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Biometric tools in neuromarketing research: A Systematic Literature Review

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KEYWORDS

Biometric tools
Systematic Literature Review
Neuromarketing
Consumer Neuroscience
Sensorial Marketing

ABSTRACT

The application of neuroscience investigation to the social sciences, especially in the areas of marketing, has led to an interdisciplinary fusion known as neuromarketing, or consumer neuroscience. Marketing researchers use biometric tools to identify unconscious activity that possibly occurs in response to stimuli and before the formation of consumer attitudes and effective behaviour. In recent years, the use of biometric neuromarketing tools such as eye-tracking (ET) and galvanic skin response (GSR) have been increasing due to the fact that they are economical, portable, and non-intrusive. Based on the SPAR-4-SLR protocol, the present study provides a systematic review of the biometric tools in consumer neuroscience research. The results suggest that the number of published studies addressing biometric tools, especially the combined use of ET and GSR is increasing. Design, advertising effectiveness, and social media are the three fields most closely related to this research paradigm.

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1. Introduction

New techniques have been developed to strengthen certain approaches involving applied multidisciplinary research, which is redefining both scientific development and the concept of interdisciplinary investigation. Advances in neuroscience are fostering a technological revolution in academic and professional research. This has led to the rapid advancement of many disciplines, including psychology, marketing, and education. As a consequence, this encourages further interdisciplinary development of these fields in connection with neuroscience. The instruments of neuroscience have been used for the purpose of measurement and evaluation in a variety of fields, especially when it comes to how people feel and react to certain things. In recent years, the application of neuroscience-based techniques has expanded across a wide range of fields, including education (Šola et al., 2021, 2024), psychology (Taib et al., 2020), automotive engineering (He et al., 2022; Vaitheeshwari et al., 2022), advertising effectiveness research (Shemesh et al., 2021, 2022), and marketing and sponsorship studies (Lyu, Mañas-Viniegra, et al., 2025; Lyu, Xu, et al., 2025).

As a result of applying neuroscience research to social science, especially in the areas of business and economics (Lee et al., 2018), an interdisciplinary field emerged known as neuromarketing (Lee et al., 2017; Vecchiato et al., 2011, 2014). By recording brain processes and other physiological indicators, it provides a broader understanding of consumer reactions to marketing stimuli (Bakardjieva & Kimmel, 2017), and is considered a combination of neuroscientific methods and designs used in behavioral science and consumer psychology (Plassmann et al., 2012).

Neuromarketing has emerged as a widely discussed topic in both academic and practical realms of marketing, with its influence steadily expanding (Harris et al., 2018; Lee et al., 2018; Plassmann et al., 2015). One of the primary advantages of employing neuromarketing techniques, as noted by Ariely and Berns (2010), is the ability to bypass the limitations associated with self-reported data, where individuals often struggle to provide conscious responses related to attention, perception, behaviour, or attitudes. Neuromarketing methods offer deeper insights by directly observing neurological and physiological responses. Furthermore, neuromarketing can be combined with traditional research methods, such as surveys, focus groups, or the Delphi technique to better understand the underlying reasons for consumer reactions (Lyu & Mañas-Viniegra, 2023). Despite its potential, the complexity of unconscious consumer decision-making processes remains only partially understood (Doborjeh et al., 2018). A decade after the initial exploration of this field, empirical neuromarketing research has advanced more slowly than expected (Lim, 2018), indicating the need for continued methodological refinement and more extensive research efforts.

Neuromarketing studies include a range of neuroscientific and physiological research techniques to measure changes in neural electrical or metabolic activity (Ahlert et al., 2006) to study cognitive and affective processes. The most widely used technologies in marketing research can be divided into three main categories based on the technology applied (Harris et al., 2018; Lim, 2018): 1. neurometrics record neural activity inside (Metabolic/energy consuming) the brain, e.g. Functional magnetic resonance imaging(fMRI) and Positron emission tomography (PET); 2.

neurometrics record neural activity inside (Electromagnetic /electrochemical) the brain, e.g. Electroencephalography (EEG) Magnetoencephalography (MEG) and Steady state topography(SST); 3. biometrics, which includes eye-tracking (ET), galvanic skin response (GSR), heart rate (or ECG), and facial coding.

Among all applied tools, functional magnetic resonance imaging (fMRI) was the predominant method (Vecchiato et al., 2014). This technique produces a series of high-resolution images depicting cerebral activity by assessing changes in oxygen levels within cerebral blood flow, providing relatively accurate imaging result (Harris et al., 2018). However, its high cost of use and complexity in data analysis are not suitable for wide application to the marketing research with low budget. Laboratories with investment constraints tend to use more convenient and low-cost tools, hoping that they will provide easy-to-analyse data while maintaining accuracy. In addition, the use of neurometric techniques has faced criticism due to concerns about potential risks of brain damage and ethical considerations (Lyu & Mañas-Viniegra, 2021). Some techniques have raised questions regarding participant safety, particularly when procedures involve direct neurological stimulation and neuroimaging. Since 2016, eye-tracking (ET) and galvanic skin response (GSR) have become two of the most prevalent neuromarketing research tools (Alsharif et al., 2021).

