

AI-enhanced neuromarketing and social media communication: Evidence from PLS-SEM analysis in an academic context

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Abstract

Artificial intelligence (AI) is reshaping neuromarketing by enabling the real-time analysis of neurometric, biometric, and psychometric data to optimize consumer engagement. This study investigates how AI-enhanced neuromarketing influences social media marketing strategies, using a structural equation modeling (PLS-SEM) approach to assess relationships between neuromarketing knowledge, application, activities, and social media communication. Data were collected through a survey of 416 Romanian university students and professors with practical exposure to neuromarketing tools in educational environments. The results confirm that neuromarketing knowledge significantly improves practical application ($\beta = 0.726$, $p < 0.001$), which in turn enhances both marketing activities ($\beta = 0.555$, $p < 0.001$) and social media communication effectiveness ($\beta = 0.633$, $p < 0.001$). AI was found to amplify these effects through predictive analytics, real-time consumer data processing, and automated content optimization. Ethical considerations—such as privacy risks and algorithmic bias—are acknowledged, and the academic sample limits generalizability to commercial contexts. Future research should explore cross-industry applications, diverse cultural settings, and longitudinal impacts to strengthen external validity.

Keywords

neuromarketing, AI, ML, consumer behavior, social media marketing, psychometric analysis

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Introduction

Artificial intelligence (AI) is transforming neuromarketing by providing real-time insight into consumer decision-making. Unlike traditional approaches that rely on surveys and post-purchase data, AI allows marketers to capture subconscious drivers of behavior. By integrating machine learning, big data, and neuroscience, AI-powered neuromarketing can predict and influence consumer responses with unprecedented precision. This advancement allows businesses to develop more precise, personalized, and ethical marketing strategies that align with both profitability and sustainability goals.

Social media can play a significant role in enhancing sustainable corporate communication strategies, namely if they use social media marketing, AI, and neuromarketing

frameworks (knowledge). On the one side, Twitter, Zoom, and Facebook produced and processed around three million terabytes of data.¹ On the other side, by leveraging the insights gained from neuromarketing techniques applied to social media platforms^{2,3} companies can develop more

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effective and ethical communication approaches that align with their sustainability goals.^{4,5} To better comprehend their consumers and provide customer insights, businesses gather data on consumers through marketing studies. There are several ethical and public policy concerns related to the procedure.⁶ Consumer privacy breaches; improper usage, misreading, and misrepresenting research findings; moral and ethical conundrums in the gathering of customer data; and moral conundrums in the developing of client insights via neuromarketing and its implementation are among the problems. It is simpler to violate privacy in the digital era. Comprehending diverse public policy and moral issues and effectively a consumer's tackling them through appropriate measures can assist businesses in persuading clients, fostering productive customer 51 connections, and attaining superior commercial performance.^{2,7-9}

The vast amounts of consumer data generated through social media, online interactions, and digital marketplaces provide an unprecedented opportunity for AI to identify patterns in neural responses, emotional triggers, and purchasing behaviors. Techniques such as eye-tracking, electroencephalography (EEG),¹⁰ facial recognition, and biometric analysis - once confined to scientific research—are now being incorporated into AI-driven marketing strategies to enhance consumer engagement. Machine learning algorithms can process these data streams to optimize advertisements, refine brand messaging, and tailor user experiences in ways that were previously impossible.

However, while AI-driven neuromarketing offers significant advantages, it also raises ethical concerns, particularly regarding consumer privacy, data security, and the potential for manipulative marketing practices. Companies must navigate these challenges carefully to ensure that AI is used responsibly in a way that benefits both businesses and consumers. The integration of AI into neuromarketing should prioritize ethical considerations, transparency, and regulatory compliance to maintain consumer trust and uphold sustainable marketing practices.¹¹

Due to the limitations of conventional marketing strategies, many marketing choices are focused on after-sales or the actual purchase of a product.¹² However, neuromarketing may help marketing programs save costs and add more value. For example, cutting-edge research approaches, like brain imaging may produce superior outcomes.¹³ In addition, market research is being pressed to incorporate AI since it is the finest tool for sifting through BigData.¹⁴ Focus groups and experimental studies may now be done in the metaverse, surveys can be fully automated, and profound insights in qualitative and non-numerical data can be created instantly using machine learning and particular algorithms.¹⁵ However, social media marketing aims to promote good behaviors, for individuals, society, and the environment as well.¹⁶

To promote good behaviors, the research raises the main question: is it possible to achieve a balance between more profits as possible and positive results that must be pursued?

Seeking to identify factors of balance between companies' profit and positive results for all, the main objective of the research is understanding better the influence of neurometrics, biometrics¹⁷⁻¹⁹ and psychometrics^{20,21} factors on decision-making process.²² Thus, this research used a neuromarketing theoretical framework (knowledge), as well as AI, to support social media marketing research and its communications.⁵

The structure presents (knowledge) conceptualization and communication, as well as the methodology, which was used to explain the main results and conclusions. This study explores the intersection of AI, neurometrics, biometrics, and psychometrics in social media marketing communications, aiming to bridge the gap between theory and practice. By leveraging a neuromarketing theoretical framework (knowledge), this research investigates how AI-enhanced neuromarketing can optimize digital communication strategies, enhance brand perception, and improve consumer engagement while maintaining ethical integrity. Using structural equation modeling (SmartPLS) and survey data from Romanian university students, this study explores the perceived potential of AI-powered neuromarketing within academic contexts, with an eye toward its future applicability in real-world business settings, while acknowledging the limitations in generalizability beyond this academic sample.

This study addresses a theoretical and empirical gap at the intersection of neuromarketing, artificial intelligence (AI), and social media communication. While prior literature has explored each domain separately, there is limited research that models how neuromarketing knowledge translates into real-world application and impacts digital engagement—particularly within AI-enhanced environments. By proposing and empirically testing a structural model that connects neuromarketing knowledge, application, activities, and social media marketing, this research extends prior conceptual frameworks (e.g., neuromarketing effectiveness models, technology acceptance theories) into a more integrative and digitally relevant structure. Furthermore, the study offers empirical novelty by using PLS-SEM to assess this model in a population with formal neuromarketing training, offering a controlled look at how conceptual knowledge translates into applied digital communication behavior.

Ultimately, this research contributes to the evolving discourse on AI's transformative impact on neuromarketing, emphasizing the need for businesses to balance technological advancements with ethical responsibility. Future research should further explore AI's role in predicting long-term consumer behavior, addressing privacy concerns, and refining the application of neuromarketing in diverse industries.

