



# Exploring global trends and future directions in advertising research: A focus on consumer behavior

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## Abstract

This study aims to select the physiological and neurophysiological studies utilized in advertising and to address the fragmented comprehension of consumers' mental responses to advertising held by marketers and advertisers. To fill the gap, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was employed to select relevant articles, and bibliometric analysis was conducted to determine global trends and advancements in advertising and neuromarketing. The study selected and analyzed forty-one papers from the Web of Science (WoS) database from 2009–2020. The results indicated that Spain, particularly the Complutense University of Madrid, was the most productive country and institution, respectively, with 11 and 3 articles. The journal *Frontiers in Psychology* was the most prolific, with eight articles. The article "Neuromarketing: The New Science of Consumer Behavior" had the most citations (152 T.Cs). Additionally, the researchers discovered that the inferior frontal and middle temporal gyri were associated with pleasant and unpleasant emotions, respectively, while the right superior temporal and right middle frontal gyrus was connected to high and low arousal. Furthermore, the right prefrontal cortex (PFC) and left PFC were linked to withdrawal and approach behaviors. In terms of the reward system, the ventral striatum played a critical role, while the orbitofrontal cortex and ventromedial PFC were connected to perception. As far as we know, this is the first paper that focused on the global academic trends and developments of neurophysiological and physiological instruments used in advertising in the new millennium, emphasizing the significance of intrinsic and extrinsic emotional processes, endogenous and exogenous attentional processes, memory, reward, motivational attitude, and perception in advertising campaigns.

**Keywords** PRISMA · Bibliometric analysis · Neuromarketing · Advertising · WoS database · Consumers' responses

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## Introduction

Qualitative methods have been used in marketing research for a long time to measure the consumer's attitudes and behaviors toward advertising campaigns, which is actually measuring consumers' awareness behavior such as attitudes and perceptions (Carrington et al., 2014). Therefore, advertisers and marketers resorted to the use of neuroscientific methods or techniques such as functional magnetic resonance imaging (fMRI) in the marketing field in general and advertising in specific to study, measure and understand the unconscious/subconscious responses of customers to stimuli, which largely contribute in the decision-making process (Harris et al., 2018; Plassmann et al., 2012). Using neuroscientific methods to better understand the concealed behavior of customers toward external stimuli such as marketing and environmental in the last 20 years has led to an emerging mixed field, so-called "Neuromarketing", which used

neuroscientific and self-report methods to get more accurate findings about conscious and unconscious responses of the customer to advertising (Alsharif et al., 2021a). According to the literature, in 2022, professor Smidts (2002) coined the NM (NM) term. According to Javor et al. (2013), NM is placed on the borderline of neuroscience, marketing, and psychology, which has been spread by the USA company named "Bright House Company" (Fortunato et al., 2014), when this company established the first neuroscience department for marketing research.

Contemporarily, NM is one of the most important fields for studying customers' neural and physiological responses, such as inner and extrinsic responses toward marketing stimuli and advertising. In addition to the aforementioned, some researchers and scholars considered NM an embryonic field that needs more improvements to overcome the artifacts in some techniques (Alsharif et al., 2021b). Bočková et al. (2021) mentioned that NM is in an improving process because of technological advancement in communication and medical fields recently. The technology has been utilized by the marketing and advertising leader to enhance marketing and advertising success by managing and reducing task conflicts, as stated by To et al. (2021). Isabella et al. (2015) have categorized neuromarketing instruments into two groups: (1) neurophysiological tools, including EEG, MEG, fMRI, PET, and TMS, and (2) physiological tools, such as GSR, ET, ECG, and EMG. As mentioned by Ahmed et al. (2022c); Izhikevich (2003), neurophysiological instruments capture the cognitive and emotional reactions toward advertising, including arousal, pleasure, engagement, approach, and withdrawal. Meanwhile, physiological tools like eye-tracking (ET), according to (Ahmed et al., 2020; Dimpfel, 2015), monitor physiological responses such as visual fixation, pupil dilation, eye movements, heartbeat, perspiration, and excitement at the point of purchase. This enables the acquisition of dependable and useful information concerning preferences, such as whether a product is liked or not liked.

According to the literature, the first official publication in NM was done in 2004 by McClure et al. (2004), which contributed to shifting the NM studies from a pure study to a practical one. NM research is highly significant for the academic and industrial world to overcome the limitations of traditional methods, such as consumer social bias (e.g., consumer choices can be affected by others) (Alsharif et al., 2022; Fortunato et al., 2014). The COVID-19 pandemic has created a lot of concerns globally in markets, businesses, and establishments' activities (Aki et al., 2020). However, understanding the global trends in advertising research within the NM field (e.g., the most prolific countries/academic institutions, the most-cited articles, the most productive journals, authors, and so forth) is still unclear in academic studies. Thus, we aim to provide a comprehensive overview of the top and new approaches in the field, recent methods, and

other relevant aspects that would be more interesting and beneficial to scholars. Our key contribution is to provide a broader perspective that goes beyond just publication and citation data, and we hope that our article will be useful to researchers and practitioners in their research. In addition, The main difference in the current paper is that the current paper focused on empirical that used neurophysiological such as fMRI, EEG, fNIRS and physiological tools such as ET, ECG, GSR/EDA, and EMG to study the mental responses of consumers behavior (e.g., inner and extrinsic emotional responds, perceptions, motivational of customers attitudes, reward system, endogenous and exogenous attentional processes, and memory) toward advertising research within NM. The present study endeavors to achieve a precise and succinct conclusion by conducting an in-depth analysis of the extracted articles. The primary contributions of this research are outlined as follows:

- Provide the latest update on the global trends in advertising research within the NM field, such as the most prolific countries/academic institutions, the most-cited articles, the most productive journals and authors, etc.
- Provides a comprehensive assessment of the up-to-date advertising studies that have used neurophysiological and physiological techniques to investigate the consumers' behavior, such as inner and extrinsic emotional responses, motivational attitudes, perceptions, reward, memory, and endogenous and exogenous attentional processes toward advertising.
- Provides a comprehensive overview of studies that used neurophysiological and physiological tools between 2009 and 2020.

In summary, this study offers a thorough examination of neuromarketing and its present research objectives. The second section outlines the data collection materials and methodologies, while the third section presents the bibliometric and content analysis of the articles selected for this study. The fourth section discusses the limitations and challenges of applying neuromarketing. Findings are discussed in section five, and the study concludes in section six.

## Methods

This study is designed to identify original articles on advertising in the field of neuromarketing by searching the Web of Science (WoS) database, thereby addressing a gap in the existing literature. WoS was selected over Scopus due to its cleaner data, which helps to minimize duplication, and because it includes publications from top-tier journals (Strozzi et al., 2017). In the first step of our research, we followed the Preferred Reporting Items for

Systematic Reviews and Meta-Analyses (PRISMA) protocol developed by Moher et al. (2015) to identify empirical articles in advertising research that used neurophysiological and physiological tools to investigate consumers' behavior in the context of neuromarketing (as shown in Fig. 2). For the second step, we conducted a bibliometric analysis to identify global trends and advancements in advertising research within the field of neuromarketing, including the most productive countries and academic institutions, the number of publications and citations, and the most prolific authors in the field (as recommended by Ahmed et al. (2022a), (Ahmed et al., 2022b); Ahmed et al. (2021); Pilelienė et al. (2022)). To conduct this analysis, we followed the guidelines Block and Fisch (2020) set forth to ensure that our analysis was impactful and accurate, and used VOSviewer software to visualize our findings. VOSviewer is a widely-used tool for bibliometric research and has been employed in previous studies (see Abbas et al. (2022); Ali et al., (2021a, 2021b); Alsharif et al. (2020); Alsharif et al. (2021c)). Figure 1 provides an overview of the analytical structure of our study, including the methods used and the organization and structure of the study itself.

These processes will give us a deep insight into advertising advancement by identifying and analyzing the general and specific domains. Additionally, it would give us a comprehensive understanding of the most common NM tools used in advertising research, the most productive academic institutions, and the top productive authors to

be considered when conducting further research in advertising research. Therefore, the findings provide a guide for scholars who are interested in the advertising and NM field.