Compared to neuroimaging, biometric tools are more portable, cost-effective, and easier to process. Clithero et al. (2024) noted that consumer neuroscience research has been overly focused on brain imaging, leading to less attention being paid to other available physiological methods. Several reviews have provided comprehensive analyses of the tools used in neuromarketing (Alsharif et al., 2021; Casado-Aranda et al., 2023; Robaina-Calderín & Martín-Santana, 2021). De Faria Pereira et al. (2024) specifically examined neuroimaging applications, but research summarizing the use of biometric tools in neuromarketing remains limited. What is its current research status? What kinds of benefits and limitations does it have? These issues are of serious concern for the future development of neuromarketing investigation. Given the lack of consensus, this article aims to do the following: (1) clarify the use of biometric tools in neuromarketing research; and (2) summarise the development of this research sub-paradigm over the last five years based on the structure of 5W. Additionally, this article aims to devote considerable attention to future research and applications for neuromarketing.

2. Methodology and Data Acquisition

To generate an up-to-date overview of existing research on biometric tools in neuromarketing studies, we conducted a systematic literature review, which helps to address investigative issues, consolidate viewpoints, evaluate the outcomes of numerous empirical findings, and propose a research agenda as well (Elsbach & Knippenberg, 2020; Snyder, 2019). In addition, systematic literature reviews stand out as the most informative and scientifically rigorous, helping contributin to identify existing gaps, which could provide instructions for future research (Paul et al., 2021).

2.1. Hybrid literature reviews

Various types of systematic literature reviews exist, encompassing domain-based, theory-based, method-based, meta-analytical, and meta-systematic reviews. According to Paul et al. (2021),

the organization of literature reviews can be structured in diverse ways to ensure optimal clarity and comprehensiveness. These approaches include the hybrid narrative approach, bibliometric review, antecedents-decisions-outcomes (ADO) framework, theories-contexts-methods (TCM) framework, theories-constructs-characteristics-methods (TCCM) framework, as well as the 5W1H approach, which addresses who, what, when, where, why, and how, or alternatively, the 3W1H approach, focusing on what, where, why, and how.

2.2. Protocol and sampling

A recent study by Paul et al. (2021) introduced a protocol designed specifically for systematic literature reviews. This protocol, termed the Scientific Procedures and Rationales for Systematic Literature Reviews (SPAR-4-SLR), delineates three primary stages: assembling, arranging, and assessing, which are further broken down into six sequential sub-stages: identification, acquisition, organization, purification, evaluation, and reporting (Figure 1).

The review has complied with the SPAR-4-SLR statement regarding systematic reviews. Journal articles stored in the Web of Science Core Collection, one of the most informative scientific databases to date (Paul et al., 2021; Singh et al., 2021; Vieira & Gomes, 2009), were collected. To search the database, a set of keywords related to biometric approaches was first identified. A query using a combination of these keywords (adopting the Boolean operators "OR" and "AND") was run in the fields related to "keywords". The search period lasted from 2013-12-31 to 2024-08-31 (Table 1). The keywords were combined in the following string to search: (biometric* OR "physiological measures" OR eye-tracking OR eye tracker OR skin-conductance OR "heart rate" OR "HR" OR "facial decoding" OR Electrodermal Reaction Activity OR "facial electromyography" OR "facial expression" OR "ECG" OR "EDA" OR "galvanic skin response" OR "GSR") AND (marketing OR consumer OR perception OR consumer neuroscience OR neuromarketing). During the collection period, a total number 106 articles were gathered. In the arranging stage, the 5W1H organizing framework was applied, and the main organizing code used this method. To further refine the articles obtained, the following exclusion criteria were applied as shown in Table 2. Lastly, a final sample of 57 relevant studies was retained to be analyzed.

2.3. Data analysis

The acquired data were then exported to an Excel spreadsheet to facilitate comprehensive check. Results within the spreadsheet encompassed bibliographic details, such as authorship, year of publication, journal source, and geographical region. Accordingly, the present study has followed the modified structure of 5W1H, combined with the bibliometric method using CiteSpace software (Chen, 2013) in order to conduct a visualisation analysis of the data obtained.

3. Results

3.1. WHEN. The development of biometric tool in neuromarketing research

Consumer neuroscience emerged in the late twentieth century (Karmarkar & Plassmann, 2019). However, the concept of neuromarketing was first coined and referred to by Smidts (2002), who defined it as the application of neuroscience tools to business (Alsharif et al., 2021; Cherubino et al., 2019). Since then, extensive databases have gradually begun to include neuromarketing-focused research, although the overall amount is still scarce. From 2014 to 2024 (Figure 2), the number of studies with the topics neuromarketing/consumer neuroscience shows an overall fluctuating upward trend. The year 2021 was one of the peak years regarding the number of neuromarketing-related research publications. There are 98 articles of various types included in the WoS core database alone.