Neuromarketing knowledge

Neuromarketing integrates principles from neuroscience to better understand consumer behavior and enhance marketing strategies. In this study, we distinguish between *neuromarketing knowledge*, referring to cognitive understanding of these principles, and *neuromarketing application*, which involves their practical deployment in communication strategies.

Neuromarketing knowledge: The Brain's role in decision-making

Although the human brain constitutes only 2% of the body's weight,²³ it consumes 20% of the total energy and is responsible for 95% of purchasing decisions, which occur subconsciously.^{24,25} Using brain imaging or monitoring emotional patterns, neuromarketing research may comprehend the contributing components and forecast customer behavior before sales.^{25,26} Neuromarketing research has demonstrated that consumers often make intuitive, emotion-driven choices before rationalizing them post-purchase.^{14,27} By understanding these subconscious triggers, marketers can create strategies that appeal directly to the emotional and cognitive processes that drive consumer behavior. In other words, Neuromarketing Knowledge can be used for consumer behavior prediction based on neural network algorithms.^{7,28,29}

Gather information from neuroscience, psychology, and marketing to understand how the brain responds to various marketing stimuli.^{18,20,21} The objective is to obtain insights to the consumer's decision-making.^{30–32} In addition, technologies such as fMRI, EEG, eye-tracking,¹⁰ and biometric measurements can be used to evaluate brain activity, as well as eye movement, and physiological responses.^{17,30,33,34}

Neuromarketing Knowledge includes three dimensions: emotional response interpretation (N1comportam), goal-directed decision processes (N1goal), and familiarity with tools like fMRI and EEG (N1tech). These subdimensions form the basis for applying neuromarketing effectively in real-world strategies (Table 1).

Regarding the neuromarketing application, it is also necessary to understand how different stimuli evoke emotional responses in consumers (NAPPstimuli),^{23,35} as well as to reveal which parts of an advertisement or website capture

the most attention and engagement (NAPPadv).^{36,37} In addition, it may explore the subconscious factors that influence purchasing decisions (NAPPpurchase),²² to improve the design³⁸ and user experience of products and digital interfaces, (NAPPUXI).^{7,8,39,40}

Furthermore, AI has advanced neuromarketing research by making tests easier to perform, (NAPPbrain),²⁰ and by helping to disclose patterns that were previously difficult to spot.⁴¹ Deep learning is used to identify consumers' interests^{8,12,15} from merged electroencephalogram (EEG)⁴² and functional near-infrared spectroscopy (fNIRS) data, (NAPPpreferences).³⁰ Table 2 shows the second variable and respective indicators. These components reflect different stages and outcomes of applying neuromarketing techniques for marketing optimization.

A critical assumption of this research is that greater neuromarketing knowledge enhances practical application. As such, the first hypothesis is defined as follows.

H1: Neuromarketing conceptualization (knowledge) is crucial to apply neuromarketing content in different context.

Neuromarketing application (N-Application) can increase neuromarketing activities (N-Activities)

Neuromarketing application refers to the practical use of neuroscience-based insights and tools to enhance marketing effectiveness. It involves translating theoretical knowledge into measurable actions across advertising, branding, design, and consumer engagement strategies.

In this study, Neuromarketing Application (N-Application) is assessed by the degree to which neuromarketing tools are used to.

- Improve the effectiveness of advertisements (*APPadv*),^{19,43}
- Enhance packaging design (*APPpackage*),^{33,34,44}
- Identify consumer preferences (*APPpreferences*),¹²
- Strengthen brand perception (*APPbrand*).^{24,45}

Advanced techniques like virtual shopping simulations (*APPvirtual*),^{46,47} that may be appropriate for young people's profiles⁴⁸ and perception,⁴⁹ as well as neurofeedback systems (*APPneurofeedback*)^{47,50–52} allow marketers to evaluate real-

Table 1. Neuromarketing knowledge and respective indicators.

Variable	Code	Description	References
Neuromarketing conceptualization (knowledge)	N1comportam	Gather information from neuroscience, psychology, and marketing to understand how the brain responds to various marketing stimuli.	16,20,21
	N1goal	The goal is to gain insights into consumer decision-making	30–32
	N1tech	fMRI, EEG, eye-tracking, and biometric measurements are used to study brain activity, eye movement, and physiological responses	10,30,33,34

Source: Own elaboration.

Table 2. Neuromarketing application and respective indicators.

Variable	Code	Description	References
Neuromarketing application (application)	NAPPstimuli	Stimuli evoke emotional responses	25,35
	NAPPadv	Identify items that capture the most attention and engagement.	36,37
	NAPPpurchase	Evaluate factors that influence purchasing decisions.	22
	NAPPUXI	Improve the user experience of products and digital interfaces.	7,8,38,39
	NAPPbrain	Studying how information is processed and stored in memory.	20
	NAPPpreferences	Identify unknown consumer preferences	8,12,15

Source: Own elaboration.

time emotional and cognitive responses^{53–55} to predict emotions and behaviours,^{56,57} such as to pricing cues (*APPprice*) through neuromarketing tools^{58–61} and social media content (*APPSM*).^{3,4,8,16,49,60} Additionally, neuromarketing supports comparative advertising analysis (*APPcompareAdv*),⁵³ political campaign messaging (*APPpolitic*),^{54,55,62} and neuro-economic studies (*APPneuroec*),^{45,52} which further explore the economic and psychological underpinnings of consumer choice.

Table 3 summarizes the full set of indicators used to measure neuromarketing activities, which reflect the operationalization of neuromarketing strategies in real-world contexts.

Together, these activities capture the practical outcomes of applying neuromarketing knowledge—ranging from improving message precision to tailoring user experience and influencing consumer behavior. The construct of Neuromarketing Activities (N-Activities) thus represents the extent to which neuromarketing insights are embedded into business strategies.

This leads to the study's second hypothesis.

H2: Effective implementation of neuromarketing content leads to better results in neuromarketing activities.

AI plays a pivotal role in scaling neuromarketing application by enabling the large-scale analysis of biometric and behavioral data. Through real-time emotional monitoring and predictive analytics, AI enhances the precision of marketing strategies and supports the continuous optimization of user experience design, messaging, and targeting.

In essence, neuromarketing application bridges theory and practice: it moves from understanding how the brain responds to stimuli to designing marketing strategies that align with those responses—effectively, ethically, and with technological support.

