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НЕЙРОНАУКА: ДОСЛІДЖЕННЯ РОЛІ НЕЙРОНАУКИ В СУЧАСНОМУ МАРКЕТИНГУ
THE NEURAL EDGE: EXPLORING THE ROLE OF NEUROSCIENCE IN MODERN MARKETING

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This article examines how neuroscience has become an influential tool in modern marketing—often called neuromarketing—by uncovering neural, cognitive, and affective processes underlying consumer decisions. Most emerging methods co-moved in popularity from 2014-2020 (especially eye-tracking and behavioral economics models, facial analysis and prediction markets, biometric response and text analytics), except for applied neuroscience, which followed a different temporal trend. We first define the field and trace its emergence, then review core neuroscientific methods and tools used in marketing research. Next, we explore major applications in advertising, branding, pricing, and user experience, followed by discussions of ethical challenges and limitations. Statistical analysis was used to find positive correlations between biometric response, facial analysis, eye-tracking, and other emerging analytical methods, and negative correlations with applied neuroscience, which followed different trends among sellers and buyers of analytical services. The popularity profiles of various analytical methods were largely similar in North America, Europe, and Asia. We also outline future directions in integrating neuroscience with AI, big data, and consumer analytics. Neuroscience offers marketers deeper insight into unconscious drivers of choice but requires careful methodological rigor and ethical safeguards to avoid manipulation or consumer mistrust. The future lies in integrating neuroscience with AI, deploying real-world measurement, and pursuing rigorous ethical practices. If neuromarketing evolves responsibly, it may become a staple of marketing strategy – a bridge between brain science and business practice that respects consumer dignity and contributes to better marketing outcomes.

Keywords: Neuromarketing, consumer neuroscience, neural methods, marketing applications, ethics in marketing.

У статті розглянуто, як нейронаука стала впливовим інструментом у сучасному маркетингу, який часто називають нейромаркетингом, розкриваючи нейронні, когнітивні та афективні процеси, що лежать в основі рішень споживачів. Більшість нових методів синхронно змінювали свою популярність у 2014-2020 роках (особливо моделі айтрекінгу та поведінкової економіки, ринки прогнозів та аналіз обличчя, біометрична реакція та текстова аналітика), за винятком прикладної нейронауки, визнання якої характеризувалось іншою часовою динамікою. Визначено категорію нейромаркетингу та історію її виникнення, розглянуто основні нейронаукові методи та інструменти, що використовуються в маркетингових дослідженнях. Досліджено основні напрями застосування нейронауки у рекламі, брендингу, ціноутворенні та досвіді користувача, після чого розглядаються етичні виклики та методологічні обмеження. Застосовано статистичний аналіз внаслідок якого виявлено позитивну кореляцію між біометричною реакцією, аналізом обличчя, відстеженням погляду та іншими новітніми аналітичними методами, та негативну кореляцію з прикладною нейронаукою, яка демонструє іншу тенденцію серед постачальників і споживачів аналітичних послуг.

Профілі популярності різних аналітичних методів виявилися переважно подібними у Північній Америці, Європі та Азії. Окреслено також майбутні напрями інтеграції нейронауки зі штучним інтелектом (ШІ), великими даними та споживчою аналітикою. Визначено, що нейронаука надає маркетологам глибше розуміння несвідомих чинників вибору споживачів, однак вимагає методологічної точності та етичних гарантій, щоб уникнути маніпуляцій та зберегти довіру споживачів.

Показано, що майбутнє нейромаркетингу полягає у поєднанні нейронауки зі штучним інтелектом, застосуванні вимірювань у реальному середовищі та дотриманні суворих етичних принципів. За умови відповідального розвитку нейромаркетинг може стати невід'ємною складовою маркетингової стратегії — зв'язковою ланкою між наукою про мозок і бізнес-практикою, що поважає гідність споживачів і сприяє ефективним та соціально відповідальним маркетинговим результатам.

Ключові слова: нейромаркетинг, споживча нейронаука, нейронні методи, маркетингові застосування, етика в маркетингу.

Statement of the problem

Neuroscience, the scientific study of the brain and nervous system, has increasingly influenced marketing, giving rise to the interdisciplinary field of neuromarketing or consumer neuroscience. This emerging area seeks to understand the neural and psychological processes underlying consumer behavior, moving beyond traditional surveys and self-reports to uncover subconscious drivers of decision-making. By employing tools such as EEG, fMRI, and eye-tracking, marketers can analyze how consumers perceive, feel, and respond to brands, advertisements, and pricing. Early research revealed that neural responses often predict preferences and purchase intentions more accurately than verbal feedback. Integrating neuroscience with marketing theory enables more effective campaign design, deeper consumer insights, and data-driven strategies – though it also raises ethical questions about privacy, consent, and potential manipulation.

