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Article

Advances in neuromarketing and improved understanding of consumer behaviour: analysing tool possibilities and research trends

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Advances in neuromarketing and improved understanding of consumer behaviour: analysing tool possibilities and research trends

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ABSTRACT

Neuromarketing, an emerging subject and generating diverse body of knowledge in the extant literature, this study aims to present qualitative and quantitative knowledge of the neuroscientific domain by analysing the application of various neuromarketing tools and techniques in conducting the research studies. This paper comprises a systematic review of 61 journal articles combined with bibliometric analysis of 577 peer-reviewed journal articles following the PRISMA framework, employing content analysis and keyword co-occurrence analysis. The comprehensive analysis presented a research profile illustrating chronological trends in neuromarketing research and discovered potential new domains, demonstrating explored and unexplored practical utility in neuromarketing. The results highlight the application of Functional Magnetic Resonance Imaging (fMRI), eye-tracking, and neural networks for data analysis as prospective areas in neuroscientific research. An overview of existing neuroscientific tools was presented based on the user context and research outcomes, outlining their benefits and limitations, along with ethical concerns. A theoretical framework was proposed to illustrate the neuromarketing effect on consumer behaviour, suggesting potential areas for future investigation. The findings of the study will be of interest to scholars and marketers in providing the insights on various neuro tools and techniques, and its significant role in decision-making, such comprehension may improve marketing effectiveness.

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1. Introduction

Businesses globally, in 2022, invested USD 793.25 billion on promotions and advertisements across various channels, encompassing digital media, print media, and omnichannel outlets (Statista, 2023). Firms implement various marketing strategies and techniques to promote their products to attract consumers' attention and persuade them to purchase by influencing their behaviour (Bahadir et al., 2015). Market research in understanding consumer behaviour is crucial, as consumers' habits and behaviours continuously evolve over time due to unprecedented choices and preferences (Nevskaya & Albuquerque, 2019). Consumer decisions are often influenced by complex factors such as intuitions, reflections, and values, and evaluating them accurately is challenging (Rand et al., 2014). In the past, companies relied on traditional methods, such as interviews, group discussions, and questionnaires, to study and analyse consumer purchasing behaviour (Detweiler et al., 1999). However, these data collection methods have gradually become less relevant due to their constraints of cost, time, and accuracy. To address these limitations of traditional techniques, researchers and marketers during late 1990s amalgamated tools and methods from other domains such as physiology, psychology, and neuroscience into consumer research

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(Lang et al., 1995), giving birth to a new marketing domain known as Neuromarketing. Businesses tap neuromarketing domain to gain fresher and in-depth insights into customer preferences and choices that influences the decision making, leading to the design of effectively targeted marketing communications.

Neuromarketing techniques have been popular over the years to conduct marketing studies, and have been used as effective tools in exploring consumer buying decisions, combining consumer psychology with behavioural science (Alsharif et al., 2021). Neuroscientific studies carried out in an stimulated, collaborative, and bias-free environment can lead to an improved understanding of consumer behavioural patterns under different conditions (Lee et al., 2007). The interdisciplinary nature of neuromarketing, integrating neuroscientific techniques with marketing theories and practice (Lim, 2018), deep dive into the psychology of human behaviour, and empower businesses to better comprehend customer choices and motivations, thus nudging them to make favourable decisions.

Neuromarketing approach focusses on various brain process and functions, that affects cognitive, attentive, and emotive faculties to influence and drive certain consumer preferences (Shaw & Bagozzi, 2018). Marketers study brain signals and eye movements in response to marketing stimuli and draw behavioural insights using various tools such as Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), Magnetoencephalography (MEG), Transcranial Magnetic Stimulation (TMS), and Eye-Tracking (Rawnaque et al., 2020). Several studies have measured, analysed, and interpret brain-waves to study the consumer psychology using signal and image processing algorithms and deep machine learning methods (Doma & Pirouz, 2020). Research have investigated the role of neuromarketing to peek into consumer minds and explore buy buttons in fostering consumer decision making process (Sharma et al., 2010). This fascinating ability of neuromarketing to comprehend subconscious motivations has unlocked new potential for businesses to design effective marketing strategies, improving their understanding of consumer behaviour.

The aim of this study was to furnish in-depth insights about various neuro-mapping tools and techniques through a comprehensive review of the extant studies in neuromarketing domain. A multidimensional array of conventional neuromarketing tools is presented categorized on the account of user context and research outcomes, illustrating their benefits and advantages referred to as brighter side, with ethical and privacy issues referred to as darker side. A broader research agenda exploring the implications and potential applications of neuromarketing was developed by taking a cumulative view of existing studies that had used neuroscientific tools and theories. In pursuit of this objective, this article addresses the following research questions (RQs):

RQ1: What are the trends in neuromarketing in terms of annual publication patterns, leading journals, geographical scope, and the methods used in empirical research?

RQ2: What has been the significant and influential themes in neuromarketing research studies?

RQ3: Which tools/techniques should be considered worthy of conducting neuroscientific research?

RQ4: What are the future avenues and potential implications for marketers and researchers in neuromarketing?

Research question 1 presented a descriptive analysis, while research question 2 sought to elucidate the clustering of co-occurring terms in research papers related to neuroscientific studies. Research Question 3 encompasses an examination of the various tools and techniques utilized in the field of neuroscientific research. This includes profiling of neuroscientific tools designed to assess user context and focus, as well as an exploration of both positive and negative aspects of these tools respectively. Research question 4 addresses the future research scope and implications for the researchers and academicians in the neuromarketing domain. The objective of this study encompasses several aspects, such as drawing conclusions, examining consequences, identifying future research opportunities, and acknowledging limits.

2. Literature review

Marketing has undergone transformation from a traditional product intensive approach to a more consumer driven interactive experience, creating a unique value and meaningful appeal to a specific group of consumers (Pralhad & Ramaswamy, 2004). Marketing strategies significantly consider customers' sub-conscious components to play an important role in engaging and decision-making in the buying

process (Suomala et al., 2012). Neuroscientific methods are therefore considered as valuable technique that can offer in-depth understanding of overall decision-making process, which are otherwise uncaptured in non-neuroscientific studies. This combination of science and technology has enriched the consumer behaviour domain, empowering marketers to devise effective marketing strategies by using various scientific 2-d and 3-d models (Solomon, 2018).

A neuromarketing approach contributes to enhancing marketing research by studying the cognitive and affective aspects of consumers, using non-invasive brain-computer interfaces and tracking physiological responses (Kawala-Sterniuk et al., 2021). Few neuromarketing methods undertake communication research by tracking eye movements, skin conductance and heart rate, thus quantitatively assessing the marketing stimuli (Dimpfel, 2015), and providing insights into mechanisms behind consumer choice and preference formation (Karmarkar & Yoon, 2016). The neurophysiological signals can be studied using spectral analysis by running machine learning algorithms to predict a near-exact indication of consumer preferential likes or dislikes (Kroupi et al., 2014). Hence, it is imperative to review neuromarketing's building blocks to assess its fields of application and provide original perspectives on neuroscientific domain (Hsu, 2017).

