number of documents), followed by Italy, which is the second producing country in the list with almost eight documents (19.51% of the total number of documents). The United States provided seven documents (almost 17% of the total number of documents), ranking third in the list. Australia and England took the fourth position with four documents from each country. In fifth place is the

Table 2
The leading journals in advertising and NM (min. = 2 papers)

Source/Journal	TPs	% of 41 papers	TCs 2020	Reference of the most cited article	Time cited	Publisher	Country
Frontiers in Psychology	8	19.5%	29	Guixeres et al. (2017)	20	Frontiers Media Sa	Switzerland
Comunicar	4	9.8%	55	Ananos (2015)	18	Grupo Comunicar	Spain
Frontiers in Neuroscience	4	9.8%	10	Wei, Z. et al. (2018)	10	Frontiers Media Sa	Switzerland
Computational Intelligence and Neuroscience	2	4.9%	62	Vecchiato et al. (2011)	57	Hindawi Ltd	England
Journal of Economic Psychology	2	4.9%	64	Stallen et al. (2010)	38	Elsevier	Netherlands
Scientific Annals of Economics and Business	2	4.9%	7	Grigaliunaite & Pileliene (2016)	5	De Gruyter Poland Sp Zoo	Poland
Behavioral Sciences	2	4.9%	4	Harris et al. (2019)	3	MDPI	Switzerland
Neuropsychological Trends	2	4.9%	1	Leanza (2017)	1	Edizioni Univ Lettere Economic Diritto	Italy
Vivat Academia	2	4.9%	1	Jimenez-Marin et al. (2019)	1	University Complutense Madrid	Spain

Note: TPs= total publications, TCs= total citations

Netherlands with three documents. Finally, the sixth position was shared by three countries – China, Lithuania and Germany (two documents each).

Table 3
The most contributed countries in advertising and NM research (min. = two papers)

#	Country	TPs	TCs 2020	% of total articles
1	Spain	11	96	26.83%
2	Italy	8	115	19.51%
3	USA	7	98	17.07%
4	Australia	4	46	9.76%
5	England	4	51	9.76%
6	Netherland	3	23	7.32%
7	China	2	80	4.88%
8	Lithuania	2	9	4.88%
9	Germany	2	8	4.88%

Table 4 shows the most productive academic institutions that published at least two papers. For example, Sapienza University of Rome, Complutense University of Madrid and Rey Juan Carlos University published nine papers, three papers from each academic institution. They are followed by Brainsigns SRL; Catholic University of the Sacred Heart; Erasmus University of Rotterdam; Vytautas Magnus University; Swinburne University of Technology; and the University of Salamanca, which submitted a total of twelve papers, two papers each.

The study showed that the most productive authors in the context of NM, who published at least two articles in the advertising field, belong to four countries – Italy, Spain, Lithuania and Australia, as shown in Table 5.

Thirteen authors from four countries published a total of twenty-six papers, two papers each, which indicates a high level of collaboration between them. It is noteworthy that all these authors published the same number of papers – two papers per author. Therefore, the authors divided the co-authors into four clusters (Figure 4). Figure 4 shows the clusters of collaboration between authors. For example, Cluster 1 is the most collaborative cluster, which involves six authors from Sapienza University Rome (Italy) such as Babiloni, Fabio; Cherubino, Patrizia; Carato, Myriam; Rossi, Dario; Modica, Enrica; and Cartocci, Giulia. Followed by Cluster 2, it is from Universidad

Table 4
The high prolific academic institutes in advertising and NM research (min. = two papers)

#	The most prolific Academic Institutions/ Affiliations	TPs	H-index	TCs 2020	% of total articles	Country
1	Sapienza University Rome	3	3	72	7.32%	Italy
2	Complutense University of Madrid	3	2	18	7.32%	Spain
3	Universidad Rey Juan Carlos	3	1	12	7.32%	Spain
4	Brainsigns SRL	2	2	15	4.88%	Italy
5	Catholic University of the Sacred Heart	2	1	1	4.88%	Italy
6	Erasmus University Rotterdam	2	1	15	4.88%	Netherland
7	Vytautas Magnus University	2	2	7	4.88%	Lithuania
8	Swinburne University of Technology	2	2	29	4.88%	Australia
9	University of Salamanca	2	1	0	4.88%	Spain

Table 5
The most contributed authors in NM and advertising (min. = two papers)

