

Complementary Analysis of Self-Report Instruments in Enhancing the Accuracy of Electroencephalography (EEG) Results in Marketing

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ABSTRACT

Neuromarketing employs tools such as electroencephalography (EEG) to uncover the unconscious layers of consumer decision-making. However, exclusive reliance on neural data may lead to incomplete and, in some cases, misleading interpretations. Using a systematic review approach, this study identified and analyzed 52 domestic and international studies in which EEG and complementary instruments were applied in the field of marketing. The studies were classified into four categories based on the types of instruments used: exclusive use of EEG/QEEG, self-report instruments, non-self-report complementary instruments, and integrated approaches. The findings indicate that although EEG possesses a strong capability for capturing unconscious responses, its integration with questionnaires, interviews, eye-tracking, physiological indicators, and machine-learning algorithms significantly enhances data interpretation accuracy and the predictive power of consumer behavior models. Furthermore, a considerable gap was observed between domestic and international studies regarding the adoption of multimodal approaches. Accordingly, the present study emphasizes the necessity of developing integrated models and designing standardized protocols to improve the accuracy and validity of neuromarketing findings.

Keywords: *Neuromarketing, Electroencephalography (EEG), Self-Report Instruments, Consumer Decision-Making, Systematic Review.*

1. Introduction

In contemporary markets, understanding consumer behavior has become one of the most critical challenges facing organizations and marketers. Traditional marketing research methods, including surveys, interviews, focus

groups, and observational techniques, have long been employed to examine consumers' attitudes, preferences, and purchasing decisions. Although these methods provide valuable insights into consumer perceptions and reported experiences, they are often constrained by respondents' ability and willingness to accurately articulate their thoughts and emotions. Consequently, researchers have

increasingly questioned whether conscious self-reports alone can fully explain the complex cognitive and emotional processes underlying consumer decision-making (Ariely & Berns, 2010; Lee et al., 2007). The emergence of neuromarketing has provided a novel perspective by integrating neuroscience methodologies with marketing research, enabling scholars to investigate the neural mechanisms that influence consumer responses beyond conscious awareness (Plassmann, Ambler, et al., 2012; Zurawicki, 2010).

Neuromarketing is generally defined as the application of neuroscientific techniques to examine consumer reactions to marketing stimuli such as advertisements, products, brands, packaging, pricing strategies, and purchasing environments (J. Hakim et al., 2021; Lee et al., 2007). Since its emergence, the field has attracted considerable attention from both academics and practitioners because it promises access to information that consumers may be unable or unwilling to express through conventional methods. Researchers have argued that many purchasing decisions are influenced by subconscious processes, emotional reactions, and automatic cognitive mechanisms that occur prior to conscious evaluation (Ariely & Berns, 2010; Plassmann, Venkatraman, et al., 2012). Consequently, neuromarketing seeks to bridge the gap between observable consumer behavior and the underlying neural processes that drive it. Recent reviews indicate that neuromarketing has evolved from an exploratory discipline into a rapidly expanding field characterized by increasing methodological sophistication and interdisciplinary integration (Guo et al., 2025; Gupta, 2025).

Among the various neuroscientific tools employed in neuromarketing, electroencephalography (EEG) has become one of the most widely used techniques due to its relatively low cost, high temporal resolution, portability, and ability to measure real-time neural activity (Cohen, 2023; Cook & Warren, 2011). EEG records electrical activity generated by neuronal firing patterns across different regions of the brain, allowing researchers to examine cognitive and emotional responses to marketing stimuli as they occur. The technique has been applied to investigate a broad range of marketing phenomena, including advertising effectiveness, consumer attention, emotional engagement, brand perception, product evaluation, purchase intention, and decision-making processes (Ozair et al., 2024; Venkatraman et al., 2015). Several studies have demonstrated that EEG signals can

successfully distinguish between preferred and non-preferred products, predict purchasing intentions, and identify neural correlates of consumer valuation (Hakim et al., 2023; Ma et al., 2024). Furthermore, EEG-based approaches have been used to evaluate responses to specific products such as coffee, footwear, and chocolate, providing insights into both emotional and cognitive aspects of consumption experiences (Artenzio et al., 2022; Pereira & Oliveira, 2021; Semunova et al., 2023).