Recent studies have systematically reviewed the neuromarketing literature to understand the latest trends in neuroscientific domain (Zhu et al., 2022), reflecting its' evolution alongside the growth of consumer-centric economy and increased preferences for tailormade choices (Archana & Mahajan, 2023). Past studies have explicated on the expansion of neuromarketing realms and its properties, aligned with the marketing activities and various processes (Jayadatta & Ramanjaneyalu, 2021). The literature emphasizes advancements in tools and techniques (Gill & Singh, 2022), providing insights into consumer choices and decision-making (Makori, 2023), and implications to develop market retaining strategies (Frederick, 2022). Neuromarketing have largely been studied in association with the psychology and marketing theories, to comprehend better the human cognition and its' effect on consumer behaviour (Royo-Vela & Varga, 2022). There has been observed a growing trend in neuromarketing research with the induction of newer technology, that explores the novel aspects of consumer marketing and behaviour (Ali et al., 2022). Hence, neuromarketing speaks of huge potential with its' inter-disciplinary collaboration, promising to reshape the consumer and industry by influencing and improving lives through customized approaches (Kaihara et al., 2018).

Consumer behavioural research on investigating the role of sub-conscious mind, considering emotional and cognitive responses, has received considerable attention from academics and industry (Hamelin et al., 2017). A comprehensive analytical description of extant studies is significant in gaining newer insights into various intricate mechanisms of brain, that govern the effects of emotion, attention, memory, and decision-making on the efficiency of neuromarketing tools. Hence, this study aims to address this research gap by conducting a comprehensive review and bibliometric analysis of various neuromarketing tools and techniques employed in the field of marketing communication and research.

3. Research methodology

In accordance with PRISMA guidelines (Page et al., 2022), we meticulously shortlisted articles for this review, a process illustrated in Figure 1 (Moher et al., 2015). This checklist promotes transparency and replicability, thereby minimizing the incidence of erroneous research methodologies. The crux of this study lies in scrutinizing the advancement in neuromarketing through the lens of bibliometric techniques (Lim & Kumar, 2024; Mukherjee et al., 2022). Bibliometric analysis serves as the cornerstone of this inquiry, designed to gauge the vitality of neuromarketing literature in terms of publication productivity, seminal works, and intellectual scaffolding (Aria & Cuccurullo, 2017). Noteworthy, bibliometric methods outshine their counterparts in objectivity, adhering to rigorous review protocols and leveraging quantitative analytics.

3.1. Aim and scope

The overarching aim of this study is to furnish a panoramic view of the existing literature on neuromarketing, concentrating on its performance (productivity, impact) and intellectual structure. This scope, is expansive, covering multiple research facets relevant to neuromarketing, as outlined by the guiding research questions (RQ1–RQ4).

3.2. Study technique for analysis

This investigation deftly amalgamates bibliometric and content analytical techniques to trace the evolutionary arc of neuromarketing research. Core productivity and impact metrics, including publication and citation count, form the foundation for our performance analysis. To further enrich the analysis, we deploy a keyword co-occurrence analysis to unpack the thematic clusters of related topics within the vibrant field.

3.3. Criteria for inclusion and exclusion

To amass a representative dataset, we followed the PRISMA guidelines, collaborating with subject-matter experts in neuromarketing to compile a robust list of search keywords. Utilizing a meticulously crafted search string, we searched the Scopus database for publications featuring neuromarketing-related keywords in the article title: ("Neuro*" OR "Neural*" AND "Consumer Behaviour"); ("Mind Mapping" AND "Consumer Behaviour"); ("Choice Prediction" AND "Consumer Behaviour") (Table 1). Our search parameters included research articles document types, English language Journal articles and a publication timeframe spanning 2007 to 2022. Conducted in June 2022, this search yielded 934 articles. Following rigorous screening with inclusion criteria of peer reviewed journal articles in English, we retained 577 articles for

Table 1. Search protocol.

| Limitations | English full text studies up to June 2022 |
|-----------------|---|
| #1 | "Neuro*" OR "Neural*" AND "Consumer Behaviour" |
| #2 | OR "Mind Mapping" AND "Consumer Behaviour" |
| #3 | OR "Choice Prediction" AND "Consumer Behaviour" |
| Search Strategy | #1 AND #2 AND #3 |

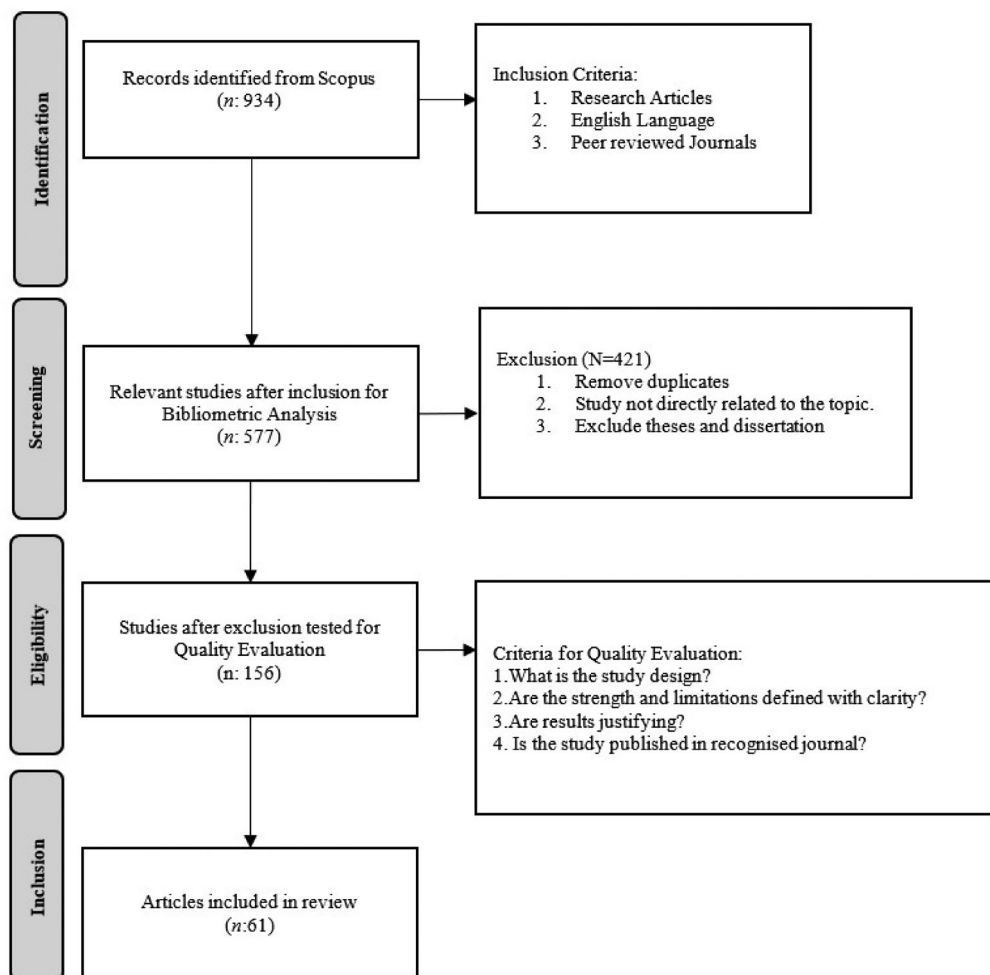


Figure 1. Study selection process as per PRISMA approach (Page et al., 2022).