Neuromarketing application (N-Application) in digital and social media communication

The Social Media Marketing (SM) construct represents the integration of neuromarketing insights into digital

communication strategies. Each indicator was selected based on its relevance to consumer engagement, emotional resonance, and ethical digital practice. The grouping is theoretically informed by media psychology, communication theory, and digital consumer behavior research.

SMvalues captures the creation of emotionally charged content that reflects users' ethical or sustainability-related values. This aligns with emotional branding and value-based marketing literature, where congruence between consumer values and brand messaging fosters trust and deeper engagement.^{25,63}

SMstrategy refers to the design and visual execution of social media content. According to visual attention theory, layout, color, and imagery influence message salience and user engagement by affecting eye movement and cognitive processing.^{22,63}

SMlanguage reflects the tone, vocabulary, and rhetorical structure used in messaging. Communication framing theory suggests that linguistic style significantly influences message interpretation, emotional impact, and perceived credibility.^{59,64}

SMattention, SMinteraction, and SMresponse represent dynamic user engagement mechanisms—capturing attention, enabling real-time feedback, and facilitating dialogue. These elements correspond to social presence theory and use-and-gratifications theory, both of which highlight the role of perceived responsiveness and interactivity in digital trust-building.^{27,62,65}

SMcontent focuses on the typology and structure of social media messages (e.g., informative, entertaining, persuasive). It draws from content marketing and dual-processing models, which show that tailored content increases cognitive involvement and behavioral intention.^{51,60}

SMstories measures the use of narrative-based messaging. Grounded in storytelling and transportation theory, narrative-driven communication fosters emotional immersion, memory retention, and stronger message internalization.^{66–69}

SMprivacy emphasizes transparency, autonomy, and ethical considerations in data-driven communication. This is

Table 3. Neuromarketing activities (N-Activities) and respective indicators.

Variable	Code	Description	References
Neuromarketing activities (N-Activities)	APPadv	Effectiveness of advertisements	19,33,34,43,44
In my activity I applied neuromarketing for:	APPbrand	Brand perception:	24,45
	APPcompareAdv	Comparative advertising analysis	53
	APPneuroec	Neuroeconomic studies	45,52
	APPneuro feedback<	Neurofeedback for behavior change	47
	APPpackage	Packaging design	24,45
	APPpolitic	Political campaign messaging	46,54,55,62
	APPpreferences	Consumer preferences for products	12,24,45
	APPprice	Neural response to pricing	48,49
	APPSM	Impact of social media content	3,4,8,48,49,51,60
	APPvirtual	Virtual shopping experiences	5,46,47,56,57

Source: Own elaboration.

supported by privacy calculus theory, which suggests that consumers evaluate privacy risks against perceived benefits in digital interactions.^{27,65,70}

SMtarget captures audience segmentation and targeting practices. Informed by personalization and relevance theory, precise targeting enhances message relevance and minimizes cognitive dissonance, increasing overall campaign effectiveness.^{22,63}

These indicators collectively capture how neuromarketing enhances social media communication through personalization, emotional alignment, ethical clarity, and content engagement. Their inclusion in a unified construct reflects a holistic understanding of consumer-brand interaction in digital contexts.

Together, these capabilities are captured in the Social Media Marketing (SM) construct, which represents how neuromarketing contributes to digital engagement through personalized, emotionally intelligent, and ethically grounded communication. The full set of indicators is summarized in Table 4.

This leads to the third hypothesis of our study.

H3: The practical implementation of neuromarketing content leads to better results in social media communications.

In sum, Social Media Communication using Neuromarketing (N-SM Communication) examines how neuromarketing—augmented by AI—enhances message effectiveness, audience targeting, and brand storytelling in digital environments. By applying these principles, companies can foster stronger consumer engagement, reinforce brand trust, and align communication efforts with both commercial and societal goals.

AI's role in strengthening these relationships

This section outlines the core variables, indicators, and relationships that shape the effectiveness of neuromarketing

applications in enhancing consumer engagement, optimizing branding strategies, and promoting ethical social media marketing practices. However, using contributions from social media marketing, AI, and big-data analysis, as well as neuromarketing frameworks, this research considers the relevance of social media on sustainable corporate communication strategies, to support social media marketing and its communications, to understand better the decision-make process.

Understanding how neurometrics, biometrics, and psychometrics influence decision-making is essential for leveraging AI-driven neuromarketing in social media marketing and communication strategies. AI significantly enhances the interactions between neuromarketing knowledge, application, activities, and social media communication through.

- Real-time consumer data processing, as AI analyzes large-scale biometric and psychometric data to refine consumer behavior predictions.
- Predictive analytics based on machine learning algorithms that identify which marketing elements drive the highest engagement.
- Automated personalization, as AI adjusts content and advertisements dynamically based on individual user responses.
- Social Media optimization, as AI-powered neuromarketing improves ad targeting, enhances storytelling, and refines brand messaging in digital communication.

This research framework is built on four key variables, each representing a critical aspect of neuromarketing and social media marketing integration. This research considers these variables and indicators to understand better the influence of neurometrics, biometrics, and psychometrics factors^{20,50} on the decision-making process,^{22,30,61} to support social media marketing and its communications. Figure 1 shows the model relationship.

Table 4. Social media marketing (SM) and respective indicators.

Var.	Code	Description	References
Social media marketing (SM)	NSM	By leveraging the insights gained from neuromarketing techniques applied to social media platforms, companies can develop more effective and ethical communication approaches that align with their sustainability goals	5,6,48
	SMattention	Help companies gain a deeper understanding of their target audience's preferences, emotions, and behaviors on social media	63
	SMcontent	Understanding how social media users respond to different types of content can guide companies in encouraging sustainable behaviors	51,60
	SMinteraction	Offer real-time interaction and feedback	27,62
	SMlanguage	Neuromarketing research can reveal the most effective language, tone, and messaging styles for communicating sustainability-related information.	59,64
	SMprivacy	Provide guidance on avoiding manipulative techniques and ensuring that communication efforts are respectful of individual privacy and autonomy	27,65,70
	SMresponse	Provides a feedback loop for continuous improvement by helping companies adapt their strategies based on evolving audience preferences and societal trends	22,63
	SMstories	Guide the development of compelling stories that effectively communicate a company's sustainability initiatives	66–69
	SMstrategy	Help optimize visual content to capture attention, convey messages clearly, and evoke desired emotional responses	22,63
	SMtarget	Help companies ensure that their communication efforts come across as genuine and resonate with their audience's values	22,63
	SMvalues	Guide the creation of emotionally engaging content that triggers positive emotions related to sustainability	25,63

Source: Own elaboration.