Many authors have pointed out, neuromarketing, as an emerging relevant topic, showing a steady increase in academic publications over the last decade (Lyu & Mañas-Viniegra, 2021; Robaina-Calderín & Martín-Santana, 2021). However, in this field, before 2018, more conceptual or review articles were published, while few studies rigorously produced empirical findings on the topic (Lim, 2018). This may be related to the fact that the theory of neuromarketing has still not been perfected, and the reliability of such research tools has not been fully tested (Ariely & Berns, 2010). Since 2018, academic research on neuromarketing has entered a period of rapid growth, both in terms of publication volume and citation frequency (Duque-Hurtado et al., 2020; Lyu & Mañas-Viniegra, 2023). Moreover, an increased number of empirical studies have been published as well. This seems to indicate that neuromarketing research tools have been accepted by the academic community since 2018.

With the rapid growth of neuromarketing articles, the number of studies focusing on the use physiological biometric tools has gradually increased. Adhering to the SPAR-4-SLR protocol (details available in the methodology section), we have organized the articles found in the WoS Core Collection, with a total of 57 papers. From 2014 to 2023 (Table 3), the number of articles that employed biometric tools in neuromarketing research experienced a fluctuated rise, increasing from 1 to 7. 2020 is the year with the most articles published, with 14 neuromarketing studies using biometric tools published. Overall, during this time period, the use of biometric tools is growing in neuromarketing research.

3.2. WHO. Who engage in the neuromarketing research using biometric tools?

From 2014 to 2024, there were 20 authors with more than one published study from four different institutions (Table 4). Among them, Luis Mañas-Viniegra, professor at Complutense University of Madrid ranked first with 4 publications, showing they are most prolific in using the research tool in this academic field.

In the selected sample, the authors were from 30 different universities or research institutions. Top 3 productive institutions are all Spanish universities. Polytechnic University of Valencia and Complutense University of Madrid were the institution that contributed the most articles, both reaching a total of 6 (Table 5), followed by Universidad Rey Juan Carlos, with 4 research papers. University of Alicante, Griffith University, Polytechnic University of Milan, SP Jain Sch

Global Management, Universidad Internacional De La Rioja, and University of Valencia all possessed 2 research outcomes. The geographic distribution of the included publications was determined based on the country or region where the study was conducted. In total, thirty-four countries distributed the articles. Among the most productive countries in this field of research, Spain provided the most significant contribution with 23 published articles, which is followed by USA, Italy, and Australia, with 7, 6 and 5 publications respectively. The distribution is broadly containing most of the continents rather than being confined to specific countries (see Table 6).

3.3. WHERE. What is studied using this paradigm?

The distribution of articles spanned across thirty-eight peer-reviewed journals, out of which the Frontiers in Psychology published the greatest number of articles (n = 12). Most of the articles were published in journals related with consumer studies, psychology, marketing and business, while with only a considerable number appearing in comprehensive journals such as Applied Sciences Basel, Behavioral Sciences, Heliyon, and Sustainability (see Table 7). These journals come from 14 publishers (Table 7). Among them, Frontiers Media Sa, Elsevier, and Mdpi rank the top three, contributing 14, 11, and 8 journals respectively.

3.4. WHAT. What is studied using this paradigm?

What has been studied by the neuromarketing research using biometric tools in the past decade? Here we have organized and counted the keywords of the research pertaining to the samples obtained. Keywords are capable of generally reflecting the problems and topics of the research, which describe the topic of the document in the most concise way. As the Table 9 shows us, the most frequently used keyword was 'eye tracking', which appeared 20 times, followed by 'responses', 'attention', 'neuroscience', which appeared 16, 12 and 11 times respectively. It can be seen that the role of eye trackers in neuromarketing research using biometrics is very critical. According to Casado-Aranda et al., (2023) this opportunity to capture visual attention in a relatively cheap way has become even more important today. Moreover, due to the fact that neuromarketing research focuses more on consumer behavior than anything else, the frequency of keywords such as 'behaviour', 'memory', 'impact', and 'perception' are relatively high. Accordingly, through high-frequency keywords, we can also understand the main research themes. For example, design, media, advertisements, decisions, and products are area of focus.

Research on design in the context of marketing includes a wide range of studies, particularly focusing on product and packaging design. For example, Rinklin et al. (2022) investigated the influence of cultural differences on both conscious and unconscious visual attention and attractiveness ratings in product design. Pascucci et al. (2022) employed eye-tracking experiments to examine how consumers allocate their attention to various marketing cues and how this process affects their evaluation of product quality. Similarly, Bettiga et al. (2020) explored consumers' emotional responses to functional and hedonic products, highlighting how product types impact consumer emotions. In addition to product design, packaging design has also been extensively studied. Niedziela et al. (2016) focused on the impact of environmental and health claims on food packaging, showing how such claims influence consumers' purchasing behavior. Juárez et al. (2020) further emphasized the importance of packaging graphics,

demonstrating its significant role in shaping consumer preferences. These studies collectively underscore the critical role of design in consumer decision-making and marketing effectiveness.