Relevant documents were extracted from the WoS by using the following query applied to the title, abstract, and keywords: (("neuromarketing" OR "consumer neuroscience") AND ("adverti\*")) to extract the relevant articles related to this study and fill the gap. This paper has focused on the papers that used neurophysiological and physiological tools in advertising research between 2009 and 2020; therefore, the total number of publications was 125 documents from 2009 to 2020. The study focused on original journal articles, which are subject to a more thorough review process than conferences and book chapters. This helps to increase the credibility of research published in journals (Saha et al., 2020).

The researchers selected 41 articles from the WoS database and followed the PRISMA protocol, which involves four steps for selecting relevant articles. These steps include identification through database searching, screening of publications, assessing eligibility, and selecting relevant articles. The included articles had to meet the specific characteristics outlined in Fig. 2:

- Articles published in advertising research within the NM context from 2009 to 2020 were included.
- Articles that used neurophysiological and physiological tools in advertising research were included.

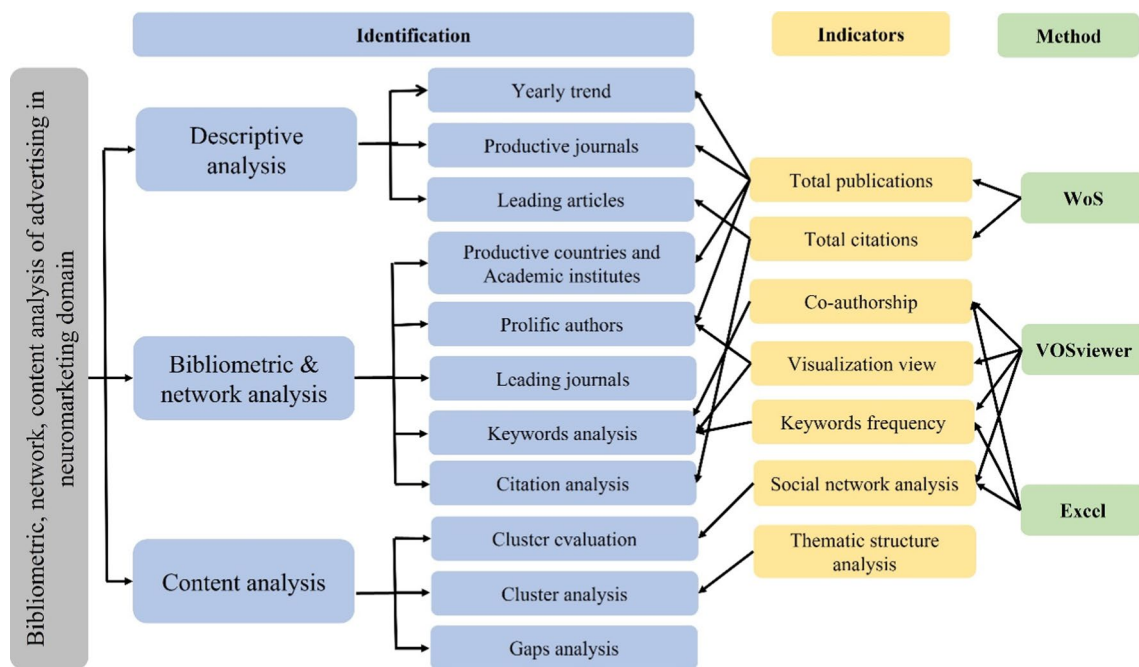
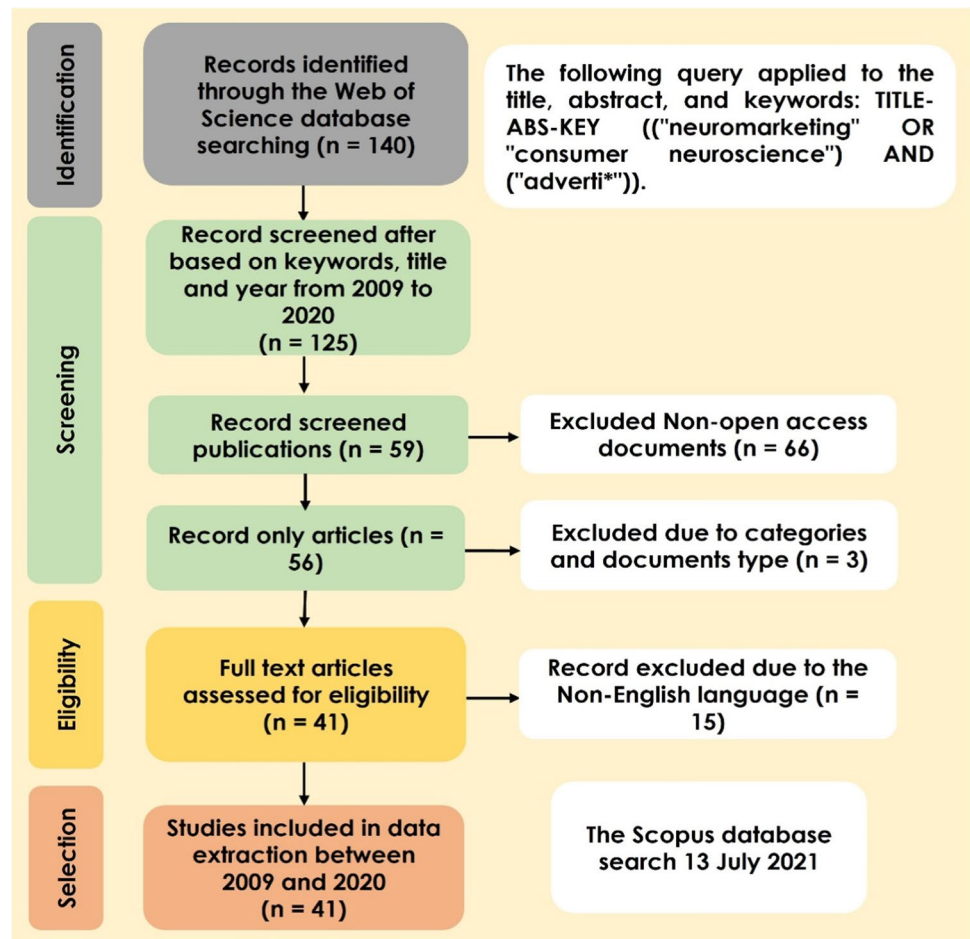


Fig. 1 Analytical structure of the current paper

**Fig. 2** PRISMA flow chart for selecting publications for the current study



- Articles published in the non-English language were excluded.
- Publications such as book chapters, conferences, and so forth were excluded.

## Result

Table 1 provides an overview of the chosen articles in advertising research. By analyzing these articles, we were able to identify three key dimensions in the field of neuromarketing: (i) studies on advertising in the context of neuromarketing; (ii) the use of neurophysiological and physiological techniques in advertising; and (iii) consumers' unconscious and subconscious reactions to advertising. Through our review of these papers, we hope to gain a deeper understanding of the subject matter and meet the goals of this review article.

## Descriptive analysis

We conducted a descriptive analysis of forty-one articles in the advertising field and utilized neuromarketing instruments to determine the overall trend in advertising, including

annual and cumulative publications of countries, academic institutions, and journal outlets.

## Growth of the publication

Forty-one articles in journals belonging to the WoS database related to advertising have been published, which have used NM tools. As we can see there is a fluctuation in the number of publications in advertising and NM research from 2009 to 2020. In 2020, it was the highest number of annual publications with thirteen articles, as depicted in Fig. 3.