the bibliometric analysis. Next, applying the exclusion criteria i.e., duplicate studies, theses and dissertations, and studies not related to the topic, studies were filtered out, that left us with 156 studies for further analysis. Later on, we did the quality evaluation for our content analysis. We got 61 articles, that most directly speak to our research questions (scope) (Bartol et al., 2014) (Figure 1).

3.4. Data organizing and analysing

For the actual bibliometric analysis, we harnessed the capabilities of VOSviewer software (Van Eck & Waltman, 2014). VOSviewer excels in visualizing complex bibliometric networks that encompass various elements such as articles, journals, authors, and countries (Chhabra et al., 2023). On the other hand, we did content analysis as well for performance analysis (productivity, impact) and science mapping (keyword co-occurrence of themes and topics). By employing this software approach, we aim to mitigate interpretation bias, a well-documented pitfall in qualitative reviews (Donthu et al., 2021; MacCoun, 1998). Through these analytical tools, we are well positioned to comprehensively address our research questions.

4. Findings

This section presents various findings of the analysis of neuromarketing literature and existing neuro mapping tools and methods in align with the research questions they aim to answer. Addressing research question 1 (RQ1), the statistical analysis comprises of various aspects, such as the number of relevant annual publications (Figure 2), most relevant geographical nations (Figure 3), international relevant journals publishing these studies (Figure 4), and methods adopted to conduct empirical studies (Figure 5). The bibliometric data for the investigative analysis was obtained from the Scopus database, depicting the contextual landscape of recent neuroscientific research studies.

4.1. Descriptive research profiling

4.1.1. Most relevant annual publications in neuromarketing

Figure 2 illustrates the chronological trend in annual publication of articles during the study period. This shows that relatively few neuromarketing papers were published from 2007 to 2016. However, there was

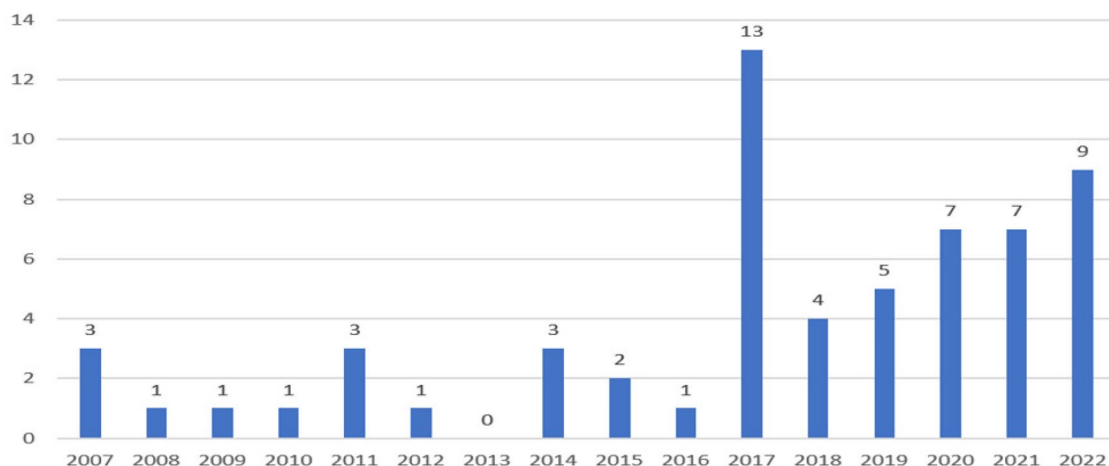


Figure 2. Annual publication of research articles.

a distinct upswing in 2017, signifying an evident surge in neuroscientific research, with 13 articles published that year, reaching the zenith. Afterwards, there was a steady increase in the publication of number of articles from 2018 to 2022, indicating the relevance and growing significance of the domain.

4.1.2. Most relevant geographical regions in neuromarketing

Figure 3 demonstrates the geographical scope of the global landscape of neuromarketing research publications spanning back to the 1990s. Noteworthy, the United States has been the leader in publishing the highest number of studies, followed by countries such as United Kingdom (UK), Germany, Italy, India, Malaysia, China, and Denmark, making significant contributions to the neuromarketing literature.

The prominent position of USA and UK in spearheading neuromarketing research can be attributed to their increased investments in marketing and information technology-driven research, that requires the usage of neuroscientific tools and techniques (Jander et al., 2020). They undertook novel studies to discover innovative ideas and insights to analyse and examine consumer behaviour, in context with the evolving market demands (Stacho et al., 2015). Educational institutions such as Harvard Business School in the USA and Warwick University in the UK played a crucial role in figuring these research studies, possibly providing the explanation to the substantial increase of publications from these countries (Hodgkinson & Healey, 2014). Moreover, the emerging number in publication of articles from countries such as Germany, Italy, India, and Malaysia testify of their growing research emphasis on propagating

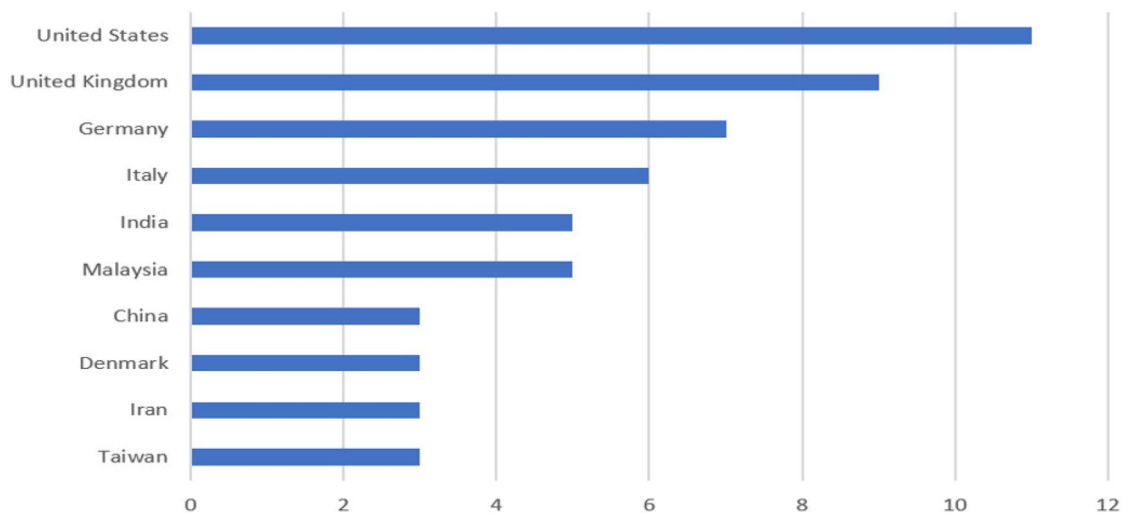


Figure 3. Geographic scope.

technology (Lang & Mohnen, 2019), innovation (Dani & Gandhi, 2022), and diversity (Glaveanu & Taillard, 2018).