Authors	TPs	TCs 2020	H-index	Affiliated institutes	Country
Babiloni, Fabio	2	68	2	UNIROMA; Brainsigns SRL	IT
Ciorciari, Joseph	2	29	2	Swinburne	AU
Modica, Enrica	2	25	2	UNIROMA	IT
Rossi, Dario	2	25	2	UNIROMA	IT
Carato, Myriam	2	15	2	UNIROMA	IT
Cartocci, Giulia	2	15	2	UNIROMA	IT
Cherubino, Patrizia	2	15	2	UNIROMA; Brainsigns SRL	IT
Banos-Gonzalez, Miguel	2	12	1	URJC	ES
Baraybar-Fernandez, Antonio	2	12	1	URJC	ES
Barquero-Perez, Oscar	2	12	1	URJC	ES
Goya-Esteban, Rebeca	2	12	1	URJC	ES
Grigaliunaite, Viktorija	2	7	2	VDU	LT
Pileliene, Lina	2	7	2	VDU	LT

Note: UNIROMA: Sapienza University Rome; Swinburne: Swinburne University of Technology; URJC: Universidad Rey Juan Carlos; VDU: Vytautas Magnus University; IT: Italy; ES: Spain; LT: Lithuania; AU: Australia

Rey Juan Carlos (Spain), which involves four authors such as Goya-Esteban, Rebeca; Banos-Gonzalez, Miguel; Baraybar-Fernandez, Antonio, Barquero-Perez, Oscar. Cluster 3 includes Pileliene, Lina and Grigaliunaite, Viktorija from Vytautas Magnus University (Lithuania). Ciorciari, Joseph from Swinburne University of Technology (Australia) belongs to Cluster 4.

The most productive were the eight journals that published at least two articles in advertising research in the context of NM, as shown in Table 6. For example, Frontiers in Psychology was found to be the most productive among the other journals with eight articles, followed by Comunicar and Frontiers in Neuroscience with four articles per journal. Finally, two articles were published in journals: Computational Intelligence and Neuroscience, Journal of Economic Psychology, Scientific Annals of Economics and Business, Behavioral Sciences, Neuropsychological Trends and Vivat Academia. According to literature sources, the number of citations is an indicator of the quality and popularity of articles. According to the literature, the number of publications is an indicator of the productivity of the journal, and the number of citations is an indicator of the quality and impact of the journal in the scientific field. The authors calculated the average citation per article (Nacpil et al., 2019) of the leading journals based on total citations (TC) and total publications (TP) from the WoS database. As shown in Table 6, despite the fact that the Journal of Economic Psychology has only two publications on advertising and NM, it has the highest impact factor in the list with 32 citations.

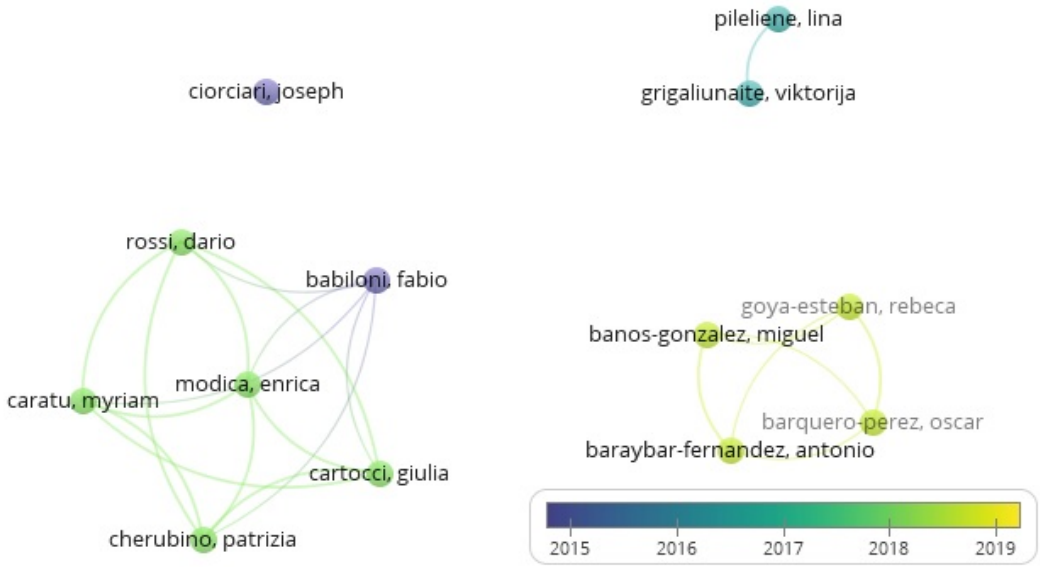

Figure 4. The network map of leading authors (min. = two papers)