## Journal outlets

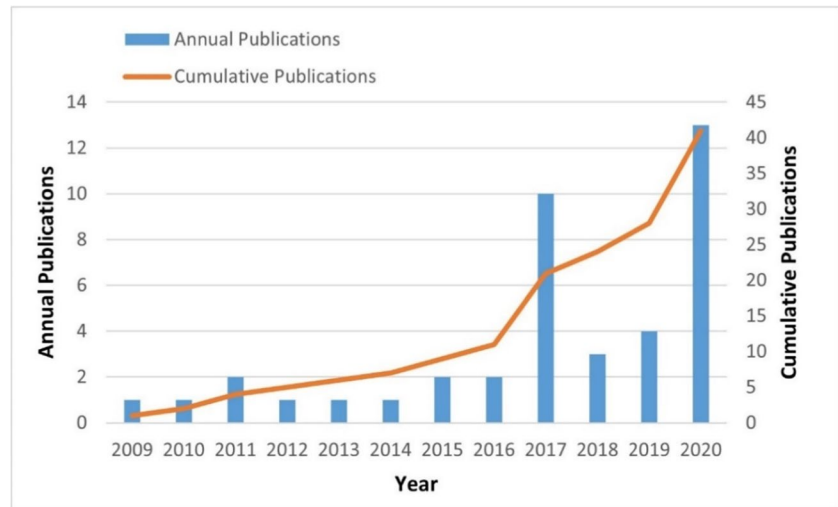
The results indicate that six countries were represented by eight publishers, who published a minimum of two articles in advertising and NM. Table 2 lists the publishers and their respective number of publications. Frontiers Media Sa and MDPI, both based in Switzerland, were the top publishers in NM and advertising with fourteen articles, which accounted for 34% of the total articles. Grupo Comunicar and University Complutense Madrid, based in Spain, followed with six articles. While Hindawi Ltd had only published two

**Table 1** Studies selected on the dimensions of this review

Dimensions		Published articles
Advertising studies within NM context	Advertising/ advertising effectiveness	Morris et al. (2009);Treleaven-Hassard et al. (2010);Ananos (2015);Guixeres et al. (2017);Wei et al. (2018);Baraybar-Fernández et al. (2017);Christoforou et al. (2015);Wang et al. (2016);Grigaliunaite and Pileliene (2016);García-Madariaga et al. (2020);Herrador et al. (2020);Pileliene and Grigaliunaite (2017);Lajante et al. (2020);Leanza (2017);Barquero-Pérez et al. (2020);Boscolo et al. (2020);Eijlers et al. (2020);Cassioli (2019);Lindell and Kidd (2013);Pozharliev et al. (2017);Harris et al. (2019);Cartocci et al. (2017);Harris et al. (2019);Shi et al. (2017);Modica et al. (2018); Falk et al. (2012);Venkatraman et al. (2015)
Neurophysiological and physiological tools used in advertising	EEG/ERP	Wang et al. (2016);Treleaven-Hassard et al. (2010);Guixeres et al. (2017);Cuesta-Cambra et al. (2017);Cartocci et al. (2017);Wei et al. (2018);Harris et al. (2019);García-Madariaga et al. (2020);Leanza (2017);Eijlers et al. (2020);Cassioli (2019);Davidson (2004);Cherubino et al. (2015);Modica et al. (2018);Venkatraman et al. (2015)
	fMRI/MRI	Bruce et al. (2014);Morris et al. (2009);Lindell and Kidd (2013);Shi et al. (2017);Falk et al. (2012)
	fNIRS	Krampe et al. (2018)
	ET	Pileliene and Grigaliunaite (2017);Guixeres et al. (2017);Ananos (2015);Cuesta-Cambra et al. (2017);Christoforou et al. (2015);Grigaliunaite & Pileliene (2016);García-Madariaga et al. (2020);Boscolo et al. (2020);Venkatraman et al. (2015)
	ECG	Guixeres et al. (2017);Cartocci et al. (2017);Baraybar-Fernández et al. (2017);Christoforou et al. (2015);Barquero-Pérez et al. (2020);Modica et al. (2018);Venkatraman et al. (2015)
	GSR/EDA	Lajante et al. (2020);Cartocci et al. (2017);Baraybar-Fernández et al. (2017);Herrador et al. (2020);Leanza (2017);Barquero-Pérez et al. (2020);Nuñez-Gomez et al. (2020);Modica et al. (2018);Venkatraman et al. (2015)
	EMG	Lajante et al. (2020);Karim et al. (2017)
Unconscious and subconscious responses of consumers toward advertising	Emotion and feelings (reward, motivation), attention (selective attention, perception), memory (remember/ not remember)	Morris et al. (2009);Baraybar-Fernández et al. (2017);Herrador et al. (2020);Lajante et al. (2020);Leanza (2017); Barquero-Pérez et al. (2020);Nuñez-Gomez et al. (2020);Eijlers et al. (2020);Cassioli (2019);Guixeres et al. (2017);Shen and Morris (2016);Davidson (2004);Cherubino et al. (2015);Treleaven-Hassard et al. (2010);Bakalash and Riemer (2013);Morey (2017);Astolfi et al. (2009);Langleben et al. (2009);Ananos (2015);Cuesta-Cambra et al. (2017);Herrador et al. (2020);Nuñez-Gomez et al. (2020);Boscolo et al. (2020);Cassioli (2019);Modica et al. (2018);Cartocci et al. (2017);Falk et al. (2012)



**Fig. 3** The annual and cumulative publications in advertising and NM



**Table 2** The most Productive journal in NM and advertising (with min. 2 documents)

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

TP; total publications, TC; total citations,

articles in advertising and NM, their article by Vecchiato et al. (2011) had the most citations with fifty-seven citations. Stallen et al. (2010) from the Netherlands had the second most cited article with thirty-eight citations, and they also published two articles.

## Bibliometrics analysis

### Productive countries and academic institutions

A total of 41 papers from the WoS database were analyzed, and the results are summarized in Table 3. The findings reveal that Spain, Italy, and the USA are the primary contributors to advertising research in the context of NM, accounting for over 60% of the total publications. This suggests that these countries play a crucial role in advancing studies in advertising research within the NM context. Specifically, Spain had the highest number of publications, with eleven papers (approximately 26.83% of total papers), followed by

**Table 3** The most productive countries (minimum contributions two documents)

#	Country	TP	TC	% 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%

Italy, with almost eight documents (19.51% of total documents). The USA ranked third with seven documents (almost 17% of total documents), while Australia and England tied for fourth place with four documents each. The Netherlands

had three documents, ranking fifth. Finally, China, Lithuania, and Germany, with two documents each.

Table 4 presents a group of academic institutions that have contributed significantly to advertising research in NM, publishing at least two papers. Sapienza University Rome, Complutense University of Madrid, and Universidad Rey Juan Carlos are the most prolific institutions. They have produced nine documents with three publications from each institution. Following them are Brainsigns SRL, Catholic University of the Sacred Heart, Erasmus University Rotterdam, Vytautas Magnus University, Swinburne University of Technology, and the University of Salamanca, having contributed two documents each, making twelve publications among them.

**Prolific authors**

We have identified the top prolific authors in the NM context who have contributed at least two advertising research papers. These authors belong to four countries, Italy, Spain, Lithuania, and Australia. Table 5 presents the list of these authors who collaborated extensively and published 26 documents. Notably, each author has published an equal number

of two papers, and hence, we have grouped them into four clusters, as shown in Fig. 4. Cluster 1, the most collaborative cluster, comprises six authors from Sapienza University Rome (Italy), namely Babiloni, Fabio; Cherubino, Patrizia; Carato, Myriam; Rossi, Dario; Modica, Enrica; and Cartocci, Giulia. Cluster 2 includes four authors from Universidad Rey Juan Carlos (Spain), namely Goya-Esteban, Rebeca; Banos-Gonzalez, Miguel; Baraybar-Fernandez, Antonio; Barquero-Perez, Oscar. Cluster 3 comprises two authors, Pileliene, Lina, and Grigaliunaite, Viktorija, from Vytautas Magnus University (Lithuania). Finally, Ciorciari, Joseph from Swinburne University of Technology (Australia) belongs to cluster 4.

**Leading journal**

In this section, we have identified eight highly productive journals that have published at least two papers in advertising research within the NM context. These journals are presented in Table 6, and *Frontiers in Psychology* emerged as the most prolific journal, publishing eight articles. *Comunicar* and *Frontiers in Neuroscience* followed closely behind, with four articles each. The remaining journals,

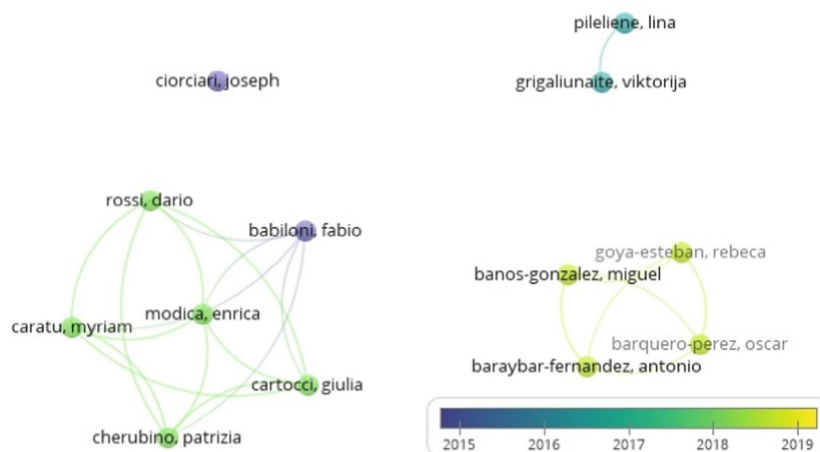
**Table 4** The most prolific academic institutions in advertising research and NM (minimum contributions two documents)