Theoretical contribution

This study advances the theoretical discourse at the intersection of neuromarketing, artificial intelligence (AI), and digital communication in three keyways.

First, it identifies and addresses a theoretical gap. Prior research has examined neuromarketing, AI-enabled personalization, and social media communication largely in isolation. Existing models—such as the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and neuromarketing effectiveness frameworks—explain adoption or communication behaviors in linear ways, often relying on self-reported or rationalized consumer data. However, there has been little effort to integrate these domains into a unified framework that explains how neuromarketing knowledge translates into applied digital communication strategies, particularly in AI-enhanced environments. This study addresses this gap by proposing and empirically testing a structural model that links neuromarketing knowledge, application, activities, and social media engagement.

Second, the study refines and extends existing theories. Our findings show that neuromarketing knowledge alone is insufficient to drive communication outcomes. Instead, application acts as a critical mediating mechanism through which knowledge is operationalized into marketing activities and social media effectiveness. This insight extends TAM and UTAUT by emphasizing the role of embodied practice and translation of cognitive

knowledge into real-world application. Furthermore, drawing on network perspectives such as informational cascades and externalities, our model illustrates how applied neuromarketing practices create observable activities that generate wider peer engagement, trust, and influence.

Third, the study introduces AI as a structural amplifier within theoretical models of communication and adoption. Traditional frameworks do not fully account for the role of AI-driven real-time personalization, biometric data processing, and predictive analytics. By positioning AI not merely as a technological tool but as a theoretical amplifier, this study demonstrates how AI intensifies the relationships between knowledge, application, and engagement. In doing so, it refines media psychology, communication framing,

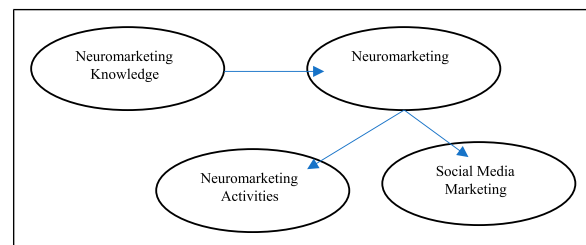


Figure 1. Variables, indicators, and respective relationships. Source: own elaboration, adapted from different references of the theoretical framework. (Variables extracted from survey available online <https://forms.gle/a7kCBjXGKUDI6LcE6>).

and social presence theories by incorporating subconscious and biometric data streams, extending their explanatory power beyond traditional self-report or behavioral data.

Taken together, these contributions provide a coherent theoretical framework that integrates adoption, network, and communication perspectives into a digitally relevant model. By demonstrating that neuromarketing knowledge must be translated into practice, and that AI amplifies these pathways, the study both clarifies the mechanisms underlying consumer engagement and extends existing theory into the domain of AI-enhanced neuromarketing.

The Peer Effect: The construct of peer effect is often used as an umbrella term, but its mechanisms are theoretically distinct and require clarification. In digital adoption and investment settings, peer effects may arise through at least three channels. First, informational influence reflects observational learning, where individuals interpret the behavior of early adopters as a signal of hidden quality or utility.⁷¹ Second, social proof refers to the normative pressure to conform with visible community practices, legitimizing one's own decisions by aligning with collective expectations.⁷² Third, herd behavior captures a more diffuse, trust-based contagion in which individuals imitate the crowd's actions without fully processing available information, often motivated by uncertainty or fear of missing out.⁷³

In the context of this study, the peer effect is best conceptualized as a combination of observational learning and social proof. Students and professors exposed to neuromarketing applications interpret early adopters' behavior as credible evidence of usefulness (informational influence) while simultaneously perceiving adoption as a legitimate norm within digitally literate academic communities (social proof). Although herd behavior is a relevant mechanism in high-uncertainty, large-scale market contexts, our controlled academic environment suggests that peer effects here are cognitively grounded rather than purely imitative. This distinction allows us to situate the construct more precisely within theories of collective behavior in digital communication and investment settings, refining its explanatory value.

The construct of peer effect in digital adoption is multidimensional and requires conceptual clarity. Prior research distinguishes between informational influence (peers as signals of hidden quality), social proof (peers as normative validators), and herd behavior (peers as triggers of contagion without independent evaluation). In this study, we conceptualize peer effect primarily as observational learning and social proof within academic networks. Students and professors interpret early adoption of neuromarketing practices as credible evidence of utility (informational influence) and simultaneously perceive adoption as a legitimate community norm (social proof). While herd behavior is a possible mechanism in large-scale, high-uncertainty markets, our controlled academic context suggests that

peer effects are cognitively grounded rather than purely imitative.”

Methodology

This research aims to bridge the gap between theory and practice in social media marketing by utilizing AI and neuromarketing to analyze big data and understand consumer behavior. By analyzing neurometrics, biometrics, and psychometrics factors, companies can identify factors of balance between profit and positive results for all, including sustainable conduct. A survey on neuromarketing was designed and applied to students, demonstrating the potential of these technologies in social media marketing strategies. The study combined AI and a neuromarketing theoretical framework to support social media marketing research and communication. The results showed that students have a good understanding of the subject and can apply neuromarketing effectively in social media marketing communication, although there are areas for improvement.

The research assumptions consider that the knowledge of neuromarketing can influence neuromarketing application, and neuromarketing application can influence neuromarketing activities and social media neuromarketing research. To test all three hypotheses, this research developed a questionnaire, based on information validated by other authors.^{45,74–76}

The instrument tries to evaluate the relationship between neuromarketing knowledge, neuromarketing application, neuromarketing activities, and neuromarketing communications and argues that knowledge of neuromarketing influences applications and applications that influence both, activities, and social media communication. The four sections of the survey evaluate a variable within this model, and the last one evaluates demographic information.

A survey was conducted between October 1-30, 2023, among university students and professors aged 18-40 from two public universities in Bucharest, the Politehnica University of Bucharest and the Academy of Economic Studies. The participants applied neuromarketing knowledge from the university's neuromarketing laboratory and European projects. Some were even working in the field. The aim was to evaluate their success in applying the knowledge and assess the course's weaknesses and strengths. The students had practical exposure to neuromarketing through lab simulations, applied coursework, and involvement in European-funded academic projects related to digital marketing and consumer behavior analysis. However, most neuromarketing applications took place in controlled educational environments, not fully commercial market-facing campaigns. This indicates a controlled and academic application of neuromarketing, not direct business implementation. The results should be interpreted considering the sample's professional experience level.

