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Neuromarketing Across the Consumer Journey: A Comprehensive Review of Tools, Neural Correlates, and Marketing Mix Applications

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Abstract:

Purpose: *Neuromarketing integrates neuroscience, psychology, and marketing to uncover subconscious consumer processes that traditional self-report methods often fail to capture. This systematic review aims to develop an integrative framework that captures stage-specific neural correlates of consumer decision-making across the entire consumer journey and links them to elements of the marketing mix, thereby addressing existing theoretical and methodological gaps.*
Design/Methodology/Approach: *Following the PRISMA framework, this systematic review analyzes 215 peer-reviewed studies published between 2004 and 2025. Data were collected from Web of Science, Scopus, and EBSCOhost, with an emphasis on high-impact journals to ensure methodological rigor. The review systematically maps neuromarketing tools, research domains, and neural mechanisms across different stages of consumer decision-making.*
Findings: *The analysis reveals a strong methodological preference for electroencephalography (EEG) (35–37%) and functional magnetic resonance imaging (fMRI) (24–25%). Research is predominantly concentrated on advertising (42–45%) and product design (22–23%). Neural evidence indicates that reward-related brain structures, particularly the ventral striatum and nucleus accumbens, play a central role in need recognition, while decision-making and emotional processing are primarily governed by the prefrontal cortex, amygdala, and insula.*
Practical Implementations: *The findings highlight the potential of neuromarketing to enhance predictive accuracy in consumer behavior, inform pricing strategies, and support the design of emotionally engaging brand experiences. By aligning neural insights with specific stages of the consumer journey and marketing mix elements, practitioners can develop more targeted and effective marketing interventions.*
Originality value: *This review advances the literature by proposing a unified 3×3 typology that integrates cognitive, affective, and behavioral neural correlates across pre-purchase, purchase, and post-purchase stages. By offering a comprehensive and stage-inclusive framework, the study positions neuromarketing as a more coherent and scientifically robust discipline with significant theoretical and applied value.*

Keywords: *Neuromarketing, consumer decision-making, neural correlates, EEG and fMRI, consumer buying stages, neuroimaging tools.*

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1. Introduction

1.1 Evolution and Definition of Neuromarketing

Neuromarketing has emerged as an interdisciplinary field that integrates neuroscience, psychology, and marketing to understand the unconscious drivers of consumer behavior that traditional methods often fail to capture. The term was formally coined by Smidts (2002), marking the beginning of systematic scientific inquiry into how neuroimaging techniques could illuminate consumer decision-making mechanisms.

The foundational watershed moment came in 2004 when McClure and colleagues conducted the landmark "Pepsi vs. Coke" study, which revealed that brand associations and emotional memories activate distinct neural pathways compared to taste preferences alone, fundamentally shifting the field from theoretical psychology to practical neuroscientific application (McClure *et al.,* 2004). This groundbreaking research signaled a critical paradigm shift—from traditional behavioral psychology focused on observable purchasing actions to neuroscientific approaches examining the brain's internal unconscious processes (Ariely and Berns, 2010).

The theoretical evolution of neuromarketing is rooted in classical conditioning principles established in early 20th-century advertising psychology, which demonstrated how emotions linked to advertisements shape consumer behavior independently of rational assessment (Watson, 1913). This foundation was enriched by mid-20th-century cognitive psychology, which challenged behaviorism's exclusive emphasis on observable actions by emphasizing the critical importance of mental processes in decision-making (Simon, 1957).

Most significantly, Daniel Kahneman's dual-process theory of decision-making (2011) fundamentally reshaped neuromarketing by distinguishing between System 1 (fast, automatic, emotional thinking driven by intuition) and System 2 (slow, deliberate, rational thinking requiring conscious effort), establishing that effective marketing operates primarily through subconscious emotional processing rather than rational analytical evaluation (Kahneman, 2011; Morin, 2011).

The commercial expansion of neuromarketing demonstrates unprecedented industry recognition. As of 2025, the global neuromarketing market was valued at approximately USD 1.44 billion in 2023 and is projected to reach USD 3.11 billion by 2032, representing a robust compound annual growth rate of 8.9% (Mordor Intelligence, 2025; Gupta *et al.,* 2025).

This exponential market trajectory reflects increasing adoption across diverse industries including retail, consumer electronics, and media, as businesses recognize the superior value of neuroscience-based insights compared to traditional selfreported data, which often contains social desirability bias and conscious distortion (Stanton *et al.,* 2017).

Geographic analysis reveals that North America leads market growth through substantial investments from major technology companies, Europe functions as an academic research innovation center, and Asia-Pacific represents the fastest-growing market, driven by rising demand in China and India (Gupta *et al.,* 2025). Addressing conceptual ambiguity in the field, scholars have developed a standardized definition.

Neuromarketing is now understood as "an interdisciplinary area which applies neuroscience and cognitive neuroscience to business. It is about creating brain-friendly content or communication which helps to understand how consumers react at non-conscious level in real time, based on brain operating principles and the responses can be measured by various neuro-metric or non-neuro-metric techniques" (Alsharif *et al.,* 2023; Gupta *et al.,* 2025).

1.2 Research Gaps and Rationale

Despite substantial progress, critical conceptual and empirical gaps severely limit current neuromarketing scholarship. The first major gap involves inadequate coverage of the consumer decision-making journey: existing research overwhelmingly concentrates on the pre-purchase stage, examining how the brain reacts to advertising, branding decisions, and product information before purchase commitment (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

Conversely, the purchase stage—where consumer intentions translate into actual behavior—remains critically underexplored due to ecological validity challenges in measuring real-time neural responses during authentic buying moments in naturalistic retail environments (Plassmann *et al.,* 2012; Meiner *et al.,* 2020).

The post-purchase stage is similarly neglected, despite its fundamental importance for understanding satisfaction, brand loyalty development, and advocacy behavior that determine long-term customer value (Lee *et al.,* 2017; Gupta *et al.,* 2025). This fragmented research landscape fails to capture the dynamic interactions among cognitive, affective, and behavioral processes unfolding across the entire consumer journey (Karmarkar and Plassmann, 2019).

The second major gap concerns insufficient integration across marketing mix elements and neural mechanisms: while advertising research constitutes 42-45% of studies, product design receives moderate attention (22-23%), yet pricing and branding remain comparatively understudied (Alsharif *et al.,* 2023; Gupta *et al.,* 2025). More critically, existing literature lacks comprehensive frameworks that simultaneously address how neuromarketing tools, neural correlates, and marketing mix applications interconnect across decision-making stages (Oliveira *et al.,* 2022).

The third gap involves definitional ambiguity: between 2002 and 2020, evolving concepts and terminology created conceptual confusion regarding what constitutes neuromarketing and its relationship to consumer neuroscience (Khamitov *et al.,* 2020; Gupta *et al.,* 2025).

1.3 Research Objectives and Questions

This systematic review addresses these interconnected gaps by synthesizing stage-specific neural responses across the entire consumer buying journey while mapping relationships between neuromarketing tools and marketing mix applications. Following rigorous PRISMA methodology as outlined by Page *et al.* (2021), this review analyzes 215 peer-reviewed articles (109 from 2020-2025 and 106 from 2004-2020) from major databases including Web of Science, Scopus, and EBSCO host, focusing on high-ranking journals ensuring methodological rigor (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

The review simultaneously examines the dominance of EEG and fMRI as measurement tools, establishes neural mechanisms underlying consumer behavior across stages, and proposes integrated frameworks unifying affective, behavioral, and cognitive processes throughout the complete consumer experience rather than isolated pre-purchase moments (Karmarkar and Plassmann, 2019; He *et al.,* 2021).

The primary research objectives are: (1) to map neuromarketing tools to consumer decision-making stages across pre-purchase, purchase, and post-purchase phases; (2) to identify neural correlates associated with marketing mix elements including advertising, branding, pricing, and product design; (3) to propose integrated frameworks and typologies for future research; and (4) to address specific research questions on theories, methodologies, and underexplored areas in neuromarketing scholarship (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

2. Theoretical Foundations

2.1 Consumer Decision-Making Models

Understanding consumer behavior requires adopting structured frameworks that organize purchasing processes into coherent stages. The classical five-stage model, developed by Kotler, Keller, and Schiffman (Schiffman *et al.,* 2011), decomposes consumer decision-making into sequential phases: need recognition, information search, and evaluation of alternatives, purchase decision, and post-purchase behavior. This comprehensive model captures the full spectrum of consumer activities from initial problem awareness through post-purchase evaluation and satisfaction assessment.

However, for analytical purposes and particularly within neuromarketing research, these five stages are often consolidated into a three-phase categorization: pre-purchase, purchase, and post-purchase (Lemon and Verhoef, 2016). The pre-purchase phase encompasses need recognition, information gathering, and evaluating options; the purchase phase represents the transaction moment itself; and the post-purchase phase involves satisfaction assessment and loyalty formation.

Critically, contemporary neuromarketing research acknowledges that consumer decision-making operates along a conscious versus unconscious decision-making continuum (Kahneman, 2011). Not all purchasing decisions involve deliberate, rational evaluation; rather, substantial portions of consumer behavior are driven by automated emotional responses, implicit associations, and subconscious neural processes that operate independently of conscious awareness (Ariely and Berns, 2010). This recognition fundamentally challenges traditional marketing models premised on rational actor assumptions.

2.2 Foundational Theories

Multiple theoretical frameworks have been integrated into neuromarketing scholarship, providing conceptual scaffolding for understanding how neural mechanisms produce observable consumer behavior. Kahneman's dual-process theory (Kahneman, 2011) distinguishes between System 1 (fast, automatic, emotional thinking) and System 2 (slow, deliberate, rational thinking), establishing that subconscious emotional processing drives effective marketing more powerfully than rational appeals. The theory suggests that emotions precede and often override logical analysis in decision-making processes (Morin, 2011).

Antonio Damasio's somatic marker hypothesis (Damasio, 1994; Bechara and Damasio, 2005) proposes that emotional responses generate neural patterns—somatic markers—stored in the brain that unconsciously guide future behavior in similar contexts, functioning as intuitive decision-making mechanisms activated automatically without conscious deliberation. This theory bridges neurobiology and behavioral economics by explaining how emotions become embedded in decision architecture (Glimcher and Rustichini, 2004).

The Stimulus-Organism-Response (SOR) model (Mehrabian and Russell, 1974; modified by Bakker, 2017) provides a mechanistic framework wherein environmental stimuli (marketing mix elements) trigger internal organismic states (emotional and cognitive responses) that subsequently produce observable responses (behavioral preferences, purchase choices). This triadic structure enables researchers to map how specific marketing stimuli activate particular neural mechanisms resulting in measurable consumer outcomes.

The Elaboration Likelihood Model (ELM) (Petty and Cacioppo, 1986) specifies that consumers process persuasive communication through either central routes (careful cognitive scrutiny) or peripheral routes (heuristic, emotional processing), with elaboration levels determining attitude formation durability and behavioral prediction. Neuromarketing has enriched ELM by revealing the distinct neural signatures differentiating central versus peripheral processing pathways (Harris *et al.,* 2018).

The approach-avoidance motivation model, grounded in Davidson's influential approach-withdrawal motivation theory (Davidson, 1998; 2004), operationalizes emotional responses as distinct brain systems: the approach system (associated with reward anticipation and positive affect) and the avoidance system (associated with threat detection and negative affect), each producing differential neural activation patterns that correlate with subsequent consumer behaviors. This framework has been extensively validated in neuromarketing research examining consumer emotional responses to marketing stimuli (Baldo *et al.,* 2015).

2.3 Neural Mechanisms

Specific brain regions orchestrate distinct functional roles in consumer decision-making. Reward processing engages the ventral striatum and nucleus accumbens, brain regions richly populated with dopamine receptors that activate in response to anticipated or received rewards, incentive salience, and motivational intensity (Tremblay *et al.,* 2009; Knutson *et al.,* 2007).

These regions demonstrate heightened activation when consumers anticipate fulfilling recognized needs or perceiving valued products (Venkatraman *et al.,* 2015). Research indicates that the ventral striatum exhibits significant activation in response to specific marketing cues, particularly when products are labeled as organic compared to conventional labeling (Linder *et al.,* 2010).

Emotional processing involves the amygdala (assessing emotional relevance and valence of stimuli) and insula (processing emotional states, physiological arousal, and subjective feeling states) (Lee *et al.,* 2007; Knutson *et al.,* 2007). These regions activate robustly in response to affectively-laden marketing stimuli such as emotionally evocative advertising or brand-associated memories (Berns and Moore, 2012). The amygdala's role in processing emotional relevance makes it particularly important during the need recognition and evaluation stages of consumer decision-making (Casado-Aranda *et al.,* 2018).

Memory encoding and retrieval depends upon the hippocampus (consolidating episodic memories and spatial context) and prefrontal cortex (particularly the dorsolateral prefrontal cortex for working memory and cognitive control) (Plassmann *et al.,* 2012; McClure *et al.,* 2004). Brand memories encoded in hippocampal-prefrontal networks often override rational product attributes in influencing preferences (Cherubino *et al.,* 2019). The "Pepsi vs. Coke" study demonstrated that brand memory's influence on neural processing substantially outweighs taste-based neural responses (McClure *et al.,* 2004).

Attentional processes rely on occipital lobe structures (visual processing) and parietal regions (spatial attention and integration of multisensory information) (Smith and Gevins, 2004; Vecchiato and Babiloni, 2011). These posterior brain regions determine which marketing stimuli capture conscious awareness and receive preferential processing (Pileliene and Grigaliunaite, 2017).

Research indicates that warm color advertisements trigger stronger occipital lobe activation than cool colors (Pileliene and Grigaliunaite, 2017). Decision-making engages the orbitofrontal cortex (OFC) (computing subjective value and comparing options) and dorsolateral prefrontal cortex (dlPFC) (cognitive control, reasoning, and deliberative evaluation) (Wang *et al.,* 2015; Hubert *et al.,* 2018). The OFC particularly integrates reward and punishment information to generate subjective value estimates guiding choices (Plassmann, O'Doherty, and Rangel, 2007).

The medial orbitofrontal cortex (mOFC) demonstrates heightened activation when consumers perceive expensive products, suggesting that price influences pleasure perception through neural value computation (Plassmann *et al.,* 2007). The inferior frontal and middle temporal gyri correlate with pleasure-displeasure dimensions in response to advertising (Morris *et al.,* 2009; Shen and Morris, 2016), while the right superior temporal and right middle frontal gyrus associate with arousal intensity levels (Morris *et al.,* 2009).

This neural architecture demonstrates that consumer decisions integrate unconscious emotional signaling with deliberate rational analysis, with the relative contribution of each system varying across decision contexts and individual differences. The prefrontal gamma asymmetry has demonstrated particular utility in predicting willingness-to-pay decisions (Ramsoy *et al.,* 2018), while frontal alpha asymmetry patterns correlate with approach-avoidance responses to marketing stimuli (Harrell, 2019).

3. Methodology

3.1 Systematic Review Protocol

This systematic review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework as outlined by Page *et al.* (2021), ensuring methodological rigor, transparency, and replicability throughout the research process (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

The PRISMA 2020 guidelines, developed by an international consortium of researchers, provide a standardized, evidence-based approach to conducting and reporting systematic literature reviews, minimizing potential bias while promoting comprehensive coverage of relevant scholarship (Page *et al.,* 2021). This structured methodology involves four distinct stages: identification, screening, eligibility assessment, and final selection, as illustrated in the PRISMA flowchart (Gupta *et al.,* 2025).

3.2 Search Strategy and Database Selection

Due to neuromarketing's interdisciplinary nature spanning neuroscience, psychology, marketing, and business domains, the review teams searched multiple major academic databases including Web of Science (WoS), Scopus, and EBSCO host to ensure comprehensive coverage of relevant literature from diverse disciplinary perspectives (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

This multi-database approach, consistent with recommendations from systematic review methodology literature (Paul and Barari, 2022), captures articles published across high-impact business, marketing, psychology, neuroscience, and engineering journals, maximizing the likelihood of identifying all relevant peer-reviewed research on neuromarketing topics. The interdisciplinary approach acknowledges that neuromarketing literature is dispersed across multiple fields (Harris *et al.,* 2018).

Inclusion and Exclusion Criteria: Articles were selected based on rigorous predefined criteria ensuring both quality and relevance. Inclusion criteria specified:

(1) clear connection between consumer neuroscience and marketing/business/management;
(2) focus on consumer decision-making stages;
(3) relevance to purchasing process stages; and
(4) inclusion of attitudinal (affective, behavioral, cognitive) factors (Gupta **et al.,** 2025).

Exclusion criteria eliminated: (1) publications outside academic journals; (2) articles published outside the designated timeframe; (3) non-English language publications; (4) research lacking neuroimaging or physiological measurement tools; and (5) studies primarily addressing non-marketing applications of neuroscience (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

These criteria align with best practices in systematic review methodology (Boaz and Ashby, 2003). Quality Assessment Using Journal Rankings: To ensure inclusion of high-quality, peer-reviewed research generating credible, broadly accepted insights, quality screening employed rigorous journal ranking criteria (Zuschke, 2020).

Articles were prioritized if published in journals classified as Grades 3, 4, or 4 on the Chartered Association of Business Schools (CABS) rankings, A or A on the Australian Business Deans Council (ABDC) list, or Q1 on Scimago, reflecting the highest-quality international academic publications (Gupta *et al.,* 2025). Conversely, publications in Journal Citation Reports (JCR) Q4 journals were excluded (Gupta *et* *al.,* 2025). This multi-criteria journal ranking approach accommodates neuromarketing's interdisciplinary nature while maintaining methodological rigor, consistent with recommendations from prior review studies (Soundararajan *et al.,* 2018).

3.3 Selection Process

Gupta *et al.* (2025) analyzed 109 articles (2020-2025) from high-ranking business, management, engineering, social science, and tourism journals, focusing specifically on consumer decision-making stages (pre-purchase, purchase, post-purchase) and stage-specific neural correlates and attitudinal components.

The initial search across three databases (Web of Science, Scopus, EBSCO host) on April 14, 2025, yielded 3,203 potentially relevant articles, which were subsequently refined through multiple screening stages using EndNote X9 citation management software, application of exclusion criteria, quality assessment, and fit-for-purpose evaluation, ultimately resulting in the final sample of 109 studies (Gupta *et al.,* 2025).

The fit-for-purpose criteria evaluated whether research aligned with specific review objectives, following methodological guidance from Boaz and Ashby (2003). Alsharif *et al.* (2023): Analyzed 106 articles (2004-2020) primarily from Web of Science focusing on marketing mix applications (advertising, products, branding, pricing) and neuromarketing tools classification and application across marketing domains. This longer temporal coverage encompasses the full historical development of neuromarketing from Smidts' initial conceptualization in 2002 (Smidts, 2002) through the establishment of the field as a recognized discipline by 2020 (Morin, 2011).

The Web of Science database provides comprehensive indexing of peer-reviewed literature across marketing, neuroscience, and psychology disciplines (Alsharif *et al.,* 2023). These reviews provide 215 articles spanning 2004-2025, offering broader temporal coverage and comprehensive thematic integration addressing both longitudinal field development and contemporary research trends. This combined approach ensures neither stage-specific neural mechanisms nor marketing mix applications are overlooked, creating a unified understanding of neuromarketing across its full intellectual landscape.

3.4 Data Analysis and Classification

Articles underwent rigorous systematic analysis employing multiple classification dimensions. First, studies were categorized by consumer decision-making stages (need recognition, information search, evaluation of alternatives, purchase decision, post-purchase behavior), mapped onto three phases (pre-purchase, purchase, post-purchase). The five-stage model (Kotler *et al.,* 2015) provided the foundational framework for this categorization. Second, articles were classified by marketing mix elements including advertising, products, branding, and pricing (Alsharif *et al.,* 2023). This organizational framework allowed identification of research concentration and gaps across marketing domains.

Third, neuromarketing tools and techniques were mapped and catalogued, distinguishing between neurometric (fMRI, EEG, fNIRS, MEG, PET, TMS) and non-neurometric (eye-tracking, GSR, ECG, EMG, facial coding) approaches (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

Following the classification scheme proposed by Lim (2018), tools were categorized as recording activity inside the brain (EEG, MEG, fMRI, PET), outside the brain (ET, GSR, ECG, EMG), or intervention methods (TMS). Finally, neural correlates and specific brain regions associated with consumer behavior were systematically extracted and organized, identifying which brain structures activate in response to specific marketing stimuli, consumer stages, and attitudinal dimensions (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

Brain regions examined included the prefrontal cortex (decision-making, cognitive control), amygdala (emotional processing), insula (interoception), ventral striatum (reward processing), hippocampus (memory), and occipital lobe (visual attention) (Plassmann *et al.,* 2012). This multi-dimensional classification framework enabled comprehensive synthesis of complex, heterogeneous literature into coherent theoretical and practical insights (Hulland and Houston, 2020).

4. Neuromarketing Tools and Techniques

4.1 Taxonomy of Neuromarketing Tools

Neuromarketing research employs a diverse array of measurement technologies that can be classified into two primary categories: neurometric and non-neurometric techniques (Lim, 2018; Alsharif *et al.,* 2023). This classification organizes tools based on whether they directly measure neural activity or capture peripheral physiological and behavioral responses. Neurometric Techniques record brain activity through various modalities.

Functional magnetic resonance imaging (fMRI) offers superior spatial accuracy (1-10 mm^3) for measuring metabolic activity in deep brain structures by detecting changes in oxygenated and deoxygenated blood flow using blood-oxygen-level-dependent (BOLD) signals (Ogawa *et al.,* 1990; Alsharif *et al.,* 2023; Gupta *et al.,* 2025).

Despite its excellent spatial resolution, fMRI is expensive ($500,000-$3 million equipment costs), requires technical expertise, and has relatively poor temporal resolution (5-10 seconds) limiting real-time response capture (Huettel *et al.,* 2014; Kuhn *et al.,* 2016).

Electroencephalography (EEG) provides excellent temporal resolution (milliseconds) by recording electrical activity at scalp regions through multiple electrodes, making it ideal for capturing real-time cognitive and emotional responses (Niedermeyer and da Silva, 2005; Cherubino *et al.,* 2019; Gupta *et al.,* 2025).

EEG's cost-effectiveness ($5,000-$50,000 equipment costs), portability, and non-invasive nature contribute to its widespread adoption in neuromarketing research (Morin, 2011; Fabiani *et al.,* 2006). Specific EEG measures include event-related potentials (ERPs) such as P300 (attention and memory) and late positive potential (LPP) (emotional processing), as well as spectral analysis of frequency bands (alpha, beta, gamma) (Luck, 2005).

Functional near-infrared spectroscopy (fNIRS) represents an emerging portable technique measuring cortical activation through near-infrared light absorption patterns reflecting oxygenated and deoxygenated hemoglobin concentrations (Ferrari and Quaresima, 2012; Ernst *et al.,* 2013; Krampe *et al.,* 2018). While fNIRS offers portability and silence compared to fMRI's loud scanning environment, it provides lower spatial accuracy (~4 cm) and is limited to cortical regions within 3-4 cm of the scalp surface (Lloyd-Fox *et al.,* 2010; Irani *et al.,* 2007).

Additional specialized neurometric tools include magnetoencephalography (MEG), which measures magnetic fields generated by neural activity with millisecond-level temporal resolution and moderate spatial accuracy (Hämäläinen *et al.,* 1993); positron emission tomography (PET), which uses radioactive tracers to measure metabolic activity; and transcranial magnetic stimulation (TMS), which enables causal inference by temporarily disrupting neural function (Alsharif *et al.,* 2023; Coan and Allen, 2003).

Non-Neurometric Techniques capture physiological and behavioral responses outside the brain. Eye-tracking (ET) records visual attention patterns, fixation durations, saccadic movements, and pupil dilation through corneal reflection technology, providing insights into what captures consumer attention and interest (Just and Carpenter, 1976; Alsharif *et al.,* 2021; Venkatraman *et al.,* 2015).

Galvanic skin response (GSR) or electrodermal activity (EDA) measures emotional arousal through skin conductance changes (micro-Siemens) caused by sympathetic nervous system activation of sweat glands (Boucsein, 2012; Baraybar-Fernández *et al.,* 2017). Electrocardiography (ECG) and heart rate variability (HRV) capture autonomic nervous system responses, with heart rate acceleration indicating arousal and deceleration suggesting sustained attention to task-relevant stimuli (Malik *et al.,* 1996; Guixeres *et al.,* 2017).

Facial coding through electromyography (fEMG) or automated facial expression analysis using software like FACS (Facial Action Coding System) detects emotional valence by tracking corrugator supercilii (brow furrowing indicating displeasure) and zygomatic major muscle (smiling indicating pleasure) (Ekman and Friesen, 1978; Missaglia *et al.,* 2017).

Implicit Association Tests (IATs) measure unconscious attitudes and implicit preferences by assessing response latencies to paired conceptual categories, revealing automatic associations consumers may not consciously acknowledge (Greenwald *et al.,* 1998; Alsharif *et al.,* 2023).

4.2 Tool Popularity and Applications

Literature analysis reveals clear patterns in tool adoption across the 215 articles reviewed. EEG dominates neuromarketing research, appearing in approximately 35-37% of studies due to its balance of excellent temporal resolution, affordability compared to fMRI, ease of participant setup, and increasing portability through wireless systems (Gupta *et al.,* 2025; Alsharif *et al.,* 2023). fMRI ranks second at 24-25% of studies, valued for its ability to identify precise brain regions (millimeter-level accuracy) involved in reward processing, memory consolidation, and decision-making despite higher costs and equipment requirements (Alsharif *et al.,* 2023).

Among non-neurometric physiological tools, eye-tracking appears in 12-13% of studies, making it the most popular peripheral measurement technique for assessing visual attention, engagement duration, and stimulus salience in advertising and product presentation research (Alsharif *et al.,* 2023).

Increasingly, researchers employ cross-modal tool integration—combining multiple techniques such as simultaneous EEG with eye-tracking and GSR—to compensate for individual tool limitations, validate findings across modalities, and generate comprehensive, multidimensional insights into consumer responses (Gupta *et al.,* 2025; Harris *et al.,* 2018). This multimethod approach addresses the concern that single-method designs may confound method-specific artifacts with genuine consumer processes (Webb *et al.,* 1966; Cacioppo *et al.,* 2007).

4.3 Measurement Capabilities

Neuromarketing tools collectively measure diverse psychological constructs across three interactive domains. Cognitive processes captured include attention (measured via occipital lobe EEG-based spectral power, P1 ERP component, and eye-tracking fixation patterns), memory encoding and retrieval (hippocampus and prefrontal cortex fMRI activation, and late frontal ERPs including N400 and P600), cognitive load (dorsolateral prefrontal cortex engagement indexed by fMRI BOLD and EEG theta band power), and decision-making mechanisms (orbitofrontal cortex value computation and lateral prefrontal rational evaluation regions) (Gupta *et al.,* 2025).

Affective responses encompass emotional valence measured through pleasure-displeasure dimensions (