Despite its growing popularity, EEG is not without limitations. One of the most frequently cited challenges concerns the interpretation of neural signals in isolation from other sources of information. While EEG can reveal whether a consumer exhibits heightened attention, emotional arousal, or cognitive engagement, it often provides limited insight into the subjective meaning of these responses. For example, increased neural activation may reflect interest, confusion, excitement, anxiety, or cognitive effort, depending on the context (Hsu & Yoon, 2021; Plassmann, Ambler, et al., 2012). Consequently, relying solely on EEG data may result in incomplete or even misleading conclusions regarding consumer preferences and decision-making processes. Scholars have therefore emphasized the importance of combining neural measures with complementary methods capable of capturing behavioral, cognitive, emotional, and subjective dimensions of consumer experience (J. Hakim et al., 2021; Khondakar et al., 2024).

One of the most widely used categories of complementary methods consists of self-report instruments, including questionnaires, rating scales, interviews, and surveys. These tools enable researchers to collect information about consumers' attitudes, beliefs, preferences, emotions, intentions, and perceived experiences directly from participants (Malhotra, 2019; Paulhus & Vazire, 2007). Self-report measures remain highly valuable because they provide access to conscious evaluations and subjective interpretations that cannot be directly inferred from physiological or neural signals. In marketing research, self-report instruments have traditionally served as the primary means of assessing customer satisfaction, brand attitudes, purchase intentions, and perceived product value (Malhotra, 2019). However, self-report methods are susceptible to several forms of bias, including social desirability bias, recall errors, response styles, impression management, and false self-presentation (Grimmond et al., 2024; Paulhus & Vazire, 2007). Recent studies have further demonstrated that individuals

frequently provide responses that differ from their actual feelings, particularly in socially sensitive or commercially relevant contexts (Grimmond et al., 2024; Nor et al., 2025). These limitations highlight the need to integrate self-report data with objective physiological and neural measurements.

The complementary strengths of EEG and self-report instruments have encouraged researchers to adopt multimethod approaches. In such approaches, EEG provides objective indicators of unconscious neural responses, while self-report measures capture conscious perceptions and evaluations. The integration of these data sources can reveal discrepancies between what consumers report and what their brains actually process, thereby offering a more comprehensive understanding of consumer behavior (Hakim, 2021; Huo et al., 2023). For example, studies investigating consumer preferences have shown that neural indicators may predict future choices more accurately than stated preferences alone, whereas self-reports help explain the cognitive reasoning underlying those choices (Hakim et al., 2023; A. Hakim et al., 2021). This complementary relationship has become increasingly important as marketers seek more reliable methods for predicting market responses and evaluating advertising effectiveness.

Beyond self-report measures, researchers have increasingly incorporated non-self-report complementary tools into neuromarketing studies. Eye-tracking technology has emerged as one of the most frequently used methods because it allows precise measurement of visual attention and information processing patterns (García-Madariga et al., 2019; Pasoorani et al., 2024). Studies combining EEG and eye tracking have demonstrated that integrating neural and visual attention data improves the interpretation of consumer responses to advertisements, packaging designs, and online shopping environments (Othman et al., 2025; Yin et al., 2021). Similarly, physiological indicators such as galvanic skin response (GSR), heart rate (HR), event-related potentials (ERP), and other biometric measures provide valuable information regarding emotional arousal, stress, engagement, and cognitive processing (García-Marques et al., 2024; Huo et al., 2023). Research suggests that combining these indicators with EEG can significantly enhance the accuracy and validity of neuromarketing findings by capturing multiple dimensions of consumer responses simultaneously (Pasoorani et al., 2024; Tabak Kızgın & Alp, 2024).

The rapid development of artificial intelligence and machine learning has further transformed EEG-based

neuromarketing research. Advanced algorithms can identify complex patterns within large EEG datasets, enabling more accurate classification and prediction of consumer preferences, purchase intentions, and valuation processes (Ghazvini et al., 2024; Mashrur et al., 2022). Machine-learning models have been successfully employed to decode neural signals associated with product evaluations and advertising responses, often outperforming traditional analytical approaches (A. Hakim et al., 2021; Ozair et al., 2024). Recent studies have demonstrated that integrating EEG data with artificial intelligence techniques improves predictive performance and facilitates the development of intelligent recommendation systems capable of personalizing consumer experiences (Mashrur, 2023; Panda et al., 2023). These advancements suggest that the future of neuromarketing will increasingly depend on multimodal frameworks that combine neural, behavioral, physiological, and computational approaches.

A growing body of empirical evidence supports the value of integrated methodologies in neuromarketing research. Studies employing EEG together with eye tracking, physiological indicators, questionnaires, and machine-learning algorithms consistently report higher levels of predictive accuracy and richer interpretations of consumer behavior than studies relying on a single method (Othman et al., 2025; Pasoorani et al., 2024). Cross-cultural investigations have also demonstrated that integrated approaches facilitate a more nuanced understanding of how contextual, cultural, and psychological factors influence neural responses to brands and marketing stimuli (Nazari Ghazvini et al., 2025). Moreover, systematic reviews have repeatedly highlighted the increasing trend toward multimodal neuromarketing methodologies and emphasized the need for methodological standardization to ensure reliability and comparability across studies (Guo et al., 2025; Khondakar et al., 2024; Nazari Ghazvini et al., 2023). Nevertheless, considerable variation remains in the extent to which researchers incorporate complementary instruments, and important gaps persist regarding the specific contribution of self-report methods to the interpretation of EEG findings.