Given the academic background and digital fluency of the sample, which is largely composed of Romanian university students and professors, the findings likely reflect a more favorable attitude toward AI and neuromarketing than would be observed in broader populations. The Technology Acceptance Model (TAM) and UTAUT suggest that individuals with higher technological exposure and confidence are more inclined to perceive AI tools as useful and trustworthy. This context may have amplified participants' willingness to adopt neuromarketing strategies while downplaying concerns such as data ethics, accessibility, or real-world complexity. Consequently, while the study offers valuable insights, the results should be interpreted with caution when generalizing beyond educational or digitally mature environments.

It is important to highlight that the survey was based on a pilot study verified by sociopsychologists and marketing specialists, and the participants were informed about the

General Data Protection Regulation (GDPR). The survey was applied anonymously, and the subjects gave their consent to use the information provided by them to extend research. To analyze the relationships between these variables, the study utilizes a structured equation modeling (SEM) approach with well-defined indicators.

Results and key findings

This section presents the key findings from the structured equation modeling (SmartPLS) analysis, which evaluates the relationships between neuromarketing knowledge, application, activity, and social media communication. The results confirm that AI and neuromarketing techniques significantly influence consumer engagement, marketing effectiveness, and digital communication strategies.

Table 5. Statistical analysis and test validation.

Variable	Code	Loading factor (LF)	Cronbach alpha (CA)	Rho_A	Composite reliability	AVE	R square	VIF
Neuromarketing conceptualization (knowledge)	Threshold NI comportam NI goal NI tech	> 0.6 0.884 0.787 0.798	> 0.7 0.862	> 0.5 0.867	> 0.5 0.864	> 0.6 0.68	> 0.7 –	<5 2.64 2.25 2
Neuromarketing applications (application)	NAPPadv NAPPbrain NAPP preferences NAPPpurchase NAPPstimuli NAPPUXI	0.61 0.768 0.725 0.837 0.701 0.629	0.862	0.869	0.862	0.513	0.6	1.72 1.79 1.81 2.17 1.78 1.67
Neuromarketing activities (activity)	APPadv APPbrand APPcompareAdv APPneuroec APPneuro feedback APPpackage APPpolitic APPpreferences APPprice APPSM APPvirtual	0.873 0.838 0.709 0.66 0.745 0.799 0.53 0.82 0.713 0.823 0.731	0.936	0.94	0.935	0.57	0.3	2.54 2.51 2.54 2.35 2.54 2.24 1.86 2.75 2.38 2.39 2.25
Social media neuromarketing (SM)	NSM SMattention SMcontent SMinteraction SMlanguage SMprivacy SMresponse SMstories SMstrategy SMtaget SMvalues	0.764 0.731 0.868 0.663 0.684 0.611 0.732 0.757 0.756 0.814 0.668	0.928	0.931	0.928	0.54	–	1.96 2.38 2.73 1.87 2.09 2.03 2.27 2.16 2.38 2.78 2.4

Source: SmartPLS analysis (reprinted from a free version of SmartPLS software, version 3.3.9, created on 2 Nov 2024).⁷⁷
The bold formatting emphasize the threshold, the landmark.

Participant demographics and sample overview

The study analyzed 416 validated responses from university students and professors aged 18-40, with a balanced gender distribution (48% male, 51% female). The respondents were from two public universities in Bucharest (Politehnica University and the Academy of Economic Studies), where they had practical exposure to neuromarketing tools in laboratory settings and European business projects. Their education level was: 57% completed university studies, 41% finished high school (lyceum), 2% in other educational stages. Regarding professional involvement, many students were already applying neuromarketing knowledge in research labs or business settings. This sample represents a younger, digitally engaged consumer segment—a key audience for AI-powered neuromarketing applications.

Statistical validation and model strength

To ensure reliability and validity, the study performed construct reliability, discriminant validity, and collinearity tests using SmartPLS. The key statistical findings include (Table 2): (1) Composite Reliability (CR). That exceeded the threshold of 0.7 and confirmed strong internal consistency.; (2) Cronbach's Alpha (CA). Show high reliability in measuring neuromarketing constructs because values ranged from 0.862 to 0.936; Average Variance Extracted (AVE) prove that convergent validity of the variables is confirmed (all values were above 0.5) and Variance Inflation Factor (VIF) values are below 5 for all variables, ensuring no collinearity issues in the model. These results indicate that the model is statistically robust and reliable, allowing valid interpretations of the relationships between variables, as presented in Table 5.

Hypothesis testing and structural model findings

The path coefficients from SmartPLS confirmed all three hypotheses, indicating significant relationships between neuromarketing knowledge, application, activities, and social media communication (Table 3). Table 6 presents the path coefficient analysis.

These findings confirm H1, H2 and H3. The key interpretations are:

H1: Higher neuromarketing knowledge improves practical application. Respondents with a stronger understanding

of neuromarketing concepts (e.g., neuroscience, biometrics, AI-driven marketing) applied the techniques more effectively in marketing activities.

H2: Effective application of neuromarketing enhances marketing activities. The successful implementation of neuromarketing improves ad effectiveness, consumer preference predictions, and brand perception.

H3: Neuromarketing application positively impacts Social Media engagement. AI-driven neuromarketing enhances social media communication, content optimization, and audience targeting strategies (Figures 2 and 3).

The study uses SEM to assess the relationship between neuromarketing knowledge, application, activities, and social media communication. It hypothesizes that neuromarketing application mediates the relationship between knowledge and communication outcomes. This suggests that individuals with a better understanding of neuromarketing may influence communication effectiveness through practical implementation. However, mediation testing was not conducted due to the study's scope. Future research should formalize this role to reveal more nuanced mechanisms and explore moderation effects, such as gender, prior experience, or platform type, to better understand how neuromarketing knowledge is effectively leveraged through AI-enhanced communication strategies.

AI's role in neuromarketing effectiveness

The study highlights four keyways AI enhances neuromarketing applications and marketing activities.

- Real-Time consumer data processing, as AI-powered neuromarketing analyzes biometric signals (EEG, eye-tracking, facial recognition) to detect emotional engagement in real-time.
- Predictive analytics for personalization, as AI predicts which advertisements, messages, and digital experiences will resonate most with specific consumer segments.
- Automated content optimization, based on machine learning algorithms that refine social media content, digital ads, and website designs to maximize engagement.
- Emotion-based advertising strategies, as AI detects consumer neural responses to colors, pricing, and

Table 6. Path coefficient analysis.