Moreover, advertising continues to be a key research field of neuromarketing. For instance, Mancini et al., (2023) studied effects of the non-ad items' presence by employing eye-tracking and facial coding techniques focusing on the YouTube online advertising. Zamith et al. (2021) determined that in-feed native advertising garners greater attention from younger demographics compared to content recommendation advertisements. Additionally, Hamelin et al. (2020) investigated the efficacy of storytelling in advertising, finding that a cognitive approach elicited attitudinal changes of prolonged duration. While emotional narratives may prompt immediate shifts in attitude, cognitive narratives contribute to more intricate cognitive development and enhanced retention over time. Research by Niño-González et al. (2019) found a pattern of visual attention regarding the attention paid to advertising stimuli, as well as gender differences in the patterns of visual travel. Cuesta-Cambra et al. (2019) analysed the cognitive processes of advertising in relation to compliance with the code of self-regulation. It was found that in gambling advertisements, there is a high level of interaction by the public with welcome bonuses and the display of presumed skills of successful players.

In addition, research on media and social media is becoming an increasingly important area of focus, particularly in measuring emotional responses to digital content. For instance, Rúa-Hidalgo et al. (2021) advanced the study of social media campaigns by measuring user emotions, revealing that explicit measurements of emotional valence indicate a more positive emotional state than implicit measures. This difference varies based on user engagement levels and the proportion of emojis in comments. Mañas-Viniegra et al. (2020) examined Instagram posts, showing that adolescents, compared to young adults, are more drawn to influencers' physical appeal, particularly those with nude body content, while demonstrating little interest in brand-related messaging.

Simultaneously, the role of spokespersons in advertising has garnered considerable attention. Zahmati et al. (2023) affirmed that the popularity of spokespersons is crucial to the success of commercial advertisements. Pelau et al. (2023) demonstrated that ad design and the number of celebrity-endorsed products significantly affect consumer attention. D'Ambrogio et al. (2023) also found that the number and duration of gazes on ad elements are strongly influenced by the endorser's popularity.

Food marketing has similarly emerged as a critical area of research. Baranda et al. (2024) explored how food shapes affect emotional responses in the elderly, while Zunckel et al. (2023) focused on consumer reactions to slogans advocating for reduced meat consumption. Pelau et al. (2022) examined how spokespersons in food ads influence attention, and Sola et al. (2022) studied how BIO labels impact purchasing behavior. Lombard (2022) analyzed how beef price tags influence consumer attention, while Ares et al. (2014) investigated the roles of rational and intuitive thinking styles in food choices. These diverse studies illustrate the growing complexity of consumer behavior in both media and food marketing contexts.

3.5. HOW have the tools become fused together in this paradigm?

The research samples selected for this paper are all experimental studies using biometric neuromarketing tools for investigation. These studies have incorporated a minimum number of 10 subjects and a maximum of 307, with the vast majority using an interval of 30-80 individuals (Table 10).

In addition, the most frequently used research tools (Table 11) in these studies is Eye-tracking (n=38), followed by GSR (n=21) and Facial coding (n=17). 17 of the studies combined two or more research tools. 21 studies used eye-tracking alone, and 10 studies used HR, GSR or Facial Coding alone. Most of these studies also used questionnaire surveys.

4. Discussion

4.1. Why employ biometric tools in this neuromarketing marketing research?

Compared to traditional marketing, neuromarketing has clear advantages. Traditional marketing regards the brains of consumers and audiences as a black box and conducts research on certain issues using questionnaires and interviews. This kind of research has obvious flaws due to environmental changes and unconscious individual aspects, which make it impossible to obtain the true cognitive perception of consumers. By contrast, neuroscience attempts to respond objectively by focusing on the unconscious, which circumvents the conscious bias of the subjects caused by certain social situations or personal backgrounds. Neuroscience-based research relies on tools to record physiological responses, which may help researchers interpret cognitive and affective processes more objectively in order to explain behaviour and ask cognitive questions from a more objective perspective.

Biometric tools are useful in neuromarketing because they are relatively real-time, non-invasive, and cost-effective. They provide precise insights into attention, emotion, and physiological responses, making them powerful tools for understanding consumer behavior without the high costs or invasiveness of other neuromarketing technologies. Portable and wearable biometric tools have allowed subjects to participate in experiments in their natural environment, rather than just in an experiment or in front of a fixed machine. Secondly, Biometric tools capture immediate, unconscious reactions. For example, GSR and HR monitor tracks changes in skin conductance or Heart rate associated with emotional arousal, giving a fast, automatic measure of excitement or stress. Thirdly, Biometric methods usually have simpler, more portable setups. For instance, Eye tracking devices can be performed as a wearable glass or as straightforward as cameras that follow gaze patterns. Facial coding can be done with software using a camera. Meanwhile, this makes it easier to conduct research in more natural settings. Lastly, Biometric tools tend to be more affordable compared to advanced neuromarketing techniques like fMRI or EEG. Moreover, due to its less intensive setup and lower costs, biometric testing can be done with larger sample sizes, increasing the robustness of data compared to expensive tools like fMRI, which are typically limited to smaller groups. Their ease of use enables efficient and rapid completion of experiments, making them a practical choice for large-scale studies in neuromarketing.