Although numerous studies have investigated EEG applications in advertising, branding, purchasing behavior, and consumer decision-making, the literature remains fragmented with respect to understanding how self-report instruments contribute to improving the accuracy and validity of EEG-based findings. Existing reviews primarily focus on technological developments, neural indicators,

predictive models, or general methodological trends (Adalarasu et al., 2025; Gupta, 2025). Comparatively less attention has been devoted to systematically examining the complementary role of self-report measures in conjunction with EEG and other multimodal instruments. Furthermore, recent developments in consumer neuroscience, including advances in machine learning, multimodal signal integration, and neurophysiological measurement, have generated a rapidly expanding body of evidence that requires synthesis and critical evaluation (Guo et al., 2025; Othman et al., 2025). Addressing this gap is particularly important because marketers, researchers, and practitioners increasingly rely on EEG findings to inform strategic decisions, and inaccurate interpretations may lead to ineffective marketing interventions and flawed managerial conclusions.

Therefore, the present study aims to systematically analyze the complementary role of self-report instruments in enhancing the accuracy, interpretive validity, and predictive power of electroencephalography (EEG) findings in neuromarketing research through a comprehensive review of domestic and international studies employing EEG and complementary methodologies.

2. Methods and Materials

The present study was conducted with the aim of providing a complementary analysis of self-report instruments in improving the accuracy of electroencephalography (EEG) results in marketing, and it adopted a qualitative approach using a systematic and analytical review design. This approach was selected to systematically collect, evaluate, and synthesize the findings of previous studies in the field of neuromarketing, particularly regarding the application of EEG and complementary instruments, in order to provide a comprehensive, accurate, and unbiased picture of the existing state of knowledge. In terms of purpose, this study is applied–developmental, and in terms of nature, it is review–analytical. Its focus is on the qualitative and comparative analysis of the key findings of the selected studies, the identification of research gaps, and the explanation of the necessity of using integrated approaches in future studies. To identify relevant studies, an extensive search was conducted in reputable national and international scientific databases, including Google Scholar, PubMed, Scopus, Web of Science, SID, Magiran, and Noormags. Persian and English keywords were used,

including terms such as neuromarketing, electroencephalography, self-report instruments, integrated approaches, consumer behavior, decision-making, QEEG, eye tracking, galvanic skin response, and fMRI. The inclusion criteria consisted of studies published between 2014 and 2024 for domestic studies and between 2013 and 2025 for international studies, studies related to EEG/QEEG in neuromarketing, studies that examined self-report or non-self-report complementary instruments alongside EEG, and relevant scientific-research articles, conference papers, dissertations, and theses. In contrast, studies that focused exclusively on the clinical or medical aspects of EEG, works written in languages other than Persian or English, and sources such as book chapters, technical reports, or conference abstracts were excluded. The article selection process was conducted in three stages: first, titles and abstracts were screened; second, relevant articles were read in full and their quality was assessed; and finally, 52 studies, including 19 domestic studies and 33 international studies, were selected for the final analysis. The data collection instrument consisted of a researcher-made information extraction form, through which information such as the researcher’s name, year of publication, instruments and methods used, EEG/QEEG self-report instruments and non-self-report complementary instruments, study topic, most important finding, and role of complementary instruments was recorded for each study. This form enabled the systematic collection of data and prepared them for analysis. Data analysis was conducted using qualitative content analysis and comparative analysis. Initially, the studies were classified into four categories based on the types of instruments used: studies that used only EEG/QEEG; studies that used self-report instruments; studies that used non-self-report complementary instruments such as eye tracking, GSR, physiological indicators, ML, ERP, or HR; and studies that simultaneously used EEG, self-report instruments, and complementary instruments. Then, the key findings of each category were extracted, compared, and analyzed to determine the strengths, limitations, research gaps, and general pattern of instrument use. Finally, by integrating these analyses, the necessity of using multi-source and integrated approaches in neuromarketing research was explained, and an appropriate theoretical basis was provided for the development of future studies.