The purpose of the research

The purpose of the article is to conduct a comprehensive study of neuroscience as an influential tool in modern marketing (neuromarketing), analyze the popularity trends of various analytical methods (biometrics, eye-tracking, facial analysis) between 2014 and 2020, and substantiate strategic directions for integrating neurotechnologies with AI and big data while maintaining rigorous ethical safeguards.

Presentation of the main research material

1. Foundation of Neuroscience in Marketing

Neuroscience, the study of the brain and nervous system, has increasingly extended into consumer research, giving rise to consumer neuroscience, or neuromarketing—a field that bridges marketing, psychology, and neuroscience (Alsharif et al., 2023) [2]. Neuroscience in marketing aims to move beyond self-report and surveys to capture implicit, unconscious, and physiological responses to marketing stimuli. The fundamental assumption is that much of human decision-making is influenced by processes that consumers themselves cannot articulate, hence relying only on questionnaires or interviews may miss critical drivers (Pickings Your Brains review) (Casado-Aranda et al., 2023) [4]. Early experiments, such as measuring brain activation in response to branded vs. unbranded stimuli, showed that neural responses predicted later consumer preferences

better than declared preferences. This foundation suggests that marketers who understand the neural correlates of attention, memory, reward, and emotion may design better campaigns or experiences.

Neuroscience in marketing is not purely about measuring the brain—it demands integration with behavioral theory and marketing constructs. As argued in recent reviews, “neuroscience tools are most useful when combined with classical marketing models (e.g. the marketing mix, consumer decision journeys)”. The value lies not just in raw neural data, but in linking it to marketing outcomes: brand recall, willingness to pay, attention, and choice. Later sections will detail how neuroscientific tools are applied and how marketers interpret findings with caution (Pilelienė et al., 2022) [11].

2. Methods and Tools in Consumer Neuroscience

A key pillar of neuromarketing is the use of neuroimaging and physiological tools to capture brain and bodily responses during exposure to marketing stimuli. Among the most common tools are electroencephalography (EEG), functional magnetic resonance imaging (fMRI), eye-tracking, facial coding/EMG (electromyography), galvanic skin response (GSR), heart rate / heart rate variability (HR/HRV), and near-infrared spectroscopy (NIRS). EEG is favored for its temporal resolution and relatively lower cost; reviews show EEG is the most frequently used tool in neuromarketing research. fMRI provides high spatial resolution and allows identification of activated brain regions (e.g., ventromedial prefrontal cortex in valuation). Eye-tracking, GSR, and facial coding supplement neural data by indicating attention, arousal, and emotional valence (Iloka & Onyeke, 2020) [8].

Each tool has trade-offs in cost, invasiveness, temporal vs spatial precision, and interpretability. For instance, fMRI is expensive and has low temporal resolution, limiting its practical use in many marketing experiments. EEG, though cheaper, provides less spatial localization (Aldayel et al., 2020) [1]. A recent systematic review of EEG-based neuromarketing highlights advances in signal processing, machine learning, and feature extraction to improve predictive accuracy. Multimodal approaches—combining EEG, eye-tracking, GSR, and behavioral data—are increasingly common to triangulate findings and overcome limitations of single-method studies. As consumer neuroscience evolves, platforms integrating multiple modalities are becoming more accessible to researchers and practitioners (Bhardwaj et al., 2023) [3].

3. Applications in Marketing: Advertising, Branding, Pricing, and UX

Neuroscience has been applied across multiple marketing domains to enhance understanding and design of marketing stimuli.

3.1 Advertising and Campaign Effectiveness

One of the earliest uses of neuromarketing is in evaluating advertising effectiveness. By measuring brain responses to ad stimuli, marketers can assess which parts of an ad elicit high attention, emotional engagement, or memory encoding. For instance, EEG studies can reveal moments of peak neural engagement (“moments of truth”), which can guide editing or message emphasis. The integration of neuroscience insights with traditional metrics helps identify which creative elements work best. A recent conceptual framework links neural activations elicited by ad stimuli to subsequent consumer behavior and marketing outputs, helping managers interpret which brain patterns correspond to effective persuasion (Duque-Hurtado et al., 2020) [5].