4.1.3. Most relevant journals in neuromarketing

Figure 4 shows the top ten journals in terms of publishing most number of neuromarketing articles, over the period from 2007 to June 2022. Noteworthy, a significant portion of these publications have been published in journals such as *Frontiers in Psychology* and *Journal of Consumer behaviour*; however, *European Journal of Marketing*, *International Journal of Consumer Studies*, *Journal of Consumer Marketing*, and *Marketing Letters* also make the list.

These journals were included owing to their high impact factors. The hierarchy of journals was ranked on the basis of data gathered from the SJR website (SCImago Research Group, 2007), which considers the global citations garnered by research publications. The impact factor of the “Journal of Consumer behaviour” over a 5-year period is comparatively highest to other journals. Moreover “Frontiers in Psychology” has the highest impact factor, which illustrates the high quality of relevant published articles considered in this paper, indicating the frequency and prominent position of publications across the chosen time frame.



Figure 4. Top ten journal publications.

4.1.4. Most relevant neuromarketing methods and techniques

Figure 5 illustrates the frequency of different research methods, that have been used to conduct a neuromarketing study. Approximately 33.3% of published research papers have used Systematic Review methods to explore neuromarketing, whereas 23.3% of research articles have used quantitative techniques.

Moreover, there has been a significant utilization of other methods in neuromarketing domain, such as experimental techniques (20%) and case study methods (13.3%), indicating their relevance. Interestingly, a moderate 10% of the research have been conducted using qualitative methods to delve into the profundity of neuroscientific domain. These analytical methods have been used stand-alone or in combination with other methods such as meta-analysis, which indicates the versatile and adaptable nature of the research methodologies employed.

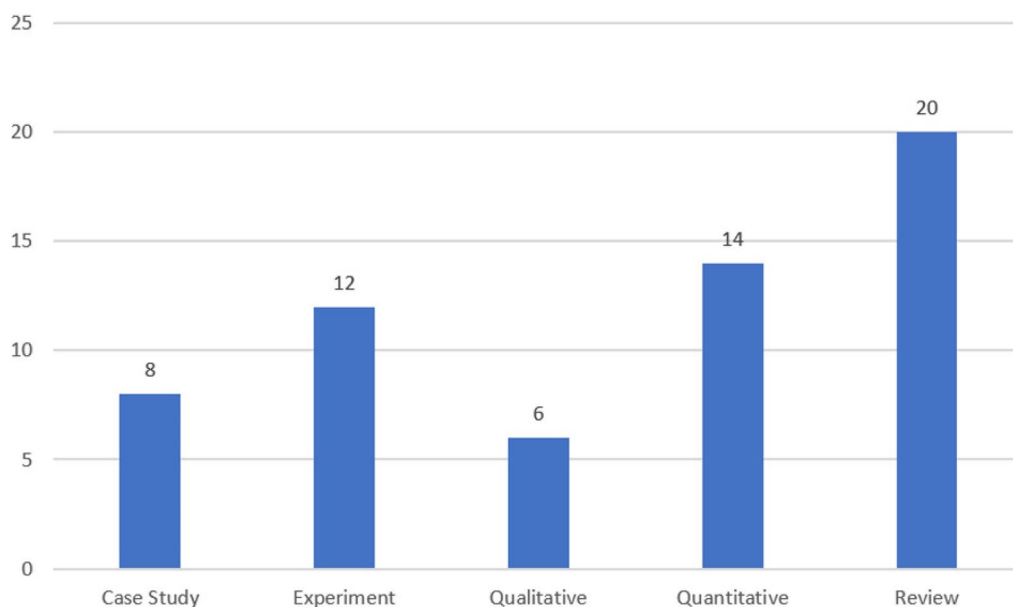


Figure 5. Research methods used in selected studies.

4.2. Conceptual structure: content analysis

Conceptual anatomy illustrates vital themes that contain the foundational structure of knowledge within a techno-scientific domain. A bibliometric analysis tool, namely word density, was utilized to generate a scientific map outlining the various contexts and terms related to prevailing

neuromarketing trends in research papers, which revealed the conceptual architecture of the subject of interest (Phan Tan, 2022). Word density serves as a visual synchronization of word clusters, where more frequently the term appears in the text being analysed, the larger the word comes in view (Atenstaedt, 2012). This methodology offers insights into the significance and effect of subjects within the discipline, thus highlighting the most prevalent gaps to be addressed in the pursuit of conducting neuroscience-related studies, providing answers to Research Question 2 (RQ2) and Research Question 3 (RQ3).

4.2.1. Frequency and development of themes: keyword analysis

The keywords used by the author indicate the context of the research studies (Comerio & Strozzi, 2019) and are used along with combined brief words to identify and extract relevant papers (Chalissery et al., 2023). Keyword density analysis was undertaken using the VOS viewer to investigate the most prevailing contexts in neuromarketing (Figure 6). An aggregate of 4666 keywords was identified in 577 papers. Notably, the keyword that was most prevalent in this analysis was “Neuromarketing,” which emerged 93 times, underscoring its widespread acceptance as a pivotal theme in the literature. The other associated keywords in the focus were “marketing” (61 occurrences), “consumer neuroscience” (51 occurrences) and “consumer behaviour” (47 occurrences). A major observation from the synthesis is the absence of uniformity in defining the theoretical concept of neuromarketing, and that a lack of unanimity has driven researchers to adopt words interchangeably, such as neuroscience, consumer behaviour, and consumer psychology.