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

**Table 5** The most Productive authors in NM and advertising (minimum contributions two documents)

Autho’s name	TP	TC	H-index	Affiliation	Country
Babiloni, Fabio	2	68	2	Sapienza University Rome; Brainsigns SRL	Italy
Ciorciari, Joseph	2	29	2	Swinburne University of Technology	Australia
Modica, Enrica	2	25	2	Sapienza University Rome	Italy
Rossi, Dario	2	25	2	Sapienza University Rome	Italy
Carato, Myriam	2	15	2	Sapienza University Rome	Italy
Cartocci, Giulia	2	15	2	Sapienza University Rome	Italy
Cherubino, Patrizia	2	15	2	Sapienza University Rome; Brainsigns SRL	Italy
Banos-Gonzalez, Miguel	2	12	1	Universidad Rey Juan Carlos	Spain
Baraybar-Fernandez, Antonio	2	12	1	Universidad Rey Juan Carlos	Spain
Barquero-Perez, Oscar	2	12	1	Universidad Rey Juan Carlos	Spain
Goya-Esteban, Rebeca	2	12	1	Universidad Rey Juan Carlos	Spain
Grigaliunaite, Viktorija	2	7	2	Vytautas Magnus University	Lithuania
Pileliene, Lina	2	7	2	Vytautas Magnus University	Lithuania

**Fig. 4** The network map of leading authors (minimum contribution of two documents)



including Computational Intelligence and Neuroscience, Journal of Economic Psychology, Scientific Annals of Economics and Business, Behavioral Sciences, Neuropsychological Trends, and Vivat Academia, contributed two papers each. Additionally, the number of citations a journal receives is an indicator of its article's quality and popularity, while the publication number reflects its productivity. To evaluate the leading journals, we computed their average citation per item (ACI) using total citations (TC) and total publications (TP) from the WoS database. Table 6 indicates that the Journal of Economic Psychology and Computational Intelligence and Neuroscience have the highest ACI, despite only publishing two papers on advertising and NM, with 32 and 31 citations, respectively. These findings suggest that many publications do not necessarily imply a high number of citations.

### Keywords analysis

The bibliometric analysis involves representing the frequency of keywords in papers numerically (Wang & Chai, 2018), to assess their relevance and coherence with the

papers' content (Comerio & Strozzi, 2019). Additionally, the correlation between pairs of keywords is expressed numerically as link strength, where a higher numerical value indicates a stronger link based on the number of times both keywords appear in the same paper (Ravikumar et al., 2015). The total number of links signifies the overall number of appearances of the two keywords in the same article. In this study, we conducted a keyword co-occurrence analysis on 56 keywords from 41 articles in 23 journals, with a minimum requirement of one source document. Synonymous keywords were also analyzed before inclusion, such as "neuromarketing" and "consumer neuroscience." To appear on the bibliometric map between two keywords that occur together in the same paper, a minimum of two occurrences of a keyword was required in VOSviewer.

According to Comerio and Strozzi (2019), keyword co-occurrence analysis is a crucial technique for understanding the content of articles and evaluating current research trends in a specific topic, such as advertising in neuromarketing. This technique is useful in identifying research directions and assessing hot themes. Ahmed et al. (2020) also noted that the analysis could reveal current academic

**Table 6** The most Productive journal in NM and advertising (with min. two documents)

Source/Journal	TP	TC	ACI	Publisher	Country
Frontiers in Psychology	8	29	3.6	Frontiers Media Sa	Switzerland
Comunicar	4	55	13.8	Grupo Comunicar	Spain
Frontiers in Neuroscience	4	10	2.5	Frontiers Media Sa	Switzerland
Computational Intelligence and Neuroscience	2	62	31	Hindawi Ltd	England
Journal of Economic Psychology	2	64	32	Elsevier	Netherlands
Scientific Annals of Economics and Business	2	7	3.5	De Gruyter Poland Sp Zoo	Poland
Behavioral Sciences	2	4	2	MDPI	Switzerland
Neuropsychological Trends	2	1	0.5	Edizioni Univ Lettere Economic Diritto	Italy
Vivat Academia	2	1	0.5	University Complutense Madrid	Spain

Note. TP; total publications, TC; total citations, ACI; average citation per item





## Citation analysis

In this section, we employed citation analysis to identify the most popular articles in the area of advertising and NM. Citation analysis is a method that counts the number of times other scholars refer to a paper. It is an effective way to determine the most popular articles in a given field (Kumar et al., 2019). We scrutinized and evaluated the citations of forty-one papers. The outcomes are presented in Table 8, which summarizes the most-referenced articles in the field of advertising and NM with a minimum of ten citations. Our results indicate that the most-cited article in this area is "Neuromarketing: The New Science of Consumer Behavior" authored by Morin (2011) and published in the journal *Society*, with a total of hundred-fifty-two citations. The second most-cited paper is "On the Use of EEG or MEG Brain

Imaging Tools in Neuromarketing Research" authored by Vecchiato et al. (2011) and published in the journal *Computational Intelligence and Neuroscience*, with 57 citations as of the end of 2020. Finally, the least cited paper on the list is "Using Support Vector Machine on EEG for Advertisement Impact Assessment" published by Wei et al. (2018) in the journal *Frontiers in Neuroscience*, with a total of ten citations.

## Content analysis of selected papers

### Inner and extrinsic emotional processes

According to Dolcos et al. (2019); Eijlers et al. (2020), feelings are an extrinsic emotional status that is a conscious response of customers, which can be translated to

**Table 8** The top papers on WOS by citation score with minimum ten citations

Title	Authors	Journal	T.Cs 2020
Neuromarketing: The New Science of Consumer Behavior	Morin, 2011	<i>Society</i>	152
On the Use of EEG or MEG Brain Imaging Tools in Neuromarketing Research	Vecchiato et al., 2011	<i>Computational Intelligence and Neuroscience</i>	57
Branding and a child's brain: an fMRI study of neural responses to logos	Bruce et al., 2014	<i>Social Cognitive and Affective Neuroscience</i>	41
EEG Spectral Dynamics of Video Commercials: Impact of the Narrative on the Branding Product Preference	Wang et al., 2016	<i>Scientific Reports</i>	40
Technologies of ironic revelation: enacting consumers in neuromarkets	Schneider, T, 2012	<i>Consumption Markets and Culture</i>	32
Mapping a Multidimensional Emotion in Response to Television Commercials	Morris et al., 2009	<i>Human Brain Mapping</i>	27
Using the P3a to gauge automatic attention to interactive television advertising	Treleaven-Hassard et al., 2010	<i>Journal of Economic Psychology</i>	26
Consumer Neuroscience-Based Metrics Predict Recall, Liking and Viewing Rates in Online Advertising	Guixeres et al., 2017	<i>Frontiers in Psychology</i>	19
Eye Tracker Technology in Elderly People: How Integrated Television Content is Paid Attention to and Processed	Ananos, 2015	<i>Comunicar</i>	18
The Cognitive Processing of an Educational App with Electroencephalogram and "Eye Tracking"	Cuesta-Cambra et al., 2017	<i>Comunicar</i>	17
Social Consumer Neuroscience: Neurophysiological Measures of Advertising Effectiveness in a Social Context	Pozharliev et al., 2017	<i>Journal of Advertising</i>	15
Evaluation of Emotional Responses to Television Advertising through Neuromarketing	Baraybar-Fernández et al., 2017	<i>Comunicar</i>	12
Consumers Favor "Right Brain" Training: The Dangerous Lure of Neuromarketing	Lindell, AK., 2013	<i>Mind Brain and Education</i>	12
Electroencephalographic, Heart Rate, and Galvanic Skin Response Assessment for an Advertising Perception Study: Application to Antismoking Public Service Announcements	Cartocci et al., 2017	<i>Jove-Journal of Visualized Experiments</i>	11
Using Support Vector Machine on EEG for Advertisement Impact Assessment	Wei et al., 2018	<i>Frontiers in Neuroscience</i>	10