Table 6
The most contributed journal in advertising and NM research (min. = two papers)

Journal	TPs	TCs 2020	ACP	H-index	Publisher	Country
Front. Psychol.	8	29	3.6	2	Frontiers Media Sa	Switzerland
Comunicar	4	55	13.8	4	Grupo Comunicar	Spain
Front. Neurosci.	4	10	2.5	2	Frontiers Media Sa	Switzerland
Comput. Intell. Neurosci.	2	62	31	2	Hindawi Ltd	England
J. Econ. Psychol.	2	64	32	2	Elsevier	Netherlands
Sci. Ann. Econ. Bus.	2	7	3.5	2	De Gruyter Poland Sp Zoo	Poland
Behav. Sci.	2	4	2	1	MDPI	Switzerland
Neuropsychol. Trends	2	1	0.5	1	Edizioni Univ Lettere Economic Diritto	Italy
Vivat Academia	2	1	0.5	2	University Complutense Madrid	Spain

Note. TPs= total publications, TCs= total citations, ACP= average citation per paper

It is followed by Computational Intelligence and Neuroscience with 31 citations. These results demonstrate that the number of publications does not necessarily indicate the number of citations.

The study identified eight journals as the most productive that published at least two articles in advertising research in the context of NM, as shown in Table 6. For example, the journal Frontiers in Psychology was recognized as the most prolific among other journals with eight articles, followed by Comunicar and Frontiers in Neuroscience with four articles per journal. Finally, journals contributed two articles: Computational Intelligence and Neuroscience, Journal of Economic Psychology, Scientific Annals of Economics and Business, Behavioral Sciences, Neuropsychological Trends, and Vivat Academia. According to the literature, the number of citations is an indicator of the quality and popularity of articles. Based on the literature, the number of publications is an indicator of the productivity of the journal, and the number of citations is an indicator of the quality and influence of the journal in the scientific field. The authors calculated the average citation per article (Nacpil et al., 2019) of the leading journals based on total citations (TC) and total publications (TP) from the WoS database. Table 6 shows that although the Journal of Economic Psychology has only two publications on advertising and NM, it has the highest impact factor in the list with 32 citations. It is followed by Computational Intelligence and Neuroscience with 31 citations. These results demonstrated that the number of publications does not necessarily indicate the number of citations.

Keywords occurrences refer to a numerical method in BA (Wang & Chai, 2018) to identify keywords, providing a content explanation of papers (Comerio & Strozzi, 2019). The correlation/connection between a pair of keywords is displayed in a numerical value, which indicates the link strength (LS) between the keyword pair; the stronger the link, the higher the numerical value (Ravikumar et al., 2015). LS between two keywords means the number of appearances of two keywords in one article. The number of total links (TLS) indicates the total occurrence together in one article. In VOSviewer, it has a value of two as the minimum number of occurrences of keywords, which means at least twice the occurrence of a pair of keywords on the bibliometric map in one article. The analysis of keyword usage conducted in this study included forty-one original articles published in twenty-three reputable academic journals, with one article considered the minimum number of articles. In addition, synonymous words were considered before using VOSviewer. For example, "neuromarketing" and "consumer neuroscience".

The keyword match analysis is very important for identifying relevant topics and trends in specific areas, which gives a brief description of the content of articles (Ahmed et al., 2022a; Ahmed et al., 2022b; Comerio & Strozzi, 2019). As shown in Figure 5, the keyword occurrence map, NM focused on marketing research, such as advertising (12 occurrences, 63 total link strength (TLS), which means that advertising occurred twelve times and the TLS for this total occurrence is 63 links to the NM topic; in addition, brand (6 occurrences, 42 TLS), followed by brain processes such as attention, emotion and memory. Finally, NM and advertising are correlated with neuroscience tools such as EEG and fMRI. This means that NM research investigates the consumer's brain responses to marketing stimuli (e.g., advertising, brand).