Hypothesis	Path coefficient	T-value	p-value	Result
H1: Knowledge → application	0.726	13.24	<0.001	Supported
H2: Application → activity	0.555	10.10	<0.001	Supported
H3: Application → social media	0.633	13.24	<0.001	Supported

Source: SmartPLS analysis (reprinted from a free version of SmartPLS software, version 3.3.9, created on 2 Nov 2024).⁷⁷

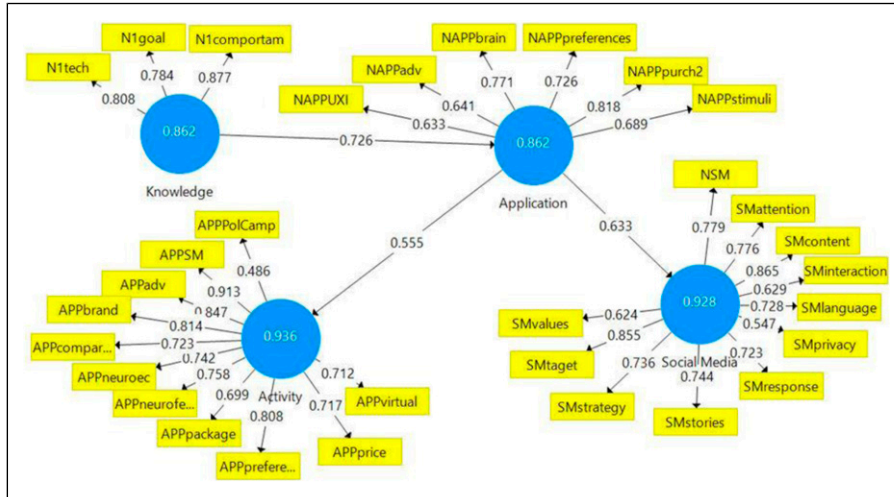


Figure 2. Cronbach's Alpha values for Knowledge, Activity, Application, Social Media. Source: Source: SmartPLS analysis (reprinted from a free version of SmartPLS software, version 3.3.9, created on 2 Nov 2024).⁷⁷

messaging, enabling hyper-personalized marketing strategies.

Despite all concerns with ethical issues,⁷⁸ these AI-driven enhancements bridge the gap between neuro-marketing insights and practical marketing execution, making campaigns more efficient, engaging, and profitable.

Ethical considerations and limitations

While the findings confirm the effectiveness of AI-powered neuromarketing, the study identifies three critical ethical and methodological challenges:

Consumer privacy risks: the use of biometric and psychometric data in marketing raises concerns about data security and consumer consent.

Bias in AI decision-making: AI models may unintentionally reinforce biases in marketing strategies, affecting brand perception and consumer trust.

Limitations in sample representation: this study is based on data from university students within academic environments, which may not fully capture the diversity and behavioural complexity of broader real-world consumer populations. However, this sample provides valuable insights into early perceptions and potential adoption pathways of AI-powered neuromarketing among digitally literate, education-focused users—an important initial step toward broader applicability.

To address these issues, future research should explore cross-industry applications of AI-driven neuromarketing and incorporate diverse consumer demographics.

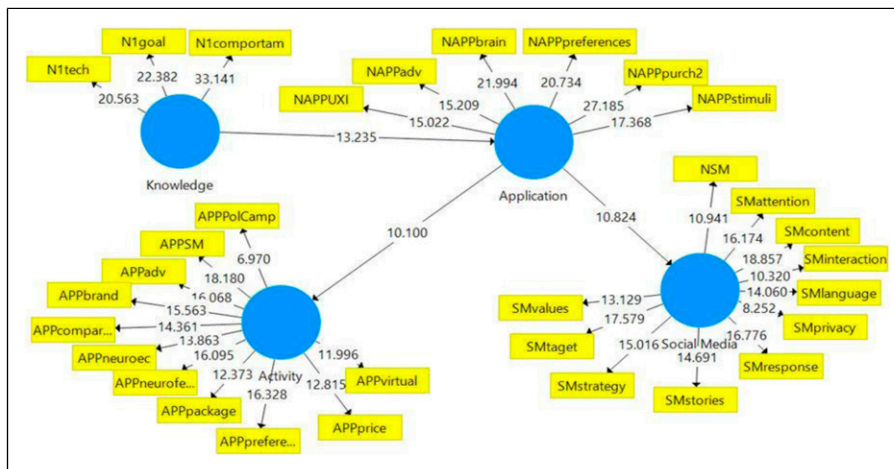


Figure 3. Bootstrapping Significance and Path Coefficients. Source: SmartPLS analysis (reprinted from a free version of SmartPLS software, version 3.3.9, created on 2 Nov 2024).⁷⁷ The path coefficients are presented in Table 6.

Although the study benefits from a sizable and engaged academic sample, the exclusive reliance on Romanian university students and professors imposes important limitations on the generalizability of the findings. Participants' neuromarketing applications primarily involved laboratory simulations, academic exercises, and participation in European projects rather than extensive real-world business campaigns. Consequently, while the findings offer valuable insights into emerging neuromarketing competencies among digitally literate populations, they may not fully capture the complexities of AI-driven neuromarketing in diverse commercial environments. Moreover, cultural factors unique to Romania—including media consumption habits, social media usage patterns, and consumer trust in digital technologies—may have influenced participants' responses and decision-making styles. These socio-cultural dynamics suggest that the results should be interpreted with caution when extrapolating to other regional or global contexts. Future research should validate these findings through cross-national studies and a broader variety of professional samples.

Discussion

Our findings confirm that AI-enhanced neuromarketing reshapes how businesses engage consumers. Neuroscience tools and machine learning now enable highly targeted strategies that meet business goals while appealing to subconscious drivers of behavior. Yet, these benefits come with risks. Ethical concerns around privacy and manipulation must remain central if companies are to maintain trust and build sustainable marketing practices.