4.2. The importance of using multiple types of measurements in marketing research

As Clithero et al. (2024) pointed out, very few of the neuromarketing techniques are used in isolation. Our study highlights that most reviewed research employed a combination of biometric tools. For instance, eye-tracking captures the participant's visual focus, while tools like GSR (galvanic skin response) or facial coding measure emotional arousal. This dual assessment of attention and emotion offers a more comprehensive understanding of the participant's reaction to stimuli, allowing researchers deeper insights into behaviour and decision-making processes.

The prediction and analysis of consumer behavior hold significant value in marketing research. Acknowledging that consumer behavior, or human behavior, is inherently multimodal and interdependent, relying on a single measure may overlook the intricate connections between various metrics (Razavi et al., 2022; Stevenson, 2014). Experiments incorporating multiple measures contribute to a deeper comprehension of the concurrent operation of senses (Critchley, 2003; Hochenberger et al., 2015), thereby enhancing the accuracy of measurements and subsequently refining predictions of human behavior. Moreover, from a statistical standpoint, the simultaneous analysis of multiple datasets is deemed more reliable than separate analyses (Leontyev et al., 2018; Leontyev &Yamauchi, 2019), particularly in elucidating and forecasting less explored behavioral phenomena that necessitate triangulation across multiple physiological measurements (Charles & Nixon, 2019).

Since the onset of the current century, information technologies, such as computer programming, have led to the development of a series of platforms, including Tobi, Sticky, OpenSync, and iMotion, facilitating the emergence of multimodal experiments. Within neuromarketing research, these platforms are collectively referred to as Computational Neuromarketing tools. They offer several advantages, notably simplicity and portability, as they can be directly installed on computers and mobile phones. Moreover, they enable various research functions, leveraging electronic equipment as a supportive framework. Additionally, these programs streamline the statistical analysis of collected data, reducing the time required for data entry compared to traditional experimental setups. In terms of research capabilities, these platforms are equipped to conduct functions such as eye-tracking imaging and facial expression analysis utilizing computer camera functionalities. The advantage is that they used one platform to combine multiple biometric tools.

4.3. Reflections on methodology and ethical issues

From a methodological perspective, the choice of neuromarketing tools is a critical issue highlighted in the reviewed studies, as each tool has a specific scope of application. The selection of neuromarketing tools is grounded in theoretical frameworks that aim to establish a connection between consumer behaviour and the physiological responses triggered by stimuli. However, these tools, whether biometric or neuroimaging, are limited in that they cannot directly measure consumers' decision-making processes. In the field of consumer neuroscience, psychological processes and underlying brain functions remain not fully understood (Mehlhose & Risius, 2021). Current tools provide only instantaneous snapshots and cannot distinguish between endogenous brain processes and reactions to external marketing stimuli, which may be the real source of certain brain events (Braeutigam et al., 2019). As a result, although neuromarketing research

into consumer behaviour is promising (Harris et al., 2018), it remains largely exploratory and uncertain (Bagozzi & Lee, 2019; Duan et al., 2021).

Another key issue facing the use of neuromarketing tools is ethics (Lyu & Mañas-Viniegra, 2021). Neuromarketing focuses on understanding consumers' thoughts and feelings to better comprehend how the human body responds to marketing stimuli, which inevitably involves studying the human brain. The brain is the core of all human experience, responsible for processing emotions, rationality, memory, risk assessment, self-control, and more (Alsharif et al., 2023). Tools like EEG and fMRI, while often considered non-invasive, require the use of electrodes or scanners to capture brain activity, which can cause discomfort and raise concerns about privacy and personal data. The ethical concerns were further intensified, after the introduction of brain-computer interfaces by companies like Elon Musk's Neuralink. In contrast, biometric tools, which measure physiological responses like heart rate or skin conductance, tend to be seen as less invasive and less ethically charged. Neuromarketing, as a field, should not be perceived as merely a tool for commercial gain (Eser et al., 2011; Wilson et al., 2008). It is crucial that businesses, governments, and research institutions develop and adhere to rigorous ethical standards when conducting neuromarketing experiments (Alsharif et al., 2024).