It has shown an excellent correlation between NM/consumer neuroscience and neuroimaging techniques (e.g., EEG, fMRI). Furthermore, a strong relationship between unconscious/subconscious reactions such as "attention", "emotion" and "memory" and stimuli such as "brand", "advertising" and "advertising effectiveness". For example, "advertising" is the first examined theme with 27 frequencies and 127 total link strength (TLS), followed by "attention" with eight frequencies and 51 TLS, next "emotion" with six frequencies and 27 TLS. In addition, it was

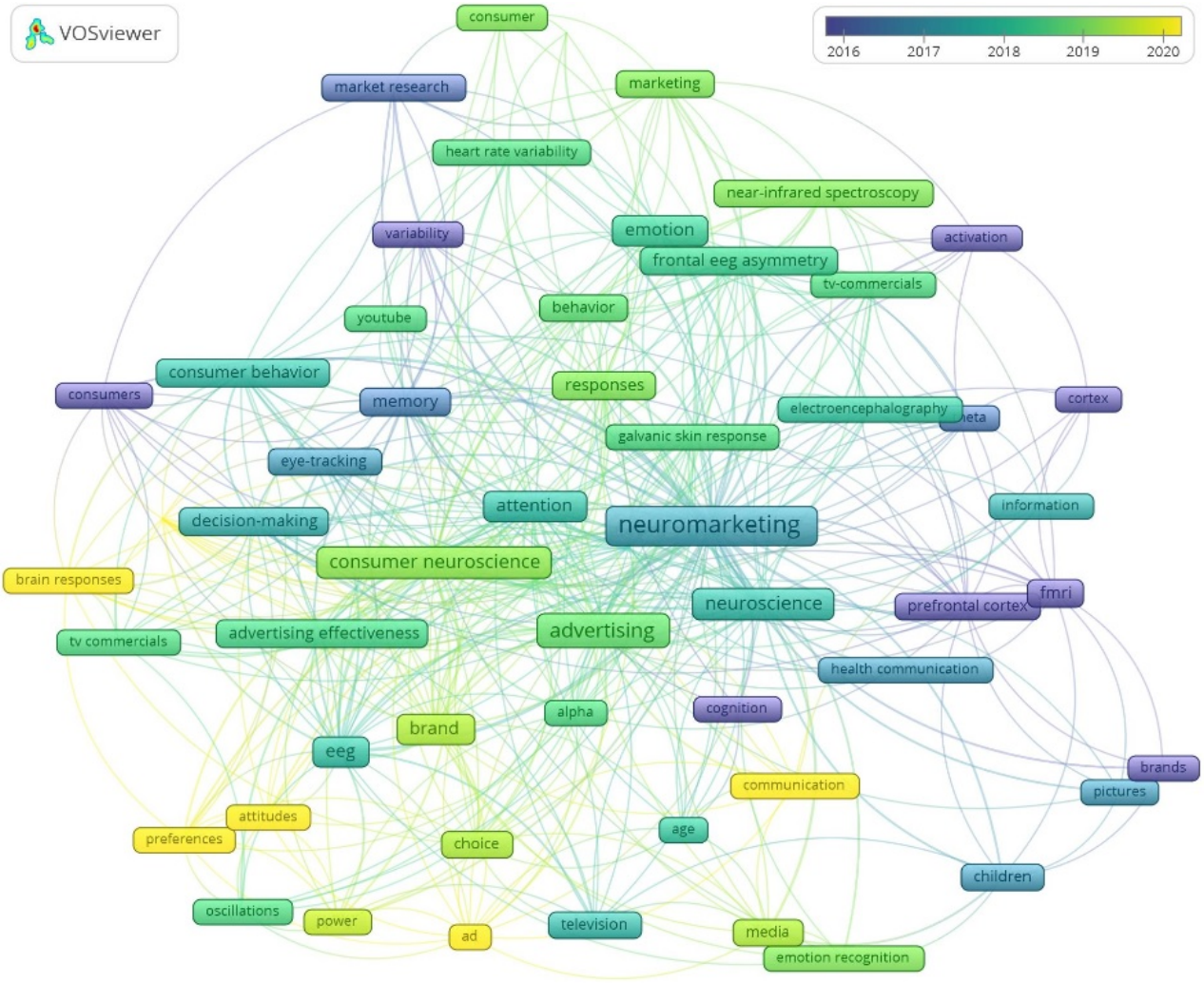

Figure 5. Keywords co-occurrence map (min. = two occurrences)

observed that "EEG" is significantly related to NM and advertising research. Table 7 shows the keywords with high frequency of occurrence, for which at least five occurrences were found.