3. Findings and Results

In this section, the findings obtained from the systematic review and analysis of domestic and international studies related to the application of electroencephalography (EEG) and complementary instruments in the field of neuromarketing are presented. The selected studies were examined and classified based on the types of instruments used, research topic, most important findings, and the role

of complementary instruments in interpreting neural data. The purpose of this analysis was to identify research trends, the extent to which integrated approaches have been used, and the role of self-report and non-self-report instruments in increasing the accuracy and validity of EEG results. Accordingly, the findings are organized into two sections, namely domestic studies and international studies, in order to enable comparison of research patterns, strengths, limitations, and existing gaps in neuromarketing research.

Table 1

Analysis of Domestic Studies Related to EEG and Complementary Instruments in Neuromarketing

Researcher	Year	Instrument / Method	Research Topic	Role of Complementary Instruments
Basraei	2024	Implicit Association Test + questionnaire	The effect of neuromarketing on purchase decision	Cognitive and self-report instruments explained purchase behavior
Nazari Qazvini et al.	2024	EEG + eye tracking	Consumer preference	The multimodal model was more accurate
Nazari Qazvini et al.	2023	Systematic review + bibliometric analysis	The role of EEG in neuromarketing	Emphasized the need to develop integrated studies
Akbarian Chaleshtari	2023	Questionnaire + structural equation modeling	Advertising and repurchase	The questionnaire-based instrument complemented cognitive analysis
Mohammadi	2022	EEG + interview	Interest in sports	Revealed discrepancies between subjective and brain responses
Hosseini and Houshmand	2022	EEG + spectral analysis	Analysis of consumer preference	Required complementary cognitive interpretation
Rostami	2021	Eye tracking + questionnaire	Home appliance purchasing behavior	Behavioral analysis complemented attention-related data
Hosseini	2021	EEG + SVM	Decision-making in online stores	Machine learning increased the accuracy of EEG analysis
Ghasemi Siani et al.	2021	QEEG	Rational and emotional advertising	Emotional analysis complemented cognitive interpretation
Bonyadi Naeini and Adib-Kia	2020	EEG	Music and shopping pleasure	Emotional analysis of consumer behavior
Rahili et al.	2020	EEG	The effect of color on brain waves	Demographic variables became important
Ghaedi et al.	2020	EEG + SAM + questionnaire	Purchase decision for sports services	Self-report instruments increased the validity of the analysis
Tabar	2020	EEG + fMRI + decision algorithm	Consumer behavior	The integrated model provided a deeper analysis
Nademi	2020	EEG + SVM + HMM	Preference classification	Machine learning complemented EEG
Farzi et al.	2019	EEG + questionnaire	Athlete brand image	The questionnaire complemented attitude interpretation
Darabi et al.	2019	EEG	Nike brand advertising	Neural analysis of purchase behavior
Movahedi	2017	QEEG	Nike brand advertising	Analysis of unconscious cognition
Shokouhian and Tarokh	2016	EEG	Brain response to marketing stimuli	Identification of important processing regions
Dehghan-Pouri et al.	2016	EEG	Adidas advertising	Analysis before, during, and after the advertisement

The review of domestic studies (Table 1) shows that the use of EEG and QEEG in neuromarketing research has followed a growing trend in recent years. The findings indicate that many studies have attempted to use EEG to analyze consumers' unconscious responses to advertisements, brands, color, music, purchase decisions,

and consumption preferences. However, a considerable proportion of studies have relied solely on neural data, and the use of complementary instruments is still observed only to a limited extent. Among the reviewed studies, some research has been able to provide a more comprehensive and accurate analysis of consumer behavior by combining

EEG with instruments such as questionnaires, interviews, eye tracking, machine-learning algorithms, and fMRI. The results also showed that self-report and behavioral instruments can play an important role in better interpreting brain data, identifying differences between conscious and unconscious responses, and increasing the validity of the

findings. Overall, although domestic studies have paid considerable attention to the application of EEG in neuromarketing, the simultaneous use of several complementary instruments remains limited, and the need to develop multimodal approaches in future research is evident.

Table 2

Analysis of International Studies Related to EEG and Complementary Instruments in Neuromarketing