These findings align with recent evidence suggesting that AI-driven personalization strategies substantially enhance social media engagement⁹ and that biometric-driven ad optimization correlates strongly with consumer trust and responsiveness.¹⁷ Similarly, immersive and neuro-enhanced reality applications have emerged as transformative tools for digital engagement, signaling an evolution from traditional neuromarketing toward highly interactive, AI-powered ecosystems.⁷⁵ For example, Zhang et al.³ demonstrated that neural indicators of engagement on platforms like Facebook correlate strongly with content effectiveness, supporting our findings related to the impact of neuromarketing on social media engagement.³ Similarly, Cheredniakova et al.⁷ and Hilken et al.⁵ showed that neuromarketing applied through digital platforms enhances consumer emotional resonance, paralleling the increased social media interaction observed in this study.^{5,7} However, unlike our research, these studies were not conducted in educational or simulated environments, highlighting the need for cross-validation in commercial settings. Additionally, while⁴ Constantinescu et al. emphasized the strategic alignment between neuromarketing and sustainable

branding, our study adds empirical support by modeling this connection via structural equation modeling.⁴

The Romanian context in which this study was conducted may play an important role in shaping consumers' cognitive and emotional reactions to AI-driven neuromarketing. Cultural dimensions such as collectivism, trust in technology, and educational exposure to digital innovations could moderate how neuromarketing strategies are perceived and implemented. Thus, while the findings provide a strong foundation for understanding the theoretical integration of AI and neuromarketing, further cross-cultural investigations are needed to assess their broader applicability.

Although this study hypothesized a mediating role of neuromarketing application in the relationship between knowledge and social media communication, formal mediation or moderation analysis was not performed due to the scope and data constraints of the research. No exploratory mediation or moderation tests were conducted; thus, the findings should be interpreted as direct-effect relationships only. Future research should formally test mediation pathways—such as whether application mediates the effect of knowledge on social media outcomes—and explore moderating influences like demographic variables, digital experience, or cultural factors. Including these mechanisms would provide a more nuanced understanding of how neuromarketing knowledge translates into applied digital communication strategies.

The role of AI in strengthening neuromarketing

This study reinforces that AI-powered neuromarketing plays a crucial role in modern marketing strategies by enabling.

- Real-Time Consumer Behavior Analysis, because AI-driven technologies such as EEG, fMRI, facial recognition, and eye-tracking capture subconscious reactions to marketing stimuli, allowing for more accurate audience segmentation and message tailoring.
- Personalized Advertising and Predictive Analytics, as AI enhances neuromarketing by analyzing biometric and psychometric data at scale, enabling real-time adjustments in advertisements, product placements, and pricing strategies to optimize engagement.
- Automated Neuromarketing Insights, as traditional neuromarketing requires extensive manual data interpretation, but AI-driven analytics streamline data processing, making insights more actionable and scalable.
- Social Media Content Optimization as AI refines social media strategies by predicting which types of content drive higher engagement, emotional responses, and conversion rates.

These AI-driven capabilities bridge the gap between neuromarketing insights and actionable marketing

strategies, making campaigns more efficient, responsive, and consumer-centric.

Neuromarketing's impact on consumer engagement

This study confirms that effective neuromarketing application enhances advertising impact, brand perception, and digital marketing success. Specifically.

- Emotional Engagement is Key –95% of purchasing decisions are subconscious, meaning AI-powered neuromarketing helps brands tap into consumers' emotions, strengthening brand-consumer relationships.
- AI Improves Brand Storytelling because AI-driven neuromarketing refines brand narratives by identifying which messages, visuals, and tones resonate best with target audiences.⁷⁹
- Higher Social Media Interaction, as respondents who applied neuromarketing techniques in social media campaigns observed increased engagement, confirming that AI-enhanced content attracts more consumer attention and interaction.

These findings highlight that neuromarketing—when integrated with AI—can create deeper consumer connections, increasing trust and long-term brand loyalty.

Ethical and practical challenges of AI in neuromarketing

While the study identifies ethical concerns such as data privacy, algorithmic bias, and over-personalization, these issues require deeper analysis through established ethical frameworks. To that end, this section draws on Floridi's AI Ethics Principles, the ACM Code of Ethics, and techno ethics in marketing⁷⁸ to structure ethical reflection across three domains: risks, governance, and strategic alignment.

Ethical risks: Autonomy, privacy, and psychological manipulation. AI-powered neuromarketing poses significant risks to consumer autonomy and mental privacy, especially when biometric and psychometric data are used without full transparency. As highlighted in Floridi's principles of non-maleficence and respect for human dignity, the collection of subconscious data (e.g., via EEG or eye-tracking) can unintentionally cross ethical boundaries if consumers are unaware of the depth of inference made from their emotional states. The ACM Code of Ethics also warns against deceptive design and manipulation, urging developers and marketers to avoid exploiting cognitive vulnerabilities for commercial gain.

Governance needs: Legal and organizational safeguards. To mitigate these risks, governance mechanisms must be strengthened. This includes compliance with legal frameworks such as the General Data Protection Regulation (GDPR), which mandates informed consent, purpose limitation, and data minimization. However, compliance alone is not sufficient. Organizations must also develop internal ethical review processes, incorporate algorithmic auditing, and establish cross-functional oversight between marketers, data scientists, and ethicists. Techno ethics in marketing⁷⁸ requires institutions to go beyond legality and embed ethical foresight into decision-making practices.

Strategic considerations: Transparency and fairness in AI personalization. From a strategic standpoint, ethical AI use should align with long-term brand equity and consumer trust. This involves practicing transparency in personalization algorithms, offering consumers opt-out mechanisms, and ensuring algorithmic fairness—so that AI does not reinforce stereotypes or systematically exclude minority audiences. Fairness, as conceptualized in both AI ethics and inclusive marketing, requires that personalization benefits are equitably distributed, avoiding disproportionate targeting based on sensitive traits such as emotion, gender, or neurodiversity.

Implications for businesses and marketers

The findings of this study have direct implications for platform design and governance. First, the strong influence of early investors suggests that platforms should carefully consider how real-time investment data is displayed. One option is to aggregate early investments into periodic updates rather than displaying them instantly, thereby reducing the risk of herd-like cascades driven by very early signals. Alternatively, platforms may highlight experienced investors more prominently, since their actions are more likely to provide informational value and reduce uncertainty, while downplaying purely novice activity that may amplify noise rather than insight.

Second, platforms could implement tiered visibility mechanisms, where investors can view aggregate trends (e.g., percentage funded, rate of growth) but are only shown individual-level contributions after a threshold of participation is reached. This design balances transparency with the need to avoid over-reliance on a handful of early movers.

Third, from a policy perspective, regulators may encourage platforms to adopt responsible transparency standards that promote informed decision-making without incentivizing speculative bandwagons. Guidelines could include mandatory disclosure of whether early investors have prior ties to founders, or requirements to flag when

investment surges are correlated with marketing pushes or external publicity.