3.2 Branding and Consumer Preference

Branding benefits from neuroscience by revealing how brand logos, packaging, or storytelling elicit affective and memory responses. Neural signals can indicate whether a brand more strongly activates reward or emotional circuits. The opinion piece by Haidinger et al. (2023) [7] highlights that neuroscience especially adds value in branding tasks where emotional resonance and memory retention are crucial (Haidinger et al., 2023) [7]. For example, neural measures may detect subtle preferences for one design over another that consumers could not articulate. Over time, brand equity may be associated with consistent neural patterns of positive activation among consumers (Iloka & Onyeke, 2020) [8].

3.3 Pricing and Willingness to Pay

Determining optimal pricing is notoriously challenging. Neuroscience offers direct insight into valuation and willingness to pay (WTP). Some studies use fMRI or EEG to correlate brain signals in value-sensitive brain areas (e.g., orbitofrontal cortex) with participants’ price thresholds, thereby revealing nonconscious valuation processes. In doing so, neuroscience can help design price anchors, promotional offers, or discounts that align with how consumers’ brains register perceived value (Mansor & Isa, 2020) [10].

3.4 User Experience (UX) and Digital Interfaces

In digital marketing, neuroscience is used to optimize website design, e-commerce flows, app interfaces, and more. Eye-tracking, combined with neural and physiological data, can identify which page elements attract attention, cause cognitive load, or elicit frustration. These insights guide layout, content prioritization, and navigation. For instance, during user testing, combining EEG + GSR + eye-tracking allows designers to detect when users experience friction or confusion, thereby guiding usability improvements. As digital touchpoints multiply, neuroscience-based UX evaluation becomes a valuable complement to surveys or A/B testing. (Haidinger et al. 2023) [7] argue that consumer neuroscience can illuminate not only where attention goes but also how it influences memory and decision-making downstream in a digital context (Haidinger et al., 2023) [7].

Collectively, these applications demonstrate how neuroscience can inform campaign design, branding choices, pricing strategy, and user experience. However, caution is necessary—interpretation of neural data must be grounded in rigorous theory and validated behavior (Pluta-Olearnik & Szulga, 2022) [12].

4. Challenges, Ethical Considerations, and Limitations

While neuroscience holds exciting promise for marketing, it also poses significant challenges and ethical risks.

Interpreting brain data is complex. Neural activation in a brain region does not always map neatly onto a specific psychological process, due to reverse inference problems (e.g., if activation in a region implies a specific mental state). The literature warns that “neuroscience tools must be integrated with theory and behavioral measures, not used as a ‘neuro-magical’ solution” (Haidinger et al., 2023) [7]. Some meta-analyses emphasize that many neuromarketing studies are underpowered, have small sample sizes, or overfit classifiers, limiting generalizability. The systematic review from 2011–2021 also identifies a “dark side” component – studies with weak methodological rigor or overhyped claims – alongside promising experimental findings. Multimodal approaches and replication studies are recommended to overcome these issues (Iloka & Onyeke, 2020) [8].

Neuromarketing raises profound ethical questions about consumer autonomy, privacy, manipulation, and consent. A recent systematic review of neuromarketing ethics identifies key concerns: the privacy and confidentiality of neural data, autonomy and informed consent, the risks of “mind control,” scientific validity, and the potential exploitation of vulnerable groups. The fear of a hidden “buy button” in the brain frequently surfaces in public debates and media coverage. Ensuring transparency, anonymizing neural data, obtaining explicit informed consent, and ensuring oversight are critical. Ethical guidelines are still emerging, and voluntary industry standards may not suffice for robust protection. Neuromarketing must balance revealing consumer insights without violating dignity or manipulating unduly (Bočková et al., 2021).

Neuroscientific experiments are often expensive, time-consuming, and require specialized equipment and expertise, limiting their scalability for many firms. fMRI has high operational costs and strict experimental protocols, which may not reflect real-world contexts. The logistical challenge of recruiting participants, calibrating equipment, and controlling experimental noise also curtails widespread adoption. Many marketing departments lack internal neuroscientific expertise and must rely on external providers, raising concerns about data ownership and the accuracy of interpretation. Finally, the gap between lab-derived insights and real-world consumer behavior remains nontrivial—translating neural insights into actionable strategies is nontrivial (Bhardwaj et al., 2023) [3].