The word-density visualization map developed from the keywords illustrates frequently recurring terms and other co-occurring terms in the published domain. The terms were neuromarketing, decision-making, physiology, consumer, fmri, neural networks, consumer neuroscience, ethics, and controlled study, that signifies its' importance within the realm of neuroscience research. The word density depicts the interconnectedness of the word neuromarketing with other words such as consumer behaviour, marketing, decision-making, cognition, attention, sales, and commerce. The combination of these words indicates that neuromarketing is a core element of the consumer behaviour domain and holds the potential to form the foundation for productive neuroscientific research theories. In addition, other emerging themes in the word cluster of keyword analysis are brain mapping, brain function, and eye movements, which show the growing influence of neuroimaging and AI models on predictive eye tracking. Notably, attention and cognition arise as two mental activities that garnered substantial attention within the literature employing neuroscientific methodologies in marketing contexts. Assessing consumer persuasiveness and behaviour within the contexts of choice behaviour and decision-making and controlled studies with neuroscience methods represent another prominent avenue of research. Although of lesser significance, the word density map highlights the contributions of neuroscientific mapping tools



Figure 6. Word density visualization map.

Note: This figure demonstrates the most frequently used keywords in neuromarketing, with a threshold limit of seven keywords.

such as brain mapping, diagnostic imaging, magnetic resonance imaging, and a few specific brain regions, such as the prefrontal cortex and frontal lobe, indicating its relative significance in future research. Furthermore, the map displayed neural networks, artificial neural networks, and convolutional neural networks, assessing their contributions in the neuromarketing literature, hinting at the potential of these frameworks to extend into novel contexts and establish neural correlations.

5. Overview of neuromarketing tools and techniques

Based on the data from the neuromarketing literature, a multi-dimensional structure displaying an array of neuromarketing tools and techniques used to conduct the behavioural study was presented. These neuromarketing tools and techniques were summarized specific to individual study context and distinct criteria such as recording of metabolic and electrical activity of the brain. Electrical activity in the brain can be recorded and measured using steady-state topography (SST) and transcranial magnetic stimulation (TMS), along with Electroencephalography (EEG), Magnetoencephalography (MEG), and Event-related potential (ERP). Other techniques such as Functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), and functional transcranial Doppler sonography (fTCS) has been found to provide information about metabolic activity in the brain (Ahlert et al., 2006). Techniques used to measure and analyse physiological biometric activity, without any facility to record metabolic activity of the brain are heart rate (ECG), Eye-Tracking, facial recognition (facial EMG), Implicit association Test (IAT), and Galvanic Skin Response (GSR).

Consumer behavioural research has witnessed the increased use of fMRI to record and measure brain activity in response to marketing communication stimuli, offering insights to decision-making process (Smidts et al., 2014); however, other alternative techniques might be deployed based on the research objective and available resources. Figure 7 categorizes the various neuromarketing tools based on their ability to measure the metabolic and electrical activities of brain.

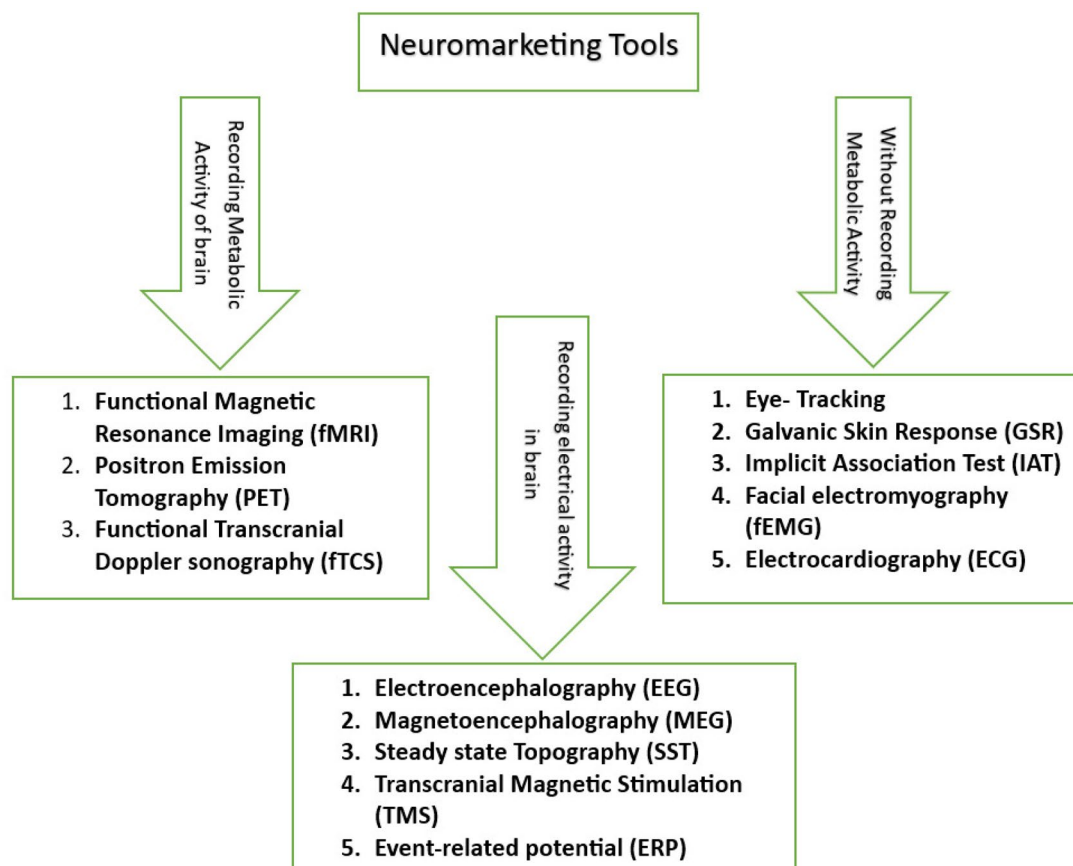


Figure 7. Neuromarketing tools and techniques.

5.1. Neuroscientific tools-user context and focus

This section presents an anthology of typical marketing studies based on the fundamental neuromarketing principles, which informs about the suitability of tool used to conduct research studies customized to specific user contexts (Table 2).

Table 2. Neuroscience tools and user Context.

| Authors | User context | Neuroscientific techniques | Focus |
|-------------------------|--|----------------------------|---------------|
| Ohme et al. (2010) | TV ads | EEG | Product |
| Reutskaja et al. (2011) | Snacks | Eye Tracking | Product |
| Khushaba et al. (2013) | Crackers | Eye Tracking | Product |
| Ravaja et al. (2013) | Grocery Products | EEG | Price |
| Bebko et al. (2014) | Advertisement | Eye Tracking | Product |
| Lepping et al. (2015) | Food | fMRI | Product |
| Telpaz et al. (2015) | Consumer goods | EEG | Product Price |
| Al-Kwafi (2016) | Soft drink & bottles filled with water | fMRI | Product |
| Kuhn et al. (2020) | Chocolate | fMRI | Product |
| Fehse et al. (2017) | Organic food | fMRI | Product |
| Clement et al. (2017) | Consumer goods | Eye tracking | Product Price |
| Samsuri et al. (2018) | Car | EEG | Product |

The integration of neuromarketing approach with consumer behavioural domain facilitates strategic decision making across diverse areas, such as market segmentation, product development, and product packaging to pricing strategy (Karmarkar et al., 2015). Businesses could leverage market segmentation based on consumer preferences and choices, which consider biases in neurological characteristics, without any reference to psychographics or demographics. In addition to product development, neuromarketing can contribute to brand development by providing valuable insights to improve brand promotional campaigns (Reimann et al., 2010), reverberating through meticulous design considerations, from advertisement banners and hoardings to posters and media planning.