5. Conclusions

This paper has reviewed the neuromarketing studies employing biometric tools. Based on the SPAR-4-SLR protocol, a hybrid systematic review was presented. A total of 57 papers were selected from the Web of Science Core Collection between 2014 and 2024. The results show that since 2014, the number of publications employing biometric neuromarketing tools has been increasing. Luis Mañas-Viniegra and David Juarez-Varon are the most productive authors in this area. Polytechnic University of Valencia was the institution that contributed the most articles, while Spain's performance in this domain has been the most active among the countries involved. Eye tracking is the most used biometric tool, and most studies use two or more tools in combination. Eye tracking can generally be used alone, but tools such as GSR, HR and Facial Coding are rarely used alone. The number of subjects invited to participate in studies was mostly in the range of 30-80 individuals. Design, media, advertisements, decisions, and products are the most important research area.

5.1. Limitations and future research agenda

This study is subject to several limitations. First, the dataset was restricted to English-language publications indexed in the Web of Science. Consequently, relevant studies published in other languages or included in alternative databases may not have been captured. Second, the search strategy was limited to publications available up to August 2024. Although additional studies have emerged since then, the predefined temporal boundary was maintained to ensure dataset stability and methodological consistency throughout the screening, coding, and analytical processes. Future reviews may extend the observation period and incorporate multiple databases to provide a more comprehensive understanding of developments in the field.

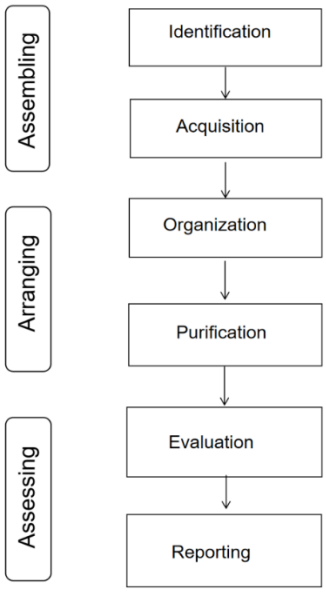
Looking ahead, the continued growth of neuromarketing and consumer neuroscience research

offers substantial opportunities for future inquiry. As Clithero et al. (2024) argue, although the relevance of consumer neuroscience to marketing has been widely established, its adoption in industry often appears to outpace its integration into academic research. Organizations increasingly employ neuroscientific methods in advertising design, branding, product development, and consumer research, demonstrating the practical value of these approaches. Beyond addressing traditional marketing questions and advancing theoretical understandings of consumer behavior, consumer neuroscience also serves as an interdisciplinary platform that promotes collaboration among scholars from marketing, psychology, communication, neuroscience, and related fields (Buyalskaya et al., 2021; Levallois et al., 2012).

Moreover, many contemporary biometric and neuromarketing tools have become increasingly accessible and user-friendly for both researchers and practitioners. Future experimental studies may benefit from combining multiple physiological and neuroscientific measures to examine complex questions across diverse domains, including product development, advertising effectiveness, spokesperson and celebrity endorsement research, food marketing, and the emerging field of sport marketing (Lyu & Xu, 2024). Such efforts would not only strengthen methodological triangulation but also contribute to a deeper understanding of consumer cognition, emotion, and decision-making processes.

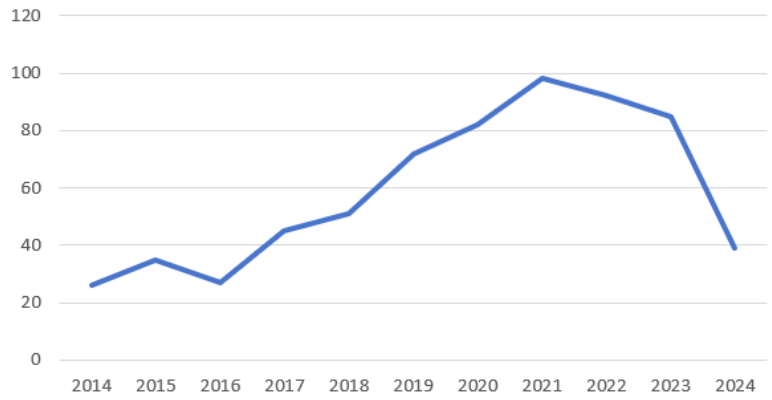
Figures

Figure 1. The Scientific Procedures and Rationales for Systematic Literature Reviews protocol (SPAR-4-SLR)