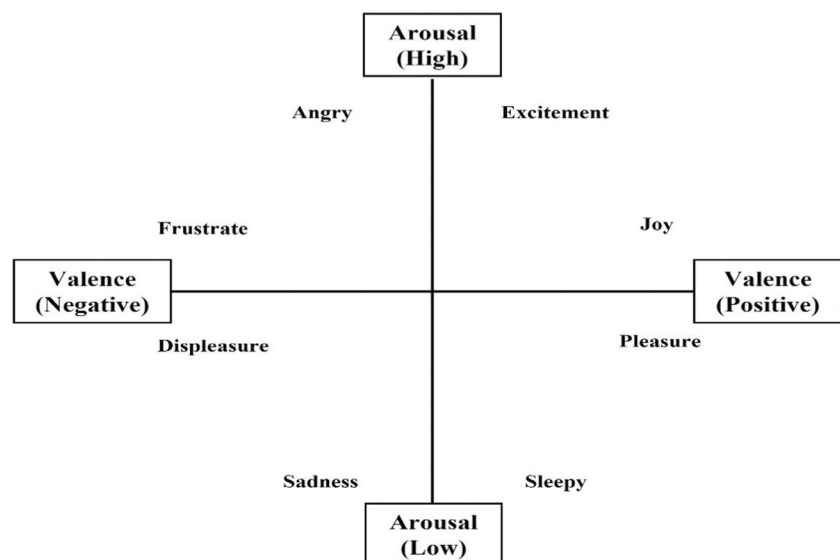
pleasant/unpleasant responses toward advertising. Feelings are considered an important aspect of understanding and interpreting the physiological response to advertising campaigns (Eijlers et al., 2020; Siddharthan et al., 2018). Morris et al. (2009); Pham et al. (2013) mentioned that feelings stimulated by advertising refer to the response of customers toward that advertisement, which can be considered as the enormous index of customers' responses to the advertisement (Ahmed et al., 2023b). According to Dolcos et al. (2019); Ramsay (2014), emotions are an inner emotional status, which is an unconscious/subconscious response of customers. These responses are linked to the involuntary nervous system, for example, increased heart rate in some cases as fear, anger, happiness, and so forth, which plays a vital role in the decision-making process, learning, and solving problems (Gordon, 2006). In addition to the aforementioned, changes in the involuntary nervous system result in changes in facial muscles, such as zygomatic and corrugator muscles, which can provide important information about unspoken decisions, customers' inner and extrinsic emotional status toward advertising (Winkielman et al., 2008). Thus, inner and extrinsic emotional responses have grabbed advertisers and marketers researchers to employ both in advertising campaigns to grab customers' attention and influence their decision (Alsharif et al., 2021a).

According to Barrett and Satpute (2013), emotions are produced from a set of neural activities, which execute basic functions psychological such as perception and memory. Emotion has several definitions based on the following way of the scholar. For example, Damasio and Carvalho (2013); Damasio (1999) defined emotion as changes in a customer's or individual's neural and physiological responses according to previous experiences. At the same time, LeDoux and Brown (2017) defined it as the relationship between

the customer/individual and the surrounding environment, including physiological and behavioral factors. Accordingly, emotions' role in decision-making has been explored and interpreted using neurological and cognitive frameworks such as somatic sign theory (Damasio, 2012; Reimann & Bechara, 2010). Valence measures from positive, i.e., a pleasure, to negative, i.e., displeasure; at the same time, arousal measures from high, i.e., a surprise, to low, i.e., calmness, as depicted in Fig. 6 (Lang et al., 1997; Posner et al., 2005; Russell & Barrett, 1999).

(Sundar & Kalyanaraman, 2004) noted that several studies have utilized self-report and physiological methods to map and measure customers' emotional responses to ads. For instance, Lajante et al. (2020) used both EMG and self-report to assess customers' positive or negative reactions to ads. They found that these reactions positively affected customers' attitudes toward the ads. Baraybar-Fernández et al. (2017) employed ECG, EDA/GSR, and questionnaires to evaluate the impact of visual and audio messages in ads on participants. They discovered that sad messages had a significant influence on the participants. Barquero-Pérez et al. (2020) used ECG, EDA, and questionnaires to investigate the emotional responses to different kinds of ads and found that each type of ad elicited a unique emotion, including surprise. Guixeres et al. (2017) conducted brain response, ECG, and eye-tracking studies and found a strong correlation between ad effectiveness and the number of views on YouTube. According to Herrador et al. (2020), the EDA experiment showed that both male and female groups experienced strong initial activation. Still, there was reduced activation during the male group's most critical part of the video material. Finally, Venkatraman et al. (2015) discovered that activity in the ventral striatum could predict the response to advertising.

**Fig. 6** Dimensions model of emotions (Posner et al., 2005)



Neurophysiological instruments like fMRI and EEG have been extensively utilized in advertising research by various researchers research (Banos-González et al., 2020; Boscolo et al., 2020; Crespo-Pereira et al., 2017; Eijlers et al., 2020; Guixeres et al., 2017; Silberstein & Nield, 2012). For instance, the EEG analysis by Vecchiato et al. (2010); Vecchiato et al. (2012) indicated that the activity in the right frontal alpha is related to positive/liked ads, whereas the left frontal alpha is correlated with negative/disliked ads. Eijlers et al. (2020) used EEG to investigate and found that arousal is positively associated with successful ads among a large population, but consumer attitudes have a negative association. Morris et al. (2009); Shen and Morris (2016) employed fMRI to determine the affective responses of individuals towards advertising and found that the inferior frontal and middle temporal gyri were activated in response to positive and negative stimuli, respectively. Furthermore, they found that the right superior temporal and right middle frontal gyrus were activated in response to low and high arousal. Leanza (2017) EEG study found that some emotional aspects of the Virtual Reality (VR) experience significantly impacted consumer preferences.

### Endogenous and exogenous attentional processes

Attention is described as "the tendency of humans to seek, accept, and absorb messages that match their interests, beliefs, values, expectations, and ideas while ignoring those that are incompatible with this system" (Hovland et al., 1949). Additionally described as selective perception (Wu et al., 2019). Selective perception is characterized by filtering away irrelevant information and focusing on essential information (e.g., different aspects of stimulus or different stimuli) (Dayan et al., 2000). Daily, customers are exposed to about 10 million pieces of visual information (such as advertisements, pictures, music, video, and color) through their senses (such as their eyes, ears, and skin). The majority of incoming data passes undetected, although consumers may digest about 40 bits of input data every second (Cherubino et al., 2019; Scheier & Held, 2006). That leads us to conclude that attention substantially impacts how consumers represent, interpret, and process information and, therefore, how they choose to prioritize information (Ahmed et al., 2020). Attentional and emotional processes are intertwined, and emotion is seen as a trustworthy and successful means of attracting customers' attention (Genco et al., 2013; Matthews & Wells, 1999). For instance, emotional stimuli are associated with the activation of the amygdala (AMY) and cingulate cortex (CC) in the brain (Montazeribarforoushi et al., 2017).

Attention is a fundamental brain activity that plays a vital role in assessing the efficiency of advertising campaigns; hence, it indicates consumer behavior and advertising

effectiveness (Hamelin et al., 2021). The bulk of researchers have identified two systems to evaluate attention to advertising: (i) the exogenous attentional system and (ii) the endogenous attentional system (Kandel, 2009; Knudsen, 2007; Venkatraman et al., 2015). The exogenous attentional system (visual saliency/exogenous/involuntary) is triggered by external stimuli such as color, discount, voice, promotion, faces, text, novelty, brightness, etc., leading to the automatic processing of the information contained in external stimuli. Top-Down (goal-driven/endogenous/voluntary) attention, this other sort of attentional system is launched by internal and external objectives and expectations; hence, it is necessary to concentrate all of your mental energy on the goal you are seeking to accomplish, thereby filtering aims to reach your goals (Knudsen, 2007; Plassmann et al., 2012; Van Zoest et al., 2004).