5. Future Directions

Neuroscience in marketing is still maturing, and future developments suggest promising synergies and new frontiers. One of the most promising directions is combining neural data with machine learning, artificial intelligence (AI), and large-scale consumer datasets. This hybrid approach may improve predictive models of consumer behavior by fusing explicit choices, online behavior, and neural signals. For example, recent work explores the application of graph neural networks to EEG-based prediction of consumer behavior. Also, an emerging trend is the synergy between neuromarketing and AI in campaign personalization and real-time adaptation. This direction could bridge neural insights with scalable analytics and drive personalized marketing interventions (Bhardwaj et al., 2023) [3].

Lab-based neuroscience, though controlled, may lack ecological validity. Future research is moving toward in-the-wild settings – embedding sensors into real shopping or digital environments (e.g., wearable EEG, eye-tracking glasses) to measure neural responses during everyday consumer activity. The Internet of Everything (IoE) genre of neuromarketing envisions integrating multiple devices (smartphones, wearables, ambient sensors) to capture consumer states in real time. This shift from lab to field enhances realism and applicability but also magnifies ethical and privacy challenges (Singh et al., 2023) [13].

Much neuromarketing research is cross-sectional and focused on WEIRD (Western, Educated, Industrialized, Rich, Democratic) populations, constraining generalizability. Future work should explore longitudinal designs, cross-cultural samples, and segments like children, the elderly, and marginalized groups. Understanding how neural responses vary across cultures, ages, or socioeconomic contexts can inform marketing adaptation and fairness. Ethical safeguards are especially important when including vulnerable populations (Khurana et al., 2021) [9].

For neuromarketing to gain trust and legitimacy, the field must adopt stronger ethical frameworks, transparency in methods, and consumer-friendly narratives. Clear disclosure of how neural data are collected, used, and protected is essential. Collaborative governance, third-party audits, and consumer opt-out rights could help balance innovation and trust. Marketing scholars also call for more replicability, open data sharing, and methodological standards to reduce hype and improve scientific credibility (Haidinger et al., 2023) [7].

6. Modelling development of neuromarketing

Greenbook (2020) [6] provided a survey of the usage of various emerging marketing methods among suppliers and buyers of analytical services (Table 1). Most of the respondents are from the US (63%), but other countries are also represented.

In 2014-2020, the largest increases were in the use of text analytics (+21%) and mobile qualitative studies (+17%), while biometric response and applied neuroscience showed the largest relative growth and almost doubled in popularity. But eye-tracking had the lowest growth rate.

Correlation analysis (Table 2) of changes in the use of the methods shows that most methods followed similar temporal patterns, with the main advances occurring in 2016 and 2020 (positive correlations). But applied neuroscience changed in the opposite direction compared to the other methods. There were also a few unrelated patterns (between big data analytics, mobile qualitative studies, mobile ethnography, micro-surveys, virtual environments, and research gamification).

Table 2. Correlations between growth rates of use of emerging market analytics methods.

	Text analytics	Social media analytics	Mobile qualitative	Big data analytics	Mobile ethnography	Micro-surveys	Eye-tracking	Behavioral economics models	Applied neuroscience	Research gamification	Facial analysis	Prediction markets	Crowdsourcing	Virtual environments	Biometric response
Text analytics	1.00														
Social media analytics	0.79	1.00													
Mobile qualitative	0.68	0.53	1.00												
Big data analytics	0.58	0.65	-0.10	1.00											
Mobile ethnography	0.63	0.51	0.50	0.17	1.00										
Micro-surveys	0.70	0.70	0.86	0.14	0.21	1.00									
Eye-tracking	0.89	0.76	0.65	0.65	0.48	0.65	1.00								
Behavioral economics models	0.96	0.76	0.76	0.54	0.51	0.77	0.96	1.00							
Applied neuroscience	-0.79	-0.57	-0.13	-0.76	-0.33	-0.31	-0.59	-0.66	1.00						
Research gamification	0.94	0.64	0.76	0.31	0.69	0.69	0.74	0.88	-0.70	1.00					
Facial analysis	0.88	0.85	0.39	0.80	0.33	0.64	0.79	0.83	-0.88	0.73	1.00				
Prediction markets	0.88	0.90	0.56	0.61	0.37	0.81	0.74	0.82	-0.76	0.78	0.95	1.00			
Crowdsourcing	0.84	0.99	0.55	0.71	0.48	0.71	0.86	0.84	-0.60	0.67	0.88	0.90	1.00		
Virtual environments	0.53	0.83	0.06	0.89	0.24	0.30	0.66	0.53	-0.51	0.24	0.74	0.64	0.85	1.00	
Biometric response	0.85	0.54	0.24	0.71	0.48	0.31	0.67	0.73	-0.97	0.79	0.84	0.71	0.59	0.45	1.00

Source: Author's calculations using Greenbook (2020) [6].