5.2. Bright side: neuromarketing tools' advantages and limitations

Marketers and researchers have highlighted various neuromarketing techniques that serve as functional strategies within different areas of marketing, considering the advantages and limitations of the tools. Strategies are formulated using neuroscientific techniques integrated with sensory marketing approaches, or traditional methods with neuroimaging applications to arrive at better consumer insights (Menezes et al., 2016). Neuroimaging tools function as per the recorded physiological metabolic activity of a localized area of action in the body, such as the brain, eye, or skin, thereby acting as a good indicator of consumers' choices and preferences. Table 3 highlights the advantages, benefits, localized area of action, and limitations of neuromarketing tools.

Table 3. Details of neuroscience tools, benefits, area of action and limitations.

| Tool | Benefits | Area of action | Limitations |
|--|--|--|--|
| Electroencephalography (EEG) (Samsuri et al., 2018) | Millisecond-scale patterns of neural activity can be measured using these techniques | Localised brain areas electrical activity | 1. Signal from specific areas of brain are hard to pinpoint 2. Nucleus accumbent 3. Deeper brain structures are not measured |
| Functional magnetic resonance imaging (fMRI) (Fehse et al., 2017) | 1. Resolve activities in small structures 2. Analyses neighbouring signals and separates them 3. Whole brain measurement | Localized brain areas oxygen use | 1. Physically constraining 2. Equipment-intensive 3. Expensive |
| Eye Tracking (Clement et al., 2017) | Pupillometry can be combined with visual attention measurement to provide stronger nuanced data. | 1. Target of gaze 2. Pupil diameter 3. Gaze Duration | Does not address inferences, valences, thoughts, or emotions |
| Transcranial magnetic stimulation (TMS) /Transcranial direct current stimulation (tDCS) (Valero-Cabr  et al., 2017) | Can be used to show causality | Transient inhibition of local brain function | Focuses only on the function of the surface brain area |

(Continued)

Table 3. (Continued).

| Tool | Benefits | Area of action | Limitations |
|---|---|---|---|
| Biometrics: skin conductance response (SCR), heart rate, pupil dilation (Bach et al., 2009) | Simple, well validated | 1. Heart rate 2. Pupil dilation | It cannot distinguish between positive and negative arousal. |
| Facial electromyography (fEMG), facial affective coding (Kuhn et al., 2020) | 1. Monitoring of ongoing emotional (unconscious) responses to ongoing stimuli 2. Software that automatically encode facial images. | Facial effective coding | It directly attaches electrodes to the face |
| Pharmacology (Carré & Olmstead, 2015) | Allows better understanding of (physiological) state-dependent effects | 1. Oxytocin 2. Testosterone 3. Cortisol | 1. Cannot measure fast/immediate changes 2. Difficult to isolate specific effects as several effects attributed to a single chemical |

5.3. Dark side: ethics and privacy issues

Neuromarketing suffers from criticism and controversy owing to its perceived lack of ethical practices and the challenges faced by marketers from a consumer behavioural perspective. These ethical concerns associated with neuromarketing can be studied from three perspectives: company, consumer, and national. Companies using neuroscientific techniques to gather data and analyse the outcomes are questioned regarding their transparency and proprietary control over using the tool, leading to ambiguity in data reliability and validity (Stanton et al., 2017). From the consumer's standpoint, the use of invasive neuroscientific tools such as fMRI, EEG, and GSR raises discomfort, leading to unpleasant experiences, as they involve interfacing with the brain and skin in the human body. In the national context, several emerging markets, such as Romania, encounter obstacles and hurdles in the adoption of neuroscientific methods due to the nation's foreign and business policies (Stoica et al., 2015). Marketers have apprehensions regarding the premature application of neuroscientific techniques, stating the fact that the neuromarketing field is still evolving (Bhardwaj et al., 2023). Henceforth, there arises a necessity to establish an ethical framework in alignment with Ethical Guidelines in Neuromarketing (Goncalves et al., 2024), that could serve as a basis for marketers and experts, helping them to address the issues and promoting unanimity.

Neuromarketing studies emphasizes the effect of subconscious components on consumer buying behaviour, which is presumed to be subtly influencing the emotional aspect of consumer in making decisions (Stanton et al., 2017). Ethical concerns are raised when consumers feel their transparency to a company, citing possible infringement on their personal thoughts and privacy (Harvard Business Review, 2023), that cast a doubt on the adoption of neuroscientific methods by marketers and researchers. While neuromarketing is depicted as a means to gauge at consumer needs, it is considered a failure in addressing the desires of consumers (Stoica et al., 2015). Therefore, it is imperative to uphold the rights to privacy, autonomy, and dignity, which comprises of not only the positive right to information but also the negative rights against deceit, non-consensual studies, and use for purposes other than those intended (Hensel et al., 2017). Belmont Report (1979) encapsulates the basic principles and ideas, and lay out widely accepted standards for research practice to address these ethical challenges and concerns. To navigate these complexities, employing established ethical theories for future evaluations of neuromarketing could safeguard consumer rights and uphold ethical standards.

6. Theoretical framework

The information generated from content analysis and the literature is synthesized into an integrated conceptual framework that delves into consumer behaviour based on neuromarketing (Figure 8). The framework is founded on the theory of reasoned action, depicting the interplay between consumers' purchase intentions and their real behaviour (Fishbein & Ajzen, 1977), elucidating the relationship between stimulus and response and with neuromarketing effect positioned at the centre of marketing activities. This model may potentially bridge the gap between the knowledge, attitude, and perception of a consumer by examining the effects of neuromarketing in specific circumstances (Schulte-Goecking et al., 2020). With consumers already showing the intent to buy and psychologically, economically, and