Table 7
Top keywords (min. = five occurrences)

Keyword	Occurrences	TLS
Neuromarketing (NM)	27	127
Advertising	12	63
Neuroscience	11	59
Consumer neuroscience	10	70
Attention	8	51
EEG	7	50
Brand	6	42
Emotion	6	27
Memory	5	32
Advertising effectiveness	5	22
fMRI	5	19

The study used citation analysis to identify common articles in NM and advertising research. Article citation analysis is very important to identify commentary articles in the relevant field by knowing the TC of selected original articles (Kumar et al., 2019). The citation of forty-one original articles was analyzed. Table 8 shows the most cited articles in NM and advertising that had at least ten references. It was found that the most cited article is "Neuromarketing: The New Science of Consumer Behavior", which has 152 TCs, written by Morin (2011), published in the journal Society. Followed by an article named "On the Use of EEG or MEG Brain Imaging Tools in Neuromarketing Research" with 57 TCs by 2020, written by Vecchiato et al. (2011), contributed by Comput. Intell. Neurosci. Finally, the least cited document in the list is " Using Support Vector Machine on EEG for Advertisement Impact Assessment" was published in the journal Front. Neurosci., and written by Wei, Zhen et al. (2018), with 10 TCs.

Table 8
The top articles by TCs (min. = ten TCs)

Title	Authors	Journal	TCs 2020
"Neuromarketing: The New Science of Consumer Behavior"	Morin, C., 2011	Society	152
"On the Use of EEG or MEG Brain Imaging Tools in Neuromarketing Research"	Vecchiato, G., 2011	Comput. Intell. Neurosci.	57
"Branding and a child's brain: an fMRI study of neural responses to logos"	Bruce, A. S., 2014	Soc. Cogn. Affect. Neurosci.	41
"EEG Spectral Dynamics of Video Commercials: Impact of the Narrative on the Branding Product Preference"	Wang, R. W. Y., 2016	Sci. Rep.	40
"Technologies of ironic revelation: enacting consumers in neuromarkets"	Schneider, T., 2012	Consum. Mark. Cult.	32
"Mapping a Multidimensional Emotion in Response to Television Commercials"	Morris, J. D., 2009	Hum. Brain Mapp.	27
"Using the P3a to gauge automatic attention to interactive television advertising"	Treleaven-Hassard, S., 2010	J. Econ. Psychol.	26
"Consumer Neuroscience-Based Metrics Predict Recall, 9Liking and Viewing Rates in Online Advertising"	Guixeres, J., 2017	Front. Psychol.	19
"Eye Tracker Technology in Elderly People: How Integrated Television Content is Paid Attention to and Processed"	Ananos, E., 2015	Comunicar	18
"The Cognitive Processing of an Educational App with Electroencephalogram and Eye Tracking"	Cuesta-Cambra, U., 2017	Comunicar	17
"Social Consumer Neuroscience: Neurophysiological Measures of Advertising Effectiveness in a Social Context"	Pozharliev, R., 2017	J. Advert.	15
"Evaluation of Emotional Responses to Television Advertising through Neuromarketing"	Baraybar-Fernandez, A., 2017	Comunicar	12
"Consumers Favor "Right Brain" Training: The Dangerous Lure of Neuromarketing"	Lindell, A. K., 2013	Mind Brain and Education	12
"Electroencephalographic, Heart Rate, and Galvanic Skin Response Assessment for an Advertising Perception Study: Application to Antismoking Public Service Announcements"	Cartocci, G., 2017	J. Vis. Exp.	11
"Using Support Vector Machine on EEG for Advertisement Impact Assessment"	Wei, Z., 2018	Front. Neurosci.	10

4. Discussion

The literature review showed that the annual and cumulative number of publications has been increasing since 2004. The PRISMA protocol guidelines were followed to select and extract original articles relevant to this study, which focused on NM advertising and research. In addition, this study adopted a baseline analysis to learn about the current global trends in the relevant topics. Forty-one articles were selected and analyzed. The results showed that three countries, namely: Spain, Italy and the USA, published more than half of the total number of papers – twenty-six articles and more than three hundred TCs. For example, Spain alone has published eleven papers out of ninety-six TCs as of the end of 2020, being the most productive country compared to Italy and the USA, which published eight and seven papers respectively. In addition, the results of the study showed that the greatest contribution was made by the University of Rome Sapienza (Italy), Complutense University of Madrid (Spain) and Rey Juan Carlos University (Spain) – three papers and 72, 18 and 12 citations respectively. At the end of the list was the University of Salamanca with two papers and only one citation.