Due to this, the underlying brain processes of attention and visual processing have a strong interest in advertising. In addition, the anterior cingulate cortex (ACC) is strongly associated with top-down and bottom-up attentional processes (Crottaz-Herbette & Menon, 2006; Meneguzzo et al., 2014). For example, Smith and Gevins (2004) revealed that the occipital lobe (OL) is connected with the processes of paying attention to television ads. Recent fMRI examinations of Casado-Aranda et al. (2018) discovered that advertisement and gender voice (male, female) stimulate attention-related brain areas. Ananos (2015) Examined the attention level and processing of information in advertising (content recognition) between groups of old and young individuals using EEG. According to their results, the attention levels of both age groups are the same, but the recognition level of young people is greater than that of the old. Guixeres et al. (2017) Using neural networks and neuroscience-based measures, we have undertaken an experiment to determine the correlation between ad efficacy (e.g., remember ad) and YouTube channel views (e.g., brain response, ECG, and ET). Their results indicate a significant correlation between neuroscience measurements, self-reported ad efficacy (e.g., ad recall), and YouTube views. Cuesta-Cambra et al. (2017) examine how information is processed and learned, as well as visual attention. Their findings indicated that the visual activity of men differs from that of women, but that this difference does not affect subsequent recall, where recall depends on the emotional value and simplicity of advertisements, while complex advertisements require more visual fixation and are therefore difficult to remember. EEG also demonstrated the significance of the fun component of memory and low involvement processing. Treleven-Hassard et al. (2010) evaluated the involvement of consumers with interactive and non-interactive television advertisements for a certain brand. The results demonstrated that companies associated with interactive advertisements get higher automatic attention. Boscolo et al. (2020) used EEG and



questionnaires; an experiment was undertaken to evaluate variations in the visual attention paid by males and females to print advertisements. Their results demonstrated a difference in visual attention between males and females but no difference between males and females.

### Perception

According to Simson (2010), the marketing mix ingredients may be altered to impact the perceived value of a product, as shown by research on the formation of value perceptions. But research on how attention systems influence customers' perceptions and behaviors have been restricted to consumer report and behavioral studies, which rely on a rational report and are insufficient to describe attention processes. Two attentional systems affect consumers' perceptions (e.g., endogenous and exogenous attentional systems) (Ramsoy, 2014). Consumer perception is the first stage in engaging with marketing stimulus or any other environmental stimulation (Rezaee & Farahian, 2015). Hogg et al. (2006) The process of selecting, organizing, and interpreting marketing stimuli is termed perception. Therefore, people add meaning and interpret information in a specific manner, resulting in perceptions as the person's discoveries for each individual. As shown by Belch and Belch (2007), perception processing relies heavily on internal processes, including previous knowledge (experiences), present objectives, beliefs, expectations, wants, and emotions, as well as exterior inputs like color, direction, intensity, and movement (Ramsoy, 2014). Although this explains how consumer perceptions are created, the section about the explanation of sensations and the internal and unique assignment of meaning to sensations remains hidden and unexplained in depth in the present literature on consumer behavior. However, it is widely thought that the unconscious drives this process.

Cartocci et al. (2017); Modica et al. (2018) performed an experiment to determine the accuracy of EEG, GSR, and ECG measurements of the cerebral and emotional perception of social advertising campaigns (i.e., antismoking). According to the approach-withdrawal index, the anti-smoking campaign that used a symbolic communication style had the greatest approach scores. While images with a "fear-inducing appeal" and a narrative style had the highest and lowest effort value indices, respectively, those with a "fear-inducing appeal" had the highest effort value index. The fMRI investigation of Falk et al. (2012) To forecast the population-wide (non-sample) efficacy of stop-smoking advertisements. The results demonstrated that activity in a previous mPFC predicted the performance of numerous real-world advertising initiatives. Plassmann et al. (2008) Using the fMRI device, research was conducted on the sense of pleasantness in the taste of wines. Their results revealed a larger activity in the brain's medial OFC (mOFC) areas, responsible for

perceived pleasure when individuals felt they were drinking costly wine. This suggested that the correlation between the pleasantness report and perceived product value and price was stronger than the correlation with flavor itself. Neuroscientists have discovered that the OFC and ventromedial prefrontal cortex (vmPFC) are engaged in decision-making via product perceived value (Daw et al., 2006). Nuñez-Gomez et al. (2020) conducted an EEG experiment to test how two groups perceive advertising materials (e.g., a healthy group and a group with Asperger syndrome). The results indicate that the two groups perceptions of emotion and attention characteristics vary significantly. Gong et al. (2018) Using EEG/ERP, we conducted an experiment to determine the effect of sales promotion (e.g., gift-giving, discount) on customer perception and purchasing choices. The data indicate that discount promotions influence purchasing choices more than gift-giving promotions.

### Motivational Attitude

Emotional and motivational processes complement one another. Lang and Bradley (2008). Chiew and Braver (2011); Pessoa (2013), motivating processes were discovered to have a significant impact on customers' cognition and behavior. The positive motivating cues, for instance, will encourage people to accomplish their objectives (e.g., get or predict a reward for performing a task correctly) (Chiew & Braver, 2016). The negative motivating stimuli may lead to distraction, whilst positive motivational stimuli can lead to focus. (Anderson et al., 2013). Pessoa (2013); Raymond (2009) argued that motivational processes are a compass of consumers' attitudes toward external stimuli in order to interact with the environment and attain objectives. Higgins (1998) proposed two dimensions for measuring motivational processes: withdrawal and approach attitudes. Researchers and practitioners examined the neurological responses of motivational processes to better comprehend customer reactions to commercials and goods. (Vecchiato et al., 2010). For instance, Cherubino et al. (2015); Davidson (2004) EEG was used to study the link between the prefrontal cortex and motivational characteristics. The results demonstrated that the PFC is associated with motivational aspects, with the right PFC correlating with withdrawal attitude and the left PFC with approach attitude. The EEG examination of Pozharliev et al. (2015); Zhang et al. (2019) documented brain reactions to luxury items (motivations). Findings revealed that social incentives play a crucial role in encouraging the purchase of luxury items to achieve social aspirations (at least one goal). The EEG investigation of Bosshard et al. (2016) In the right parietal cortices, liked brands display greater motivational features and activity signals than disliked ones. Therefore, a high correlation exists between PFC activity and motivational characteristics in response to marketing



stimuli such as ads (Davidson et al., 1990). In order to orient the marketing mix, marketing academics, and practitioners must concentrate on the motivating processes of customers (e.g., target appropriate audiences and increase the effectiveness of ads and products) (Bahrabad & Farrokhian, 2017). According to past studies, NM study has evaluated television advertisements using an approach-withdrawal attitude (Di Flumeri et al., 2016). Therefore, approach/withdrawal motivational attitudes are critical to marketing and advertising research.

### Reward Processing

According to the findings, scientists and practitioners must examine and understand the brain responses involved in processing rewards such as money, food, and social activities (Case & Olino, 2020); (Berridge, 1996; Knutson et al., 2001; Lehner et al., 2017). Because the positive incentive, such as monetary gain, food, or other rewards, improves precision and cognitive task performance (Anderson, 2016; Gilbert & Fiez, 2004; Krawczyk et al., 2007) by the modification of the initial attentional process. Anderson et al. (2013) It has been established that visual characteristics (e.g., product design) that are associated with reward will immediately capture the consumer's attention since they are prioritized. For instance, the design/preference of a product or brand may enhance activity in regions involved in reward processing, resulting in increased activation in areas of motives that may influence customers' purchasing choices (Cherubino et al., 2019). Numerous research focused on people's reactions to monetary rewards by analyzing their approach/avoidance attitude (Case & Olino, 2020; Knutson et al., 2001). For instance, Bechara et al. (1994) used GSR, an experiment titled "Iowa Gambling Task" was conducted to examine the effect of reward on decision-making. Participants were separated into two groups: the healthy group and the group with vmPFC lesions. The results indicated that healthy individuals were more perspiring, indicating that they experienced a negative emotional response when picking up cards from a losing deck, but the lesion group picked up cards regardless of whether they were winners or losers. Consequently, rewards significantly impact decision-making (Bechara & Damasio, 2005; Case & Olino, 2020; Maia & McClelland, 2004).

Numerous researchers have proven the significance of striatal activity in reward processing, with striatal components such as the caudate nucleus, nucleus accumbens (NAcc), and putamen playing a vital role in reward anticipation and appraisal (Knutson & Wimmer, 2007; Lehner et al., 2017; Padmala & Pessoa, 2011). For example, Galvan (2010); Geier et al. (2010) Investigated the link between reward processing and the striatum via experimentation. Their results demonstrated that the ventral striatum (VS) is crucial in reward prediction. Padmanabhan et al. (2011)

examined the relationship between the reward system and attention processes. Their research demonstrated that rewards promote cognitive control. Prior neurophysiological research has shown that rewards engage the ventral medial prefrontal cortex (vmPFC) and ventral striatum (Davey et al., 2010; Izuma et al., 2008; Lieberman, 2013). The ventral striatum has previously been mentioned in relation to the reward system (Fliessbach et al., 2007). Consequently, the results imply that neurodevelopmental changes in striatum systems may lead to alterations in the manner in which reward influences attentional processes (Dolcos et al., 2019).