Source: created by the authors

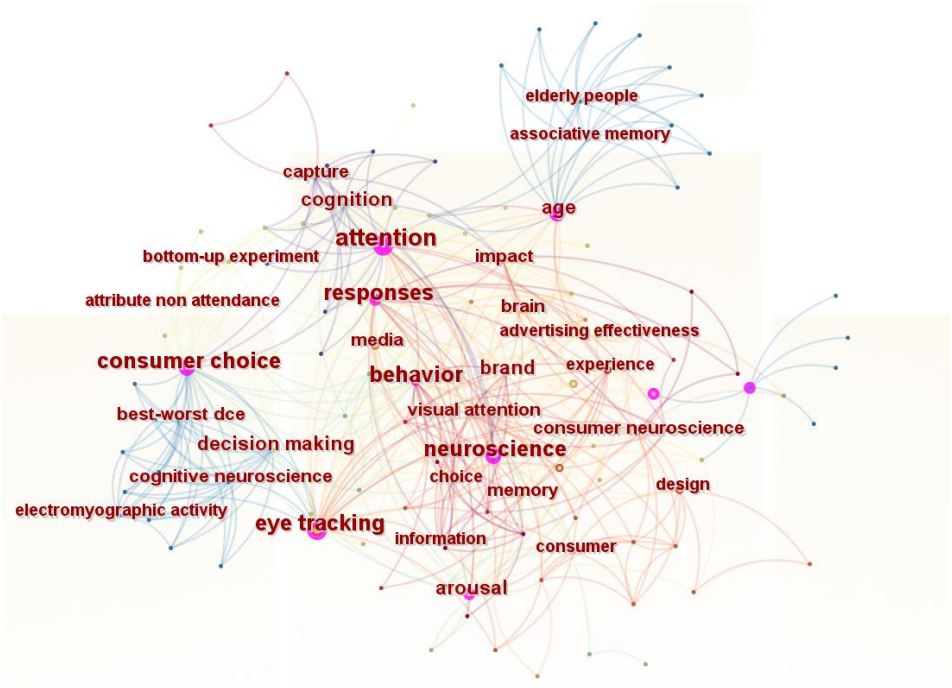
Figure 2. Number of publications on Neuromarketing in Web of Science (2014-2023)



Source: created by the authors.

Note(s): The search was conducted by November 2, 2024; consequently, it does not include data for the entire year of 2024.

***Figure 3*. Key words with high frequency**



Source: created by the authors via Citespace.

Tables

Table 1 Data Collection

Database	Web of Science Core Collection
Search period	2013-12-31 to 2024-08-31
Search time	2024.09.02
Article types	Journal Article
Search fields	Title and abstract
Final results	*57*

Source: created by authors.

Table 2. Exclusion criteria used for eligibility screening.

Inclusion Criteria
-Research article -Review article, even if not identified in the database -Full-text papers published in peer-reviewed journals in the English language -Articles focusing on the application of biometric approaches in the agri-food sector
Exclusion criteria
-Opinion papers and outlooks; conference papers and abstracts; concept articles -Not related to the marketing area -Articles employing other no physiological / biometric neuromarketing techniques (e.g. fMRI, EEG) -Articles focusing on developing technologies, rather than applying them.

Source: created by authors

Table 3 Publication year distribution

Publication year	n
2014	1
2015	4
2016	1
2017	5
2018	1
2019	4
2020	14
2021	8
2022	8
2023	7
2024	2
Total	57

Note(s): The search was conducted by November 2, 2024; consequently, it does not include data for the entire year of 2024.

Table 4. Top Authors with papers published (2014-2024)

Author	n
Mañas-Viniegra, Luis	4
Juarez-Varon, David	3
Núñez-Gómez, Patricia	3
Tur-Viñes, Victoria	2
Noci, Giuliano	2
Dellacasa Levrini, Gabriel Roberto	2
Javier Marin	2
Lamberti, Lucio	2
Hamelin, Nicolas	2
Mauri, Maurizio	2
Sutil, Dolores Lucía	2
Bettiga, Debora	2
Goya-Esteban, Rebeca	2
Thaichon, Park	2
Baños, Miguel	2

Source: created by the authors.

Table 5. Top Institutions with papers published (2014-2024)

Institutions	n
Polytechnic University of Valencia	6
Complutense University of Madrid	6
Universidad Rey Juan Carlos	4
University of Alicante	2
Griffith University	2
Polytechnic University of Milan	2
SP Jain Sch Global Management	2
Universidad Internacional De La Rioja	2
University of Valencia	2

Source: created by the authors.

Table 6. Top Countries with papers published (2014-2024)

Countries	n
Spain	23
USA	7
Italy	6
Australia	5
Brazil	3
England	3
Germany	3
Mexico	3
PRC China	2
Denmark	2
Portugal	2
Romania	2
South Africa	2
Turkey	2

Source: created by the authors.

Table 7 Journal distribution (n>1)

Scientific journal	n
Frontiers in Psychology	12
Journal of Neuroscience Psychology and Economics	4
Journal of Retailing and Consumer Services	2
Applied Sciences Basel	2
Asia Pacific Journal of Marketing and Logistics	2
Behavioral Sciences	2
Comunicar	2
Heliyon	2
Journal of Business Research	2
Physiology Behavior	2
Sustainability	2

Source: created by the authors

Table 8 Top publisher (n>1)

Scientific journal	n
Frontiers Media Sa	14
Elsevier	11
Mdpi	8
Emerald Group Publishing	5
Educational Publishing Foundation-American Psychological Association	4
Taylor & Francis	4
Wiley	3
Grupo Comunicar	2
Springer Nature	2

Source: created by the authors

Table 9 Top key words (n>2)