Regarding the most productive authors or researchers, although all authors in Table 5 published the same number of publications with two papers, it was found that Babiloni, F. is the most productive author with two papers based on the highest impact factor scores (68 TCs). According to the top journals, this study found that nine productive journals with at least two publications belong to six countries such as Switzerland, Spain, England, Poland, the Netherlands and Italy. The total volume of publications from these six countries amounted to twenty-eight articles, of which Swiss journals (e.g., Front. Psychol., Front. Neurosci. and Behav. Sci.) contributed fourteen articles and Spanish journals (e.g., Communicar and Vivat Academia) published six articles. In addition, it was found that the most prolific journal among others is Front. Psychol. with eight articles, followed by Comunicar and Front. Neurosci. with eight articles (four articles in each journal). The remaining journals, such as Comput. Intell. Neurosci., J. Econ. Psychol.,

Sci. Ann. Econ. Bus. and Neuropsychol. Trends published two articles each.

Analysis of keywords and citations showed that the most frequent keyword is "neuromarketing" with 27 occurrences and 127 TLS, followed by "advertising" and "neuroscience" with 12 and 11 occurrences and 63 and 59 TLS, respectively. According to the most cited papers, it was found that the most cited article among others is "Neuromarketing: The New Science of Consumer Behavior" with almost 152 citations, which was published by Morin (2011) in the journal "Society". While in the tail of the list was "Using Support Vector Machine on EEG for Advertisement Impact Assessment" with 10 TCs which written by Wei, Z. et al. (2018) and published by Front. Neurosci.

Summing up, the authors noticed that developing countries do not publish papers in the field of NM advertising and research. Therefore, this article encourages authors and scientists in these countries to share their ideas and contributions, and to increase funding for this revolutionary field that can help society (e.g., encouraging people to use seat belts in cars and now, during the COVID-19 pandemic, encouraging people to use disinfectants and masks, and also to care more about cleanliness, but for business, some companies and firms used emotional aspects, i.e., fear aspects in their advertising campaigns to increase their profits from the sale of their products), health (e.g., creating anti-smoking campaigns) and other areas. Hopefully, this study will provide comprehensive information that can be a guide for scientists in further research.

5. Conclusions and implications

Theoretically, the current findings can be divided into two components: first, neuroscientific techniques/methods allow to capture/measure signals of consumers' brain and body activity (e.g., emotions and feelings, attention, memory, perception, reward processing and motivation) to advertising campaigns. For example, neuroimaging tools (e.g., fMRI, EEG/ERP, fNIRS) allow the recording of neural signals of mental reactions (e.g., pleasure/displeasure, low/high arousal, recall and recognition of ads) to advertisements, which can be useful for advertisers and marketers in creating more effective advertising campaigns to attract, capture and influence consumers. Meanwhile, physiological tools, such as eye movement tracking, can enrich scientists with valuable information about physiological responses such as pupil dilation, fixation, and eye movements towards stimuli. Secondly, it is possible to identify problems related to the attractiveness, strengths and weaknesses of incentives (e.g., advertising, brand logo, products, ... etc.) that lead to consumer decisions by practitioners before their actual implementation.

NM is a new generation marketing industry that has the prospect of not only studying but also solving such commercial problems as the issue of advertising effectiveness, as well as reducing the waste of advertising budget, creating more effective advertising campaigns in the social, political and medical sectors in order to raise people's awareness. Today, the competition between companies and firms has increased significantly due to technological progress, so each firm resorts to the use of technology to win the competition and increase its market share. Thus, large companies turn to NM agencies to conduct their advertising research and maximize profits with the help of NM methods that allow tracking unconscious/subconscious reactions of consumers to advertising. Most studies in the field of advertising research have identified the main mental processes of interest in advertising research, such as emotions and feelings, attention, memory, reward processing, motivation and perception.

The findings suggest that neuroscientific methods and techniques are very important in mapping consumers' neural and physiological responses to advertising. The authors believe that this study will provide comprehensive information about the latest advertising research, which can help beginning researchers and students interested in NM and advertising research.

6. Limitations and future research directions

Although it reduced the methodology shortcomings, there are obstacles in this study that give a chance for future research. For example, it focused on original English language articles that conducted experiments in advertising using NM methods or techniques and obtained results, and this study ignored other non-English language papers such as, but not limited to, review articles. Therefore, this study is not completely free from bias. To identify future trends, it is suggested to expand the research to include other areas such as social sciences, education, management, consumer behavior, leadership and productivity. As can be seen, developing countries have not been involved in neuromarketing research, so the authors call on scientists from these countries to contribute to this revolutionary field of marketing and consumer behavior science.we

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