### Memory

Memory is described as a continuous, brain-based learning process with input and output functions (Endo & Roque, 2017; Myers & DeWall, 2021). The input function encodes information while the output function retrieves it, which is important for advertising research (Atkinson & Shiffrin, 1968; Genco et al., 2013). Recall and recognition of advertising information are examples of the retrieval function (Venkatraman et al., 2015). Atkinson and Shiffrin (1968); Myers and DeWall (2021) proposed a three-step model of memory, known as the multistore model, which includes sensory memory, short-term memory (STM), and long-term memory (LTM) (McLeod, 2017). As McGaugh (2000) demonstrated, memory-related brain processes can positively impact customer behavior, particularly regarding advertising recall and recognition. Research has shown that memory-related brain processes positively impact customer behavior, such as in advertising recall and recognition (Genco et al., 2013; Plassmann et al., 2012). Memory and emotion are intricately intertwined. For instance, past research has shown that emotional experiences are often recalled more than neutral ones, particularly if they match the events occurring at the time (Bradley et al., 1992).

According to extensive research, the hippocampus (HC) situated in the temporal lobe (TL) plays a crucial role in forming and processing memories (McGaugh, 2000). Additionally, HC activation has a strong association with long-term memory (LTM) and short-term memory (STM), which significantly influences customers' purchasing choices (Murty & Adcock, 2014; Wittmann et al., 2005). The AMY, located near the HC, is also critical for the memory system (McGaugh, 2000). Research has shown that stronger activity in the left prefrontal areas is connected with advertising efficacy and is deemed a predictor of advertising success (Silberstein & Nield, 2008) (Rossiter et al., 2001). Astolfi et al. (2009); Fallani et al. (2008) have utilized the EEG to assess the brain areas activated by effective memory encoding of television advertisements. They discovered increased activity in the cortical areas. Morey (2017) The effect of advertising messages on recognition memory was explored. The

results demonstrated that gamma band activity has a direct influence on memory. The fMRI investigation of Bakalash and Riemer (2013); Seelig et al. (2014) tested the brain areas responsible for memory advertising. Stronger activity in the amygdala (AMY) and frontotemporal areas was related to memorable versus forgettable advertisements. Tests have been conducted to examine the relationship between ad content and the activity of frontal areas and memory, indicating that ad content boosted activity in frontal areas and memory input function (Langleben et al., 2009). Additionally, systematic fixations on the brand and graphical aspects of printed advertisements enhance brand memory, while text fixations have little impact on later recall Pieters and Wedel (2004).

To improve advertising research, it is important to focus on mental processes such as emotion, attention, memory, reward processing, motivation, and perception.

## Difficulties and constraints of NM application

### Data interpretation, time-consuming, and sample size

According to the literature, NM deployment around the globe faces a number of challenges, including data interpretation and time consumption. For example, according to Ariely and Berns (2010b); Banos-González et al. (2020); Cherubino et al. (2019); Gang et al. (2012), the extracted data from the NM experiment using fMRI or EEG is more difficult to understand than eye tracking data, which is one of the difficulties addressed by NM researchers. NM employs neurophysiological and physiological technologies that are exclusive to the medical industry, hospitals, and a few institutions. Consequently, NM trials often include small populations. According to Banos-González et al. (2020); Bercea (2012); Berns and Moore (2012); Dierichsweiler (2014); Gang et al. (2012); Hensel et al. (2017b); Isa et al. (2019); Plassmann et al. (2015); Stanton et al. (2017); Wolf and Ueda (2021), Small sample sizes in NM and consumer behavior research are seen as one of the obstacles to generalizing experimental results. According to Eser et al. (2011), it is difficult to recruit subjects for experiments due to the unfavorable reputation associated with legal and ethical difficulties. In addition, employing neurophysiological techniques such as but not limited to the fMRI is time-consuming, with each participant requiring between 30 and 60 min for a single experiment. Banos-González et al. (2020); Dierichsweiler (2014); Schiessl et al. (2003); Turna and Babus (2021) mentioned that the complexity of the data, which necessitates time-consuming analysis, as well as the requirement for adequate time to design the experiment and recruit

individuals to execute an experiment, are cited as one of the NM's most time-intensive obstacles.

### Cost of NM approaches and research

According to the available literature, NM trials use pricey equipment. For instance, the fMRI device cost more than \$1.5 million US. As endorsed by Ahmed et al. (2023a); Ariely and Berns (2010a, 2010b); Bercea (2012); Chandwaskar (2019); Dierichsweiler (2014); Gang et al. (2012); Mansor and Isa (2018); Sebastian (2014); Turna and Babus (2021), the expense of NM techniques like as fMRI (estimated at \$1.5 million) is one of the most significant hurdles and limits encountered by neuro-marketers and researchers interested in conducting trials. Additionally, NM research is costly. As shown by Ariely and Berns (2010a, 2010b); Bercea (2012); Hensel et al. (2017a); Isa et al. (2019); Plassmann et al. (2015); Turna and Babus (2021) The high expense of performing NM trials in the business area to examine consumer behavior, such as emotions and decision-making, is one of the most significant obstacles and limitations to the expansion of NM research.

### Neuromarketing specialists

Neurophysiological and physiological instruments need the employment of specialists with a medical or physiological background. As described by Dierichsweiler (2014); Hammou et al. (2013), NM research utilizes software and advanced technology. Experiments thus need a high degree of technical understanding of how to utilize NM tools, how to conduct experiments, and how to analyze the data/findings, which we lack (Ahmed et al., 2023a; Banos-González et al., 2020).

### Ethical concerns

In the last decade, there has been a rapid increase in interest in the phrase "NM." (Ariely and Berns (2010a, 2010b); Du Plessis, 2011). NM is a relatively young branch of study concerned with cognitive and emotional neuroscience as well as tactics for influencing consumer behavior. This prompted society and academic sectors (e.g., researchers, journalists, and press) to explore the ethical implications (e.g., privacy, autonomy, secrecy) of utilizing these new approaches to control/influence consumer behavior (Martineau & Racine, 2019; Murphy et al., 2008; Singer, 2004; Thompson, 2005; Ulman et al., 2015). For instance, when the press and media have reported on the possible dangers of employing NM methods to locate a "purchase button" in the brains of persons (Blakeslee, 2004; Isa et al., 2019; Stanton et al., 2017; Thompson, 2003) to analyze their thoughts, memory, attention, and

emotions in order to influence their purchase choices, in addition to ads and marketers manipulating their brains (Racine et al., 2010). The primary objective of NM is to locate a "purchase button" in the human brain that may be targeted and activated by commercial advertising in the future (Spence, 2020). Undoubtedly, some folks are concerned about the influence of NM. Thus, NM's potency has prompted several nations (such as France) to adopt specific measures against the unauthorized use of brain-imaging methods (Nemorin & Gandy-Jr, 2017; Oullier, 2012; Ulman et al., 2015). For instance, the French parliament updated its 2004 bioethics regulations to read: "brain-imaging methods may only be employed for medical or scientific research or in the framework of judicial expertise" (Spence, 2020).

In fact, NM is used to produce more appealing goods and advertisements, but not to control people's thoughts. (Stanton et al., 2017). According to Ariely and Berns (2010a, 2010b), The use of NM methods in harmful advertising campaigns (e.g., cigarettes, alcohol, etc.) to promote profit rather than the well-being of customers led to a rise in concerns, and therefore, the discussion of the possible ethical difficulties of NM. The Malaysian Communication and Multimedia Commission has prohibited these sorts of advertisements (MCMC) (Isa et al., 2019). Therefore, ethical concerns should be carefully explored (Pop et al., 2014). Thus, businesses must comply with government regulations and ethical standards (Arlauskaitė et al., 2013). In this context, several scientists and academics have identified the following ethical considerations for corporations and researchers: (i) privacy and secrecy; and (ii) independence (Isa et al., 2019).