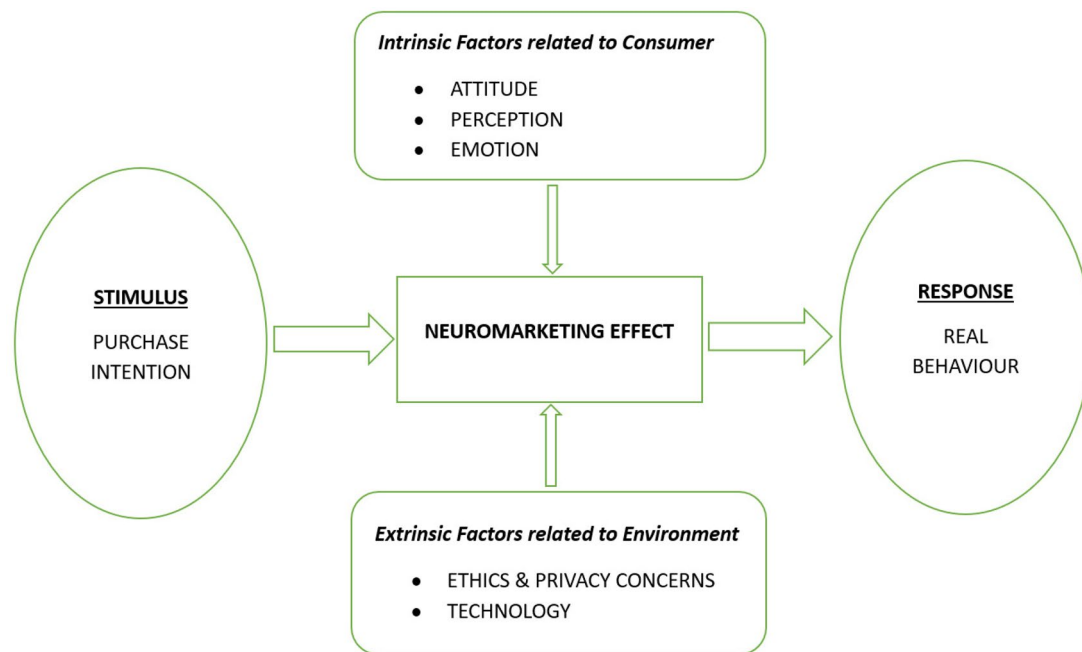


Figure 8. Theoretical framework.

emotionally aligned to the next stage of purchasing process (Peña-García et al., 2020), this theoretical framework augments the existing knowledge domain by bridging the gap and identifying the role of neuromarketing as a new dimension that affects the decision-making process.

The framework portrays the logical relationship between purchase intention as an antecedent and real buying behaviour as the outcome. Various factors influence the mechanism of antecedents and outcomes, namely decision-making and conversion of purchase intent into real buying behaviour. The expansion of factors can be broadly categorized into two groups: intrinsic factors related to consumers and extrinsic factors rooted in the surrounding environment. Intrinsic factors related to consumers include those that are concerned with the consumer and influence their decision-making, such as attitudes, perceptions, and emotions. Conversely, extrinsic factors related to the environment, such as ethical concerns, privacy issues, and technology, critically affect the use of neuroscientific techniques in organizations. Intrinsic factors related to consumers have the potential to moderate consumer responses, whereas extrinsic factors related to the environment may have a direct impact on consumer behaviour that affects purchase outcomes.

Notwithstanding, the framework may help marketers and managers to determine the reasons for the failure of a brand, significantly explaining the critical elements for the success of a brand. Integrating neuromarketing with the theory of reasoned action may help marketers extend the lifespan of a brand, especially by delaying the final declining stage, which could offer insights into the understanding of intrinsic and extrinsic factors influencing the desired outcome. Furthermore, the theoretical model holds for thorough study and empirical validation.

7. Reflections and directions for future research

The following research directions were derived using clusters and thematic areas: To answer the research question (RQ4), this study suggests research directions that are explained in detail below.

7.1. Scope for future research

Neuromarketing is an emerging topic and has contributed significantly to the realm of behavioural marketing research, offering many new and exciting concepts. This section though, identifies few critical areas in theoretical dimensions of neuromarketing that requires attention, highlighting some gaps.

Table 4. Future research directions.

| Categories | Future directions |
|-----------------------------|--|
| Context settings | <ul style="list-style-type: none"> a. Testing the ethical dimensions in various countries and investigating the causal effect of brain parts and human cognitive actions b. Examining the interconnections between neuroscience and technology such as nanoscience, exploring its' scope in healthcare and other allied disciplines, with focus on neuro-governance c. Integration with other fields such as economics and engineering leading to improved outcomes in interface design and financial risk strategies d. Fusing experimentation of multiple neuroscientific tools such as Eye-Tracking with EEG or GSR for improved outcomes and informed decision making e. Study of various cognitive factors such as word of mouth, perception, trust and influence on decision-making process |
| Methods/process orientation | <ul style="list-style-type: none"> a. Conducting inter-disciplinary studies integrating the theories of marketing, economics, psychology, adding to the body of literature on consumerism and psychology b. Further studies on various existing marketing theories and testing the concepts such as theory of planned behaviour, dual process theory, theory of reasoned action, and signalling theory c. Undertake timeline based longitudinal studies and comprehend the neuroscientific effects |
| Consumer centric focus | <ul style="list-style-type: none"> a. Future research focussed on human brain and its' underlying neuroscientific mechanisms affecting decision-making behaviour b. Studies to be conducted based on neuroscientific data to effectively understand the need orientation mechanism of customers c. Applying neuroscientific tools and techniques to study various human cognition factors of emotions, feelings, behavioural intentions |
| Marketing applications | <ul style="list-style-type: none"> a. Expanding the neuromarketing horizon by integrating technology such as virtual reality or augmented reality, and branding effects, providing consumers an enriching experience b. Focus on improved use of neuromarketing techniques to design an effective marketing communication mix to enhance the consumer reach c. Devising a marketing channel using neuromarketing tools for ecofriendly and green marketing products d. Mitigating the risks of ethical aspects and privacy issues by optimal use of communication, advertising and promotional activities |

Those areas have been broadly classified into four categories namely: context settings, methods/process orientation, consumer centric focus, and marketing applications (Table 4). Several marketing studies have examined consumer attention as a developing construct using methods such as brain activity, eye tracking, and facial coding; however, few studies have investigated customer retention (Hsu, 2017). Neuromarketing studies horizon can be expanded by integrating technology such as virtual reality or augmented reality, and branding techniques providing consumers an enriching experience, but the interacting effects among them should be considered (Adeola et al., 2022). Future neuromarketing research could explore neuromarketing as part of marketing strategy mix, integrating it with theories from other domains, giving it an inter-disciplinary perspective comprehending its' strength and challenges.