Key words	**n**	**Key words**	**n**
eye tracking	20	cognition	3
responses	16	consumer	3
attention	12	social media	3
neuroscience	11	choice	3
behavior	10	decision making	3
impact	10	model	3
visual attention	7	advertising effectiveness	3
memory	7	online reviews	2
arousal	6	emotion	2
perception	5	movements	2
information	5	decision	2
galvanic skin response	5	challenges	2
consumer neuroscience	5	consumers	2
design	4	products	2
brain	4	science	2
experience	4	capture	2
product	4	architecture	2
consumer choice	4	attitude	2

brand	4	facial coding	2
media	4	disgust	2
age	3	strategy	2
advertisements	3	avoidance	2
attitudes	3	food labels	2

Source: created by the authors

Table 10 Techniques employed in research

Citation	Sample size	Used tools	Other methods
Ülker et al., 2024	40	GSR, photoplethysmography (PPG)	
Baranda et al., 2024	50	GSR, Facial coding	Questionnaires
Mancini et al., 2023	175	Eye-tracking, Facial coding	Questionnaires
Zunckel et al., 2023	56	Eye-tracking	
Kim & Kim, 2024	28	Eye-tracking	
Juárez-Varón et al., 2023	30	GSR, Eye-tracking	
Gil-López et al., 2023	57	Eye-tracking, VR	Body posture, Spatial navigation
Zahmati et al., 2023	80	Eye-tracking	
D'Ambrogio et al., 2023	77	Eye-tracking	
Pelau et al., 2022	24	Eye-tracking	
Herrando et al., 2023	194	HR	Questionnaires
Rinklin et al., 2022	42	Eye-tracking, GSR	
Sola et al., 2022	168	Eye-tracking	
González-Mena et al., 2022	39	Eye tracking, Facial coding	
Lombard, 2022	307	Eye-tracking	Questionnaires
Chen et al., 2022	40	Eye-tracking	ROI analysis
Pascucci et al., 2022	62	Eye-tracking	
Johnson et al., 2022	64	Eye-tracking	Questionnaires
Mauri et al., 2021	160	IAT, Facial coding	
Sik & Soba, 2021	32	Eye-tracking	Questionnaires
Karmarkar et al., 2021	66	Eye-tracking	
Baños-González et al., 2021	56	Facial coding	
Rúa-Hidalgo et al., 2021	30	Eye-tracking, GSR, Facial coding	
Zamith et al., 2021	60	Eye-tracking, GSR	
Levrini & dos Santos, 2024	80	Eye-tracking, Facial coding	

David et al., 2021	30	Eye-tracking	
Barquero-Pérez et al., 2020	43	GSR, HR	
Nuñez-Gomez et al., 2020	32	GSR, EDL	Questionnaires
Bettiga et al., 2020	21	GSR	Questionnaires
Mañas-Viniegra et al., 2020	31	Eye-tracking, GSR	
Aguiló-Lemoine et al., 2020	42	Eye-tracking	
Lajante et al., 2020	51	Facial coding	
Rojas et al., 2020	28	Eye-tracking	
Otamendi & Martín, 2020	100	Facial coding	
Juárez-Varón et al., 2020	30	Eye-tracking, GSR	
Boscolo et al., 2021	180	Eye-tracking	
Hamelin et al., 2020	57	Eye-tracking, GSR, Facial coding	
Levrini et al., 2020	268	GSR, Facial coding	
Mañas-Viniegra, Núñez-Gómez & Tur-Viñes, 2020	60	Eye-tracking, GSR	
Mañas-Viniegra, García-García & Martín-Moraleda, 2020	30	Eye-tracking, GSR	
Dos Santos et al., 2019	240	Eye tracking	
Singhet al., 2020	40	GSR, Facial coding	
Prieto-Pinto et al., 2019	155	Eye-tracking, GSR	
Hernández-Fernández et al., 2019	10	Facial coding	
Muñoz-Leiva et al., 2019	60	Eye-tracking	Questionnaires
Meyerding, 2018	17	Eye-tracking	
Missaglia et al., 2017	40	GSR	
Baraybar-Fernández et al., 2017	26	GSR, HR	Questionnaires
Bettiga et al., 2017	160	GSR	Questionnaires
Ramsoy et al., 2017	30/98	Eye-tracking	body posture
Hamelin et al., 2017	60	Facial coding	
Niedziela et al., 2016	18	HR, GSR, Facial coding	Questionnaires
Lewinski, 2015	16	Facial coding	
Añaños, 2015	60	Eye-tracking	
Christoforou et al., 2015	16	Eye-tracking, HR	

Rasch et al., 2015	37	Eye-tracking, Facial coding	Questionnaires
Ares et al., 2014	71	Eye-tracking	

Source: created by the authors

Note(s): EDA and other electro dermal activity recorder are marked as GSR,

Table 11 Top Techniques employed in research

Measurements	n
Eye-tracking or other visual attention recorders	38
Galvanic Skin Response or EDA or other electro dermal activity recorders	21
Facial Coding or fEMG	17
Heart rate or ECG	5
Implicit Association Test (IAT)	1
Photoplethysmography (PPG)	1

Source: created by the authors

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