Researcher	Year	Instrument / Method	Research Topic	Role of Complementary Instruments
Nazari Qazvini et al.	2025	EEG	Energy drink brand	Cultural analysis of consumer behavior
Adalarasu et al.	2025	EEG	Response to advertisements	Analysis of content type
Osman et al.	2025	EEG + eye tracking + DL	Prediction of consumer choice	Integration of neural and visual data
Uzir et al.	2024	EEG + ML	Preference classification	Machine learning increased analytical accuracy
Pasorny et al.	2024	EEG + eye tracking + ERP	Online shopping	Data integration provided more accurate interpretation
Hakim et al.	2023	EEG + deep learning	Willingness to pay	Artificial intelligence improved EEG analysis
Mashrur et al.	2023	EEG + eye tracking + SVM	Advertising preference	The integrated model had higher performance
Panda et al.	2023	EEG + recommender system	Shopping experience	Development of personalized systems
Huo et al.	2023	EEG + GSR + questionnaire	Brand personality	Revealed a cognitive gap
Semenova et al.	2023	EEG + WTP	Willingness to pay for chocolate	Integration of EEG and subjective perception
Mashrur et al.	2022	EEG + ML	Future consumer choice	Selection of optimal channels
Hu et al.	2022	EEG	Natural online shopping	Analysis of real purchase decisions
Artenzio et al.	2022	EEG	Coffee preference	Role of individual variables
Balkin et al.	2021	EEG	Product touch in stores	Sensory marketing was strengthened
Yin et al.	2021	EEG + eye tracking + MRI	Online advertising	Multimodal analysis of cognition
Pereira and Oliveira	2021	EEG + ERP	Shoe choice	Cognitive analysis of purchase decisions
Hakim et al.	2021	EEG + ML + questionnaire	Preference prediction	Increased prediction accuracy
Hsu and Chen	2020	EEG	Hotel advertising	EEG operated beyond conscious responses
Matthews and Kasri	2020	EEG	Social advertising	More effective advertising design
Zhang et al.	2020	EEG + physiological signals	Emotion recognition	Analysis of complex emotions
González-Morales	2020	EEG	Emotional response to images	Affective analysis of advertisements
Alvino et al.	2020	Review of studies	Neuromarketing instruments	Emphasized instrument integration
Bettiga et al.	2020	EEG + survey + physiological indicators	Affective response to products	Data integration strengthened the analysis
Gountas et al.	2019	EEG + focus group	Beverage campaign	Complemented advertising analysis
Glenarnyk et al.	2019	EEG	Prediction of consumer preference	EEG had high predictive power
García-Madariaga et al.	2019	EEG + ET + preference test	Product packaging	Necessity of using integrated methods
Avinash et al.	2018	EEG	Music and emotions	Analysis of musical emotions
Blum et al.	2017	Mobile-based EEG	Mobile music	Development of the practical application of EEG
Cartocci et al.	2017	EEG + GSR + HR	Anti-smoking advertisements	Simultaneous analysis of emotion and cognition
Lee	2016	EEG	Prosocial brands	Brand preference was identifiable
Pozharliev et al.	2015	EEG + ERP	Luxury products	Role of social conditions
Yilmaz et al.	2014	EEG	Shoe preference	Identification of key channels
Khushaba et al.	2013	EEG + eye tracking	Product choice	Multimodal analysis of purchasing behavior

The review of international studies (Table 2) shows that neuromarketing research has gradually moved from the exclusive use of EEG toward integrated approaches. In many of these studies, instruments such as eye tracking, physiological indicators, questionnaires, and machine-learning algorithms have been used alongside EEG to increase the accuracy of analyzing consumer behavior and

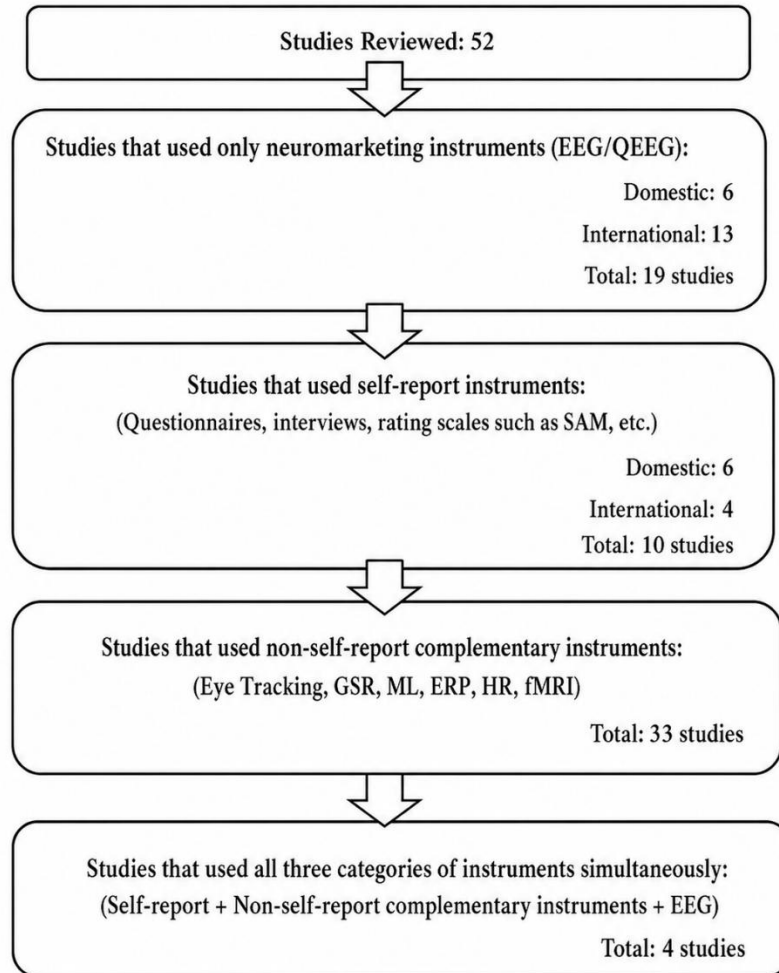
preferences. The findings also show that neural data alone are not sufficient to fully explain purchasing behavior, and the use of complementary instruments can play an effective role in better interpreting consumers' cognitive and emotional responses. To complete the analysis of the findings, the flowchart for classifying the 52 studies included in the research is presented below. This figure