Several regression models are made here to show the dependence of the change in use of neuromarketing methods on other methods, with the highest correlations:

$$ET = -1.1 + 0.98BEM \quad (R^2 = 0.93, b_1 \text{ t-stat} = 7.2, p < 0.05)$$

$$ANS = 4.4 - 0.68TA \quad (R^2 = 0.63, b_1 \text{ t-stat} = -2.6, p < 0.1)$$

$$FA = -0.05 + 0.92PM \quad (R^2 = 0.91, b_1 \text{ t-stat} = 6.3, p < 0.05)$$

$$BR = -0.6 + 0.60TA \quad (R^2 = 0.72, b_1 \text{ t-stat} = 3.2, p < 0.05)$$

Therefore, the most apparent co-movements are among eye-tracking and behavioral economics models, facial analysis and prediction markets, and biometric responses and text analytics. Meanwhile, applied neuroscience and text analytics are substitutes for each other, although the relationship is less significant. But these are preliminary conclusions only. The published time series are too short, as the field of study is novel and only a little statistical data is available yet.

Table 3 presents information on differences among regions in the use of analytical methods.

We use the North America region as a benchmark (most respondents are from it). The regression models for the use of a method in Europe (E) and Asia-Pacific (AS) are calculated as dependent variables on the use of the method in North America (NA) and the dummy (D) for the neuromarketing method (the first 4 methods in Table 3):

$$E = -0.44 + 1.04NA + 5.5D \quad (R^2 = 0.89, b_1 \text{ t-stat} = 11.0, p < 0.01, b_2 \text{ t-stat} = 1.6, p = 0.12)$$

$$PA = 5.7 + 0.97NA - 4.4D \quad (R^2 = 0.84, b_1 \text{ t-stat} = 8.0, p < 0.01, b_2 \text{ t-stat} = -1.0, p < 0.33)$$

On average, both Europe and the Asia-Pacific have similar profiles in the use of emerging analytical methods, like in North America. Europe uses somewhat more neuromarketing methods, and Asia somewhat less, but the differences with North America are insignificant in this group of techniques.

Conclusions and prospects for further research

Neuroscience has opened a new frontier in marketing by offering tools to peer into the brain, revealing underlying mechanisms of attention, emotion, memory, and valuation that drive consumer behavior. When used carefully and in combination with behavioral and theoretical models, neuroscience can sharpen marketers' ability to design more engaging ads, build stronger brands, optimize pricing, and refine user experiences. However, challenges in interpretation, cost, ethical concerns, and ecological validity must be addressed.

Biometric response and applied neuroscience are the fastest-developing analytical methods. Most emerging methods co-moved in popularity from 2014-2020 (especially eye-tracking and behavioral economics models, facial analysis and prediction markets, biometric responses and text analytics), except for applied neuroscience, which followed a different temporal trend. As for regional breakdown, in Europe and Asia, the difference in the adoption of neuromarketing techniques is not significant compared to North America.

The future lies in integrating neuroscience with AI, deploying real-world measurement, and pursuing rigorous ethical practices. If neuromarketing evolves responsibly, it may become a staple of marketing strategy – a bridge between brain science and business practice that respects consumer dignity and contributes to better marketing outcomes.

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Table 3. The share of respondents using marketing analysis methods in 2020.

Use regularly or occasionally	All regions	North America	Europe	Asia-Pacific	Rest of World
<i>Applied neuroscience</i>	25	22	28	26	35
<i>Eye-tracking</i>	39	37	47	41	40
<i>Facial analysis</i>	26	25	29	22	32
<i>Biometric response</i>	19	17	21	14	29
Mobile-first surveys	64	61	63	75	69
Mobile ethnography	45	46	45	34	55
Mobile qualitative	54	54	52	55	55
Research gamification	36	35	45	28	27
Virtual Environments/VR	18	18	17	22	18
Crowdsourcing	22	23	15	28	21
Social media analytics	57	54	63	68	52
Big Data analytics	47	49	44	49	37
Micro-surveys	41	40	40	45	44
Causal analysis	40	40	35	50	37
Text analytics	61	63	62	64	44
Prediction markets	26	25	27	33	31
Chatbots	20	19	18	32	19
Behavioral economics models	37	35	48	37	31
Passive data measurement	25	23	26	32	23
<i>Number of respondents</i>	785	498	149	76	62

Source: Author's calculations using Greenbook (2020) [6].

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