Together, these measures would allow platforms to stimulate engagement while mitigating distortions from unbalanced peer effects, ultimately supporting more sustainable and trustworthy digital investment ecosystems.

Cultural and contextual considerations

While the findings offer important insights into the integration of AI, neuromarketing, and social media marketing, it is essential to consider the cultural and contextual factors underlying the study. The sample consisted exclusively of Romanian university students and professors, whose attitudes toward technology, social media usage patterns, and consumer behavior may differ from those in other cultural contexts. Romania's relatively high digital literacy rates among younger populations, combined with strong engagement on social media platforms such as Facebook and Instagram, could have influenced participants' receptiveness to AI-driven marketing approaches.

Furthermore, educational exposure to neuromarketing concepts within the university environment may have shaped participants' familiarity with and openness to biometric and psychometric data collection. Cultural factors such as levels of trust in technology, attitudes toward privacy, and consumer skepticism toward digital advertising can moderate emotional and behavioral responses captured through neuromarketing tools.

Although some implications suggested relevance for business practice, the academic nature of the sample means that any extrapolations to commercial or industry-wide applications should be made with restraint.

Given these factors, the study's findings should be interpreted cautiously when generalizing to other national or regional populations. Future research should explore the cross-cultural applicability of AI-enhanced neuromarketing strategies by conducting comparative studies across different countries and consumer demographics. Examining cultural moderators such as individualism-collectivism, uncertainty avoidance, and technological acceptance would further enrich the understanding of neuromarketing effectiveness across global markets.

Limitations and future research

While this study offers novel insights into the role of neuromarketing knowledge, application, and peer effects in AI-enhanced communication, its findings should be interpreted within the boundary conditions of our research design. Data were collected from a single platform with specific design features and visibility rules, which may shape the strength and form of peer influence. Platforms with alternative algorithms, display formats, or governance policies may generate different dynamics.

Similarly, our sample—comprising Romanian university students and professors—represents a digitally literate yet academically oriented user base. Their adoption patterns may differ from those of professional investors, industry practitioners, or users in other cultural contexts. As such, while our design strengthens internal validity, it also limits the generalizability of our conclusions across broader populations and markets.

Future research should therefore test the robustness of these findings across diverse platforms, industries, and geographic contexts. Considering that other campaign characteristics may co-vary with investment surges, it is suggested to implement it in the next investigations.

In addition, comparative studies could investigate whether peer influence mechanisms vary under different cultural norms, levels of digital literacy, or regulatory environments. Longitudinal research would also help capture how peer dynamics evolve as platforms mature and as users gain more experience with AI-driven communication tools. By extending inquiry across these boundaries, scholars can refine theory and provide more nuanced insights into the interplay between neuromarketing, AI, and collective behavior in digital ecosystems.

Conclusion

This study examined how neuromarketing knowledge translates into application, marketing activities, and social media communication in AI-enhanced environments. Using a structural equation modeling approach, we demonstrated that knowledge alone is insufficient: only when operationalized into practice does it generate meaningful communication outcomes. Neuromarketing Application appears to function as an important translational mechanism through which knowledge is converted into marketing activities and social media communication outcomes. While the structural model supports strong direct relationships, formal mediation testing was beyond the scope of this study and should be addressed in future research.”

Theoretically, the research extends adoption and communication models by showing that peer effects, informational signaling, and application pathways operate dynamically across digital contexts. By situating neuromarketing knowledge within a temporal and networked framework, the study clarifies how influence shifts from early informational cues to normative alignment and, in some cases, herd-like contagion. This adds precision to existing theories of cascades, social proof, and digital collective behavior.

Managerially, the findings provide actionable insights for platform designers and marketers. Real-time visibility of peer activity is a double-edged sword: it can stimulate participation but also amplify cascades or herd effects. Platforms should consider moderating the immediacy and form of displayed signals—for instance, by aggregating early investment data, emphasizing the activity of experienced contributors, or introducing tiered visibility

mechanisms. Such design choices can enhance informed decision-making while mitigating distortions from over-reliance on early movers.

From a policy perspective, the results highlight the importance of responsible transparency standards. Regulators may encourage disclosure of whether early adopters have ties to founders, require platforms to flag campaigns experiencing unusual surges linked to external publicity, or set guidelines for ethical use of biometric and psychometric data in marketing. These measures can promote trust, accountability, and consumer protection in AI-powered digital ecosystems.

At the same time, ethical considerations remain central. As neuromarketing becomes increasingly data-driven, the risks of privacy violations, manipulation, and bias grow. Companies must therefore adopt governance mechanisms—such as algorithmic audits, informed consent protocols, and continuous ethical oversight—that go beyond compliance to actively safeguard consumer well-being.

Finally, this research is not without limitations. The study's focus on a Romanian academic population provides valuable insights into digitally literate users but limits generalizability across industries, cultures, and market contexts. Future studies should explore longitudinal effects, cultural moderators, and industry-specific dynamics to extend and test the robustness of the proposed model.

In conclusion, AI-enhanced neuromarketing holds the potential to transform digital communication by uniting cognitive science, data analytics, and ethical practice. Realizing this promise requires not only technical precision but also a commitment to responsible implementation—ensuring that the future of marketing fosters engagement, trust, and sustainable value creation.

Core contribution summary

This study extends neuromarketing theory by integrating AI-driven personalization with social media marketing, offering a unified model that links cognitive knowledge, practical application, and digital engagement outcomes.

By applying PLS-SEM to a multidimensional construct design across neuromarketing knowledge, application, activities, and social media communication, the study provides a replicable analytical framework for future research in AI-enhanced consumer engagement.

The findings highlight that ethical awareness and transparency in AI-powered neuromarketing are as critical as technological precision, guiding marketers toward responsible personalization strategies that build trust and long-term brand equity.

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Ethical considerations

The authors declare that the work described has been carried out in accordance with the Declaration of Helsinki of the World Medical Association revised in 2013 for experiments involving humans as well as in accordance with the EU Directive 2010/63/EU for animal experiments.

Consent to participate

Respondents gave their informed consent and participation was voluntary. The authors declare that this report does not contain any personal information that could lead to the identification of the patients and/or volunteers. The authors declare that they obtained written informed consent from the patients and/or volunteers included in the article and that this report does not contain any personal information that could lead to their identification.

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Declaration of conflicting interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

The datasets (GENERATED/ANALYZED) for this study can be found in the Google Form <https://forms.gle/a7kCBjXGKUDI6LcE6>.

Declaration of generative AI in scientific writing

The authors would like to inform you that AI was not used in the writing process.

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