shows how the studies were organized into four main categories based on the types of instruments used and how the share of each group was distributed across domestic and

international studies. This classification provides a basis for analyzing research trends and identifying existing gaps.

Figure 1

Classification of the Reviewed Studies Based on the Use of Complementary Instruments Alongside EEG



According to Figure 1, this review examined 52 studies, including 19 domestic studies and 33 international studies. The results of the classification of the instruments used show that a considerable proportion of the studies relied only on EEG/QEEG-based neuromarketing instruments. Specifically, 19 studies, including 6 domestic studies and 13 international studies, were conducted without using any complementary instrument and relied solely on EEG data to analyze consumers' neural responses. In contrast, some studies attempted to combine neural data with self-report methods such as questionnaires, interviews, or surveys. In total, 10 studies, including 6 domestic studies and 4 international studies, used this approach. This category of studies was conducted with the aim of comparing or

complementing neuroscientific data with individuals' subjective perceptions and reports. In addition, 33 studies used non-self-report complementary instruments alongside EEG. These instruments included technologies such as eye tracking, galvanic skin response (GSR), physiological indicators, machine learning (ML), ERP, heart rate (HR), and other biological measures. The use of these instruments made it possible to simultaneously record behavioral and physiological responses and increased the accuracy of neural data interpretation. However, a more detailed review shows that only 4 international studies were able to simultaneously use all three categories of instruments, including neuromarketing instruments, self-report instruments, and non-self-report complementary

instruments. These studies include the research conducted by Huo et al. (2023), Hakim et al. (2021), Bettiga et al. (2020), and García-Madariaga et al. (2019). Among domestic studies, no research used such a comprehensive combination of instruments. Overall, this pattern indicates that although the use of EEG is highly common in neuromarketing research, multi-source data integration has not yet been fully employed in a considerable proportion of studies. Particularly in domestic studies, there is a stronger tendency to use one or two instruments, and the simultaneous use of neural, behavioral, and self-report instruments remains limited. This issue indicates that the development of multi-instrument research can contribute to a more accurate understanding of consumer responses and increase the validity of findings in the field of neuromarketing.

4. Discussion and Conclusion

The present study aimed to systematically analyze the complementary role of self-report instruments in improving the accuracy and interpretive validity of electroencephalography (EEG) findings in neuromarketing research. The review of 52 studies, including 19 domestic and 33 international investigations, revealed several important patterns regarding the current state of EEG-based consumer research. First, the findings demonstrated that EEG has become one of the most widely applied neuromarketing tools for examining consumers' unconscious cognitive and emotional responses to marketing stimuli. Second, although many studies relied exclusively on EEG or QEEG measures, research that integrated self-report instruments and other complementary methods consistently produced richer interpretations and more robust explanations of consumer behavior. Third, a substantial difference was observed between domestic and international studies with respect to the adoption of multimodal approaches, with international research demonstrating a greater tendency to combine neural, behavioral, physiological, and subjective data sources.

The first major finding concerns the widespread reliance on EEG as a primary neuromarketing instrument. Across both domestic and international studies, EEG was used to investigate consumer reactions to advertisements, packaging designs, brand perceptions, product preferences, purchasing decisions, and emotional responses. This finding is consistent with the broader neuromarketing literature, which identifies EEG as one of the most practical

and accessible neuroscientific methods for marketing applications because of its relatively low cost, portability, and excellent temporal resolution (Cohen, 2023; Cook & Warren, 2011). Previous scholars have emphasized that EEG enables researchers to capture neural responses that occur within milliseconds of exposure to marketing stimuli, thereby providing access to cognitive and emotional processes that may remain outside conscious awareness (Ariely & Berns, 2010; Plassmann, Ambler, et al., 2012). The growing popularity of EEG observed in the reviewed studies therefore reflects a broader movement toward consumer neuroscience approaches that seek to overcome the limitations of conventional marketing research methods (Lee et al., 2007; Zurawicki, 2010).