### Confidentiality and privacy

They are regarded as one of the most critical challenges, including maintaining participant data's confidentiality and anonymity. Due to the fact that neurophysiological procedures might reveal sensitive information that, if disclosed to the general public or marketing agencies, could be abused and breach ethical standards, these techniques are not permitted. Consequently, NM approaches may threaten people's privacy if this technology can efficiently and precisely interact with the consumer's brain (Murphy et al., 2008). Others, however, have stated that these concerns are probably unwarranted since current imaging technology does not provide exact forecasts of consumer choices (Brammer, 2004; Neurology, 2004). Therefore, the ethical dimension poses the greatest obstacle to the application of NM techniques. The protection of experiment participants is one of the top ethical concerns in NM research, as identifying the neural correlates of emotional and cognitive processes of interest for advertising can produce crucial information

about consumer behavior (i.e., decision-making) and, thus, may compromise the participants' privacy (Hubert & Kenning, 2008; Javor et al., 2013; Murphy et al., 2008; Ulman et al., 2015), the risks associated with data confidentiality (Flores et al., 2014).

### Autonomy

It is people's right that must make choices without external influence. However, some opponents have argued that the neuro marketer may employ NM tactics to influence customer decisions and disregard their autonomy in selecting items or commercials (Dierichsweiler, 2014). For instance, it conducted an experiment to explore the influence of the frequent presentation (without their conscious knowledge of the brand) of a Dasani water bottle on customer decisions, in which participants were instructed to pick one bottle from four distinct brands. The majority of participants selected the Dasani water bottle above others, indicating that regular exposure to a product, brand, or commercial may influence the consumer's brain and decision-making (Stanton et al., 2017). According to detractors, this is improper and immoral since it demonstrates that consumer autonomy has been undermined by repeated exposure to a certain product (Isa et al., 2019). However, the critics' argument that repeated exposure to a particular product, marketing, or brand plays a major role in affecting decision-making is not entirely accurate since the human brain is not that straightforward. It may be accurate to say that frequent exposure will lead to the prioritization of this product at the point of purchase but not necessarily to a purchase decision. Furthermore, decision-making processes in the brain are not easily measured or predicted because they are interconnected with numerous brain processes (e.g., emotional and cognitive processes). It has openly challenged what they define as a rush to embrace neurophysiology and explain all human brain activities, prompting him to invent the word "neuromania" to represent all of these concerning elements (Cherubino et al., 2019).

### Discussion

Based on an evaluation of relevant literature, the number of publications both yearly and cumulatively, has risen since 2004. The PRISMA framework recommended by Moher et al. (2015) was used to determine the appropriate papers for this study, as mental processes must be considered in advertising research. Among all publications, more than half were produced by three nations: Spain, Italy, and the United States. Spain was the most prolific, with eleven papers and 96 citations by the end of 2020, while Italy only released eight papers. The study employed bibliometric analysis to

identify global trends in the subject area of interest. The most prolific journals with at least two publications each were located in six nations, including Switzerland, Spain, England, Poland, Netherland, and Italy. *Frontiers in Psychology*, with eight papers, was the most productive journal in NM and advertising, followed by *Comunicar* and *Frontiers in Neuroscience*, each with four papers. Additionally, the most-cited paper was "Neuromarketing: The New Science of Consumer Behavior," published by Morin (2011) in the journal *Society*, with over 152 citations.

According to this study, inner and extrinsic emotional responses, endogenous and exogenous attentional processes, memory, perception, motivational attitudes, and reward processing are the most important brain functions to be addressed in advertising research. The authors revealed that the right dIPFC plays a vital role in the motivational attitudes of customers, which in turn influences customer behavior to approach or avoid the advertisement, product, or even brand. At the same time, the gyrus regions have a key role in emotional valence and arousal responses such as pleasure/displeasure and high arousal/low arousal, wherein the inferior frontal and middle temporal gyri are related to pleasant and unpleasant responses. At the same time, the right superior temporal gyrus and middle frontal gyrus are associated with the intensity of arousal, i.e., high and low. In terms of memory and attention, the occipital lobe (OL) is important for both endogenous and exogenous attention processes, whereas the hippocampus (HC) plays a critical role in memory processes. Other brain regions, such as the amygdala and frontotemporal regions, are associated with remembering/un-remembering information. The ventral striatum (VS) in the basal ganglia plays a central role in reward processing, with components like the putamen, caudate nucleus, and nucleus accumbens (NAcc) involved in assessing consumer expectations versus actual reward. The ventral tegmental area is also considered part of the reward system, transmitting dopamine to other brain regions to influence goal-seeking behavior. The anterior cerebral hemispheres are important for withdrawal/approach motivation, with activity in the right prefrontal cortex (PFC) associated with withdrawal behavior and activity in the left PFC linked to approach behavior (Cherubino et al., 2015; Davidson, 2004). The orbitofrontal cortex (OFC) and ventromedial prefrontal cortex (vmPFC) are crucial in perceiving reality and perceived value (Daw et al., 2006).

## Conclusion

**Implications for theory and practice of the study findings** Theoretically, neuroscientific tools and methods allow the measurement of brain and body activity signals

that indicate consumers' reactions to advertising campaigns. These signals can include emotions, attention, memory, perception, reward processing, and motivation. For example, neurophysiological instruments such as fMRI, EEG, and fNIRS can record the neural signals of mental responses, such as advertising recall and recognition, while physiological instruments like ET, GSR, EMG, and ECG can provide valuable information on physiological responses like pupil dilation, heart rate, and so forth. By identifying the strengths and weaknesses of advertising campaigns before implementation, advertisers can develop more effective campaigns and rectify negative aspects that generate a negative attitude towards advertising. Furthermore, researchers can use the neural and physiological correlates of emotions, attention, memory, reward processing, motivation, and perception to predict consumer behavior following advertising campaigns, such as in response to presenter features like celebrities, gender voice, commercial appeal, social efforts like anti-smoking campaigns, and public health. Practically, this study can provide insight into how advertising works in customers' minds, which can be applied to develop appealing advertising in various sectors, including political, social, and commercial.

**General Conclusion** Neuromarketing is a field with enormous potential to address commercial issues such as advertising effectiveness and budget waste and to develop more impactful advertising campaigns in the social, political, and public health domains to increase public awareness. With intense competition in the advertising industry, each agency seeks to discover the most advantageous strategies to outperform rivals and become the consumer's top choice. Therefore, advertisers and marketers have employed neuroscientific methods and techniques to explore, analyze, explain, and predict consumers' mental and physiological responses to marketing stimuli, especially advertising. They can increase advertising effectiveness by identifying the most important mental and physiological processes involved in advertising research (as described above in Sect. 3.3). The majority of advertising research studies have focused on these primary mental processes.

The results indicated that neuroscientific approaches and procedures are crucial for capturing and recording consumers' mental and physiological reactions to marketing stimuli, including but not limited to advertising research. For instance, neurophysiological instruments allow for measuring and recording the brain's activity signals, while physiological tools may record bodily reactions such as eye movements, perspiration levels, and fixation. We think this study gives a complete review of the current and most important



neuroscientific approaches used in advertising research and the most important mental processes to be addressed in advertising research. Furthermore, we think that this study will assist researchers in identifying the appropriate mental processes for obtaining accurate and high-quality outcomes.

## Limitations and future directions

The aim of this study was to reduce errors in methodology, but there are constraints that offer opportunities for further academic research. The study focused exclusively on empirical papers in advertising within the neuromarketing context, published in English, and using physiological and neurophysiological instruments, ignoring non-English books, conference papers, proceeding books, and chapter books, resulting in some bias. To overcome these obstacles in future studies, including the high cost of instruments and research, inadequate facilities in Business Schools, time consumption in data interpretation, experiment design, and participant recruitment, as well as increased funding in NM research and instruments (Ahmed et al., 2023a). The authors suggest investigating the effect of ads on consumer persuasion, attractiveness, engagement, and enthusiasm, as well as the contributions of NM research to other areas, such as social sciences, public health, politics, and stocks. Additionally, researchers from developing countries are invited to publish in this field. To obtain accurate results, researchers and practitioners must use the appropriate instruments for their research.

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**Data Availability** Not applicable.

## Declarations

**Conflicts of Interest** The authors of this manuscript declare that they have no conflict of interest concerning its drafting, publication, or application.

**Ethical Statement** Not applicable.

**Informed Consent** Not applicable.

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