Neuroscientific studies are significant in determining consumer neuro-variables that lead to loyalty, attitudes, and choices or preferences towards certain buying decisions (Stoica et al., 2015), but do not specify the type of products, services, or industry. Future studies should explore these aspects and address the concerns related to neuro-governance, based upon neuroscientific metrics to effectively understand the need orientation of customers and study human cognition factors of emotions, feelings, and intentions. Many neuromarketing studies have centred on specific product lines, such as eco-friendly items, green marketing, and edible products (Stasi et al., 2018), and the generalization of the results is challenging. Further behavioural studies could be conducted to optimize the effectiveness of neuroscience techniques for products and services. Further neuromarketing studies may be conducted using mixed methods techniques raising new research questions and integrating existing theories, asserting its' practical implementation (Ruiz-Rodríguez et al., 2023). Additionally, research has highlighted ethical and privacy issues as critical considerations in the use of neuroscience techniques (Hensel et al., 2017; Stanton et al., 2017) to study consumer behaviour. Therefore, future behavioural research may be undertaken considering all stakeholders' concerns by adhering to the norms and ethical standards and establishing it by fostering education, interaction, and awareness among consumers (Ramsøy, 2019), thereby alleviating the apprehensions surrounding neuromarketing techniques. Neuromarketing studies have drawn their context from marketing theories, psychological perspectives, and technological aspects, providing an interdisciplinary approach (Chattopadhyay, 2020), which could be further explored by calibrating neuromarketing to gain competitive advantages. Future research may undertake study considering

context-specific cross-dimensional neuroscientific techniques, incorporating cognitive factors namely trust, word of mouth, and perception to arrive at informed decision-making at various levels of business and organisation.

7.2. Theoretical contributions

Theoretically, this study complements the existing body of knowledge by providing a new perspective on the neuromarketing tools, methods, and techniques used by marketers and researchers, comprehending the results multi-dimensionally through research profiling of publication trends and keyword analysis. The proposed theoretical framework can be studied and tested in various marketing contexts and across diverse industries and products (Lee et al., 2018). Researchers may identify various other variables as mediators or moderators that influence consumer decision making and strengthen the model (Fugate, 2007). Overall, this review includes the landscape of published articles centred on neuromarketing techniques and practices, thereby charting a course for prospective research endeavours within the conceptual structure.

7.3. Managerial implications

The managerial implications of this study will help researchers, academicians, and marketers assess each neuroscientific tool's relative strengths and weaknesses in comprehending the behaviour of consumers and facilitating more informed decision-making processes. Marketers and neuroscience experts with distinct but related areas of expertise can synergize by leveraging the findings of this study to enhance the effectiveness of marketing stimuli. In today's era of online marketing, where consumers prefer personalized and one-to-one offerings, neuromarketing can equip marketers with nuanced insights to gain a deeper understanding of individual consumers' minds (Amiri et al., 2022). Neuroscientific techniques could be explored by integrating it across diverse fields like engineering, finance, economics and social sciences disciplines, reshaping the paradigms and fostering innovation (Sengur & Goncalves, 2023). Neuroscience can aid in the design of intuitive human-machine interfaces and advanced prosthetics in engineering domain by understanding neural mechanisms, enhancing its' accessibility and functionality (Liu et al., 2024). Finance professionals could be benefitted by the insights from neuro-finance, illuminating the cognitive biases shaping the financial decision-making process, and strategizing the risk management and market forecasting (Willett, 2022). Moreover, inter-disciplinary integration of economics with neuroscience would provide insights on consumer behaviour, shaping marketing strategies and policy formulation with greater span of influence on neuroeconomics domain (Levallois et al., 2012). Social sciences field such as behavioural health sciences domain has always been innately linked with neuroscience offering holistic perspectives on cognitive, psychosocial, and behavioural genetics domain, fostering effective interventions in areas like public policy and healthcare (Mabry et al., 2008). These inter-disciplinary neuroscientific collaborations not only enrich our understanding of complex systems but also hold the promise of tangible real-world impact, driving societal progress and improving outcomes across domains. Managers, academicians and domain experts ought to understand the potential impact and consequences of employing neuroscientific techniques on the psychology of a customer, thus devising holistic strategies to improve their understanding of consumers' preference patterns and decision-making.

7.4. Limitations

This study has identified certain limitations. The literature review primarily relies on the Scopus database, which predominantly comprises peer-reviewed research papers but might have inadvertently excluded some relevant articles from other databases. These published research papers were extracted from the journals, thereby did not consider any books and conference proceedings. Few articles could have been excluded due to non-availability or language, as research papers in English were considered. Future research endeavours should explore data from other databases to mitigate this potential bias. Few relevant articles, such as those originating from fields belonging to social science and clinical psychology, might have been omitted during the study selection procedure. The study used a broader term in the

search protocol instead of a precise aspect, which could have led to non-inclusion of few studies due to absence of any related term. Notwithstanding these limitations, the findings of this study offer marketers, researchers, and experts a conceptual overview of current scientific studies and insights that have the potential to shape the direction of future research pursuits.

7.5. Conclusion

The realms of neuroscience, marketing, consumer psychology, decision science, and economics are gradually being integrated, creating a base for consumer neuroscience that is gaining credibility and momentum. The present study systematically investigated research papers on use of neuromarketing tools and techniques from Scopus database, using PRISMA approach to extract the relevant articles. It presented an overview of various existing neuromarketing tools, evaluating the suitability of its' user context in various product segments and mix, advantages and limitations in the bright side, and various ethical challenges in the dark side. A theoretical framework was proposed based on the generated information from literature and content analysis, illustrating the effect of neuromarketing on behavioural intention. Notably, the word density analysis described a key map that indicated the significant, relevant, and diminishing subjects, considering the clustering and density criterion. In particular, the analysis illustrates the prevalence of consumer behaviour, cognition, and physiology, with machine learning and neural networks contributing to fundamental research within the neuromarketing domain. While fMRI holds a dominant position as the favoured technique, other techniques such as Eye tracking, EEG, and implicit measurements have been identified as complementary and cost-effective alternatives. This study attempts to furnish all the known and unknown aspects of neuromarketing advancements, by highlighting the implications of neuroscience techniques in marketing research as a whole, thereby contributing towards improved understanding of consumer behaviour.

The analytical approach of this review study identifies new key thrust areas for prospective research in neuromarketing, where future scope could be discussed under: concepts, theory and methods. The conceptual understanding of the relationship between theoretical constructs needs clarity due to existing scientific and theoretical technicalities. Hence, there is a lack of focus on comprehending neuromarketing's behavioural and psychological aspects in aligned with newer areas namely data security, bio-sensing devices, blockchain technology, and digital regulations. From a theory perspective, neuromarketing being relied on the theoretical knowledge of various disciplines of science and psychology to study consumer behaviour, cognitive theories will gain a bigger stage, with introduction of metadata used for decision-making. The dynamic nature of technology and intelligent systems would force us to reckon the potential of artificial intelligence, machine learning and big data in generating patterns to understand neuromarketing domain better. Finally, the change in methods and techniques in projection used in neuromarketing, such as consumer transformed to a virtual or metaphysical medium, leads us to newer methods of data collection such as eye-tracking, and analysis such as netnography and sentiment analysis.

Author contributions

Seema Bhardwaj: Contributed towards conception and design, acquisition of data, manuscript write – up, analysis and interpretation of data. **Surya Bahadur Thapa:** Co-ordinated the study, drafting the manuscript and revising it critically for important intellectual content. **Aradhana Gandhi:** Outlining the research plan of the study, reviewing the manuscript critically, and overall supervision of the study.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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