However, the findings also revealed that a significant proportion of studies relied solely on EEG data without employing complementary instruments. Nineteen studies used only EEG or QEEG measures to interpret consumer responses. While such studies contribute valuable insights into neural activity, the present review suggests that neural indicators alone may not provide a complete explanation of consumer behavior. This observation aligns with concerns raised in previous research regarding the risk of overinterpreting neural data in the absence of contextual, behavioral, or subjective information (Hsu & Yoon, 2021; Plassmann, Venkatraman, et al., 2012). Neural activation patterns often indicate the occurrence of cognitive or emotional processes but do not necessarily reveal their precise psychological meaning. For example, elevated attention-related activity may reflect curiosity, confusion, interest, or cognitive overload. Consequently, studies relying exclusively on EEG may face challenges when attempting to translate neural signals into actionable marketing insights. Similar concerns have been highlighted in systematic reviews that emphasize the need for methodological triangulation in neuromarketing research (Gupta, 2025; Khondakar et al., 2024).

One of the most important findings of this review is the demonstrated value of self-report instruments in complementing EEG-based analyses. Studies that combined EEG with questionnaires, interviews, rating scales, or surveys were better positioned to compare conscious evaluations with unconscious neural responses. The reviewed evidence indicates that self-report instruments play a critical role in clarifying the subjective meaning of neural activity and identifying discrepancies between reported preferences and actual cognitive processing. This finding strongly supports the theoretical

position that consumer decision-making involves both conscious and unconscious mechanisms that should be examined simultaneously (J. Hakim et al., 2021; Paulhus & Vazire, 2007). Self-report measures provide direct access to attitudes, perceptions, motivations, and evaluations that cannot be fully inferred from physiological data alone. Accordingly, studies employing questionnaires alongside EEG were able to generate more comprehensive interpretations of consumer preferences, purchase intentions, and brand perceptions.

At the same time, the findings highlight why self-report instruments should not be used in isolation. Numerous scholars have documented the vulnerability of self-report methods to social desirability effects, memory distortions, impression management, and response biases (Grimmond et al., 2024; Paulhus & Vazire, 2007). Recent research further demonstrates that individuals frequently alter their responses to conform to social expectations or present themselves in a favorable manner, particularly in consumer-related contexts (Nor et al., 2025). Therefore, the integration of EEG with self-report measures appears particularly valuable because the weaknesses of one method are compensated by the strengths of the other. Neural measures provide objective indicators of cognitive and emotional processing, while self-report instruments contribute subjective explanations and contextual understanding. The reviewed studies collectively suggest that this combination enhances both the validity and interpretability of neuromarketing findings.

Another significant finding concerns the increasing use of non-self-report complementary instruments such as eye tracking, galvanic skin response (GSR), event-related potentials (ERP), physiological indicators, heart rate measures, and machine-learning algorithms. Thirty-three studies incorporated at least one of these methods alongside EEG. This pattern reflects a broader methodological trend toward multimodal consumer research. Studies combining EEG with eye tracking demonstrated improved understanding of how visual attention influences consumer decision-making, particularly in advertising and packaging contexts (García-Madariga et al., 2019; Pasoorani et al., 2024). Eye-tracking data reveal where consumers focus their attention, while EEG simultaneously measures cognitive and emotional processing. The integration of these measures therefore provides a richer explanation of how consumers perceive and evaluate marketing stimuli. Similar conclusions have been reported in studies

examining online advertising and digital consumer environments (Othman et al., 2025; Yin et al., 2021).

The review also identified growing interest in combining EEG with physiological indicators such as GSR and heart rate. These approaches allow researchers to assess emotional arousal, stress, engagement, and affective responses while simultaneously monitoring neural activity. Studies employing such combinations reported greater accuracy in distinguishing emotional reactions from purely cognitive processes (Garcia-Marques et al., 2024; Huo et al., 2023). These findings are consistent with the argument that consumer experiences are multidimensional phenomena involving intertwined cognitive, emotional, and physiological mechanisms. Consequently, capturing multiple response systems simultaneously produces more valid and reliable interpretations than relying on a single measurement source.

A particularly noteworthy trend identified in the reviewed literature is the rapid integration of machine learning and artificial intelligence into EEG-based neuromarketing research. Several studies demonstrated that advanced computational algorithms substantially improve the ability to classify preferences, predict future choices, and decode consumer valuations from neural signals (A. Hakim et al., 2021; Mashrur et al., 2022). Machine-learning models can identify complex patterns within EEG datasets that may be difficult or impossible to detect through traditional statistical techniques. Recent investigations have shown that combining EEG with artificial intelligence can significantly improve preference prediction accuracy and facilitate the development of personalized recommendation systems (Ghazvini et al., 2024; Panda et al., 2023). The present findings therefore support the growing consensus that artificial intelligence represents a transformative force in consumer neuroscience and neuromarketing research (Hakim et al., 2023; Ozair et al., 2024).

Another important outcome of this review is the identification of substantial differences between domestic and international research practices. International studies demonstrated considerably greater methodological diversity and were more likely to employ multimodal research designs. Notably, only four international studies incorporated all three categories of instruments simultaneously: EEG, self-report measures, and non-self-report complementary methods. No domestic study employed such a comprehensive design. This finding suggests that although domestic neuromarketing research has increasingly adopted EEG technologies, it has not yet

fully embraced the integrated methodological frameworks that characterize leading international investigations. Similar observations have been reported in recent reviews examining the evolution of neuromarketing methodologies and the growing importance of multimodal data integration (Guo et al., 2025; Nazari Ghazvini et al., 2023). The relative scarcity of comprehensive multimethod studies may limit the explanatory power and practical applicability of findings within domestic research contexts.

The present findings further support the proposition that the future of neuromarketing lies in integrated analytical frameworks rather than isolated measurement techniques. Studies utilizing multiple sources of evidence consistently produced stronger predictive models and more nuanced interpretations of consumer behavior than those relying on single-method approaches. This observation aligns with contemporary consumer neuroscience perspectives, which emphasize the importance of triangulating neural, behavioral, physiological, and subjective data to achieve a comprehensive understanding of consumer decision-making (J. Hakim et al., 2021; Venkatraman et al., 2015). Furthermore, recent advances in EEG analytics, machine learning, multimodal sensing technologies, and cross-cultural neuromarketing research continue to expand the possibilities for integrated consumer analysis (Adalarasu et al., 2025; Nazari Ghazvini et al., 2025). Collectively, the reviewed studies demonstrate that self-report instruments remain indispensable components of this integrated framework because they provide the psychological context necessary for interpreting neural signals accurately.

Overall, the evidence synthesized in this review indicates that EEG is a highly valuable instrument for examining unconscious consumer processes; however, its greatest potential emerges when it is integrated with self-report measures and complementary behavioral or physiological methods. The combination of these approaches enhances explanatory depth, improves predictive accuracy, reduces interpretive ambiguity, and strengthens the validity of neuromarketing findings. Consequently, future progress in the field will likely depend on the continued development of standardized multimodal methodologies capable of capturing the full complexity of consumer cognition, emotion, and behavior.

This study has several limitations that should be considered when interpreting the findings. First, the review was limited to studies published in Persian and English, which may have excluded relevant research conducted in other languages. Second, the included studies varied

substantially in research design, sample characteristics, EEG configurations, analytical procedures, and complementary instruments, making direct comparisons challenging. Third, the review focused primarily on published academic studies and may therefore be affected by publication bias. Finally, because many studies used different operational definitions and measurement frameworks, it was not possible to quantitatively compare effect sizes across investigations.

Future studies should investigate the relative contribution of different complementary instruments to the interpretation of EEG data and determine which combinations provide the highest levels of predictive accuracy. Researchers are encouraged to conduct longitudinal and cross-cultural studies to evaluate the stability and generalizability of neuromarketing findings across diverse consumer populations. Additional attention should also be devoted to developing standardized protocols for multimodal data collection and analysis. Furthermore, future research could explore emerging technologies such as wearable EEG systems, real-time biometric monitoring, and advanced artificial intelligence models to create more ecologically valid and scalable neuromarketing frameworks.

Marketing practitioners should avoid relying solely on EEG findings when evaluating advertisements, brands, products, or consumer experiences. Instead, they should integrate neural data with self-report feedback, behavioral indicators, and physiological measurements to obtain a more complete understanding of customer responses. Organizations investing in neuromarketing initiatives should prioritize multidisciplinary research teams capable of interpreting data from multiple sources. Businesses should also adopt standardized data collection procedures and ethical guidelines to improve the reliability and transparency of neuromarketing applications. Finally, the use of integrated analytical approaches can help organizations design more effective marketing strategies, improve customer experiences, and make more informed decisions regarding product development, branding, and advertising campaigns.

Authors' Contributions

All authors equally contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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Declaration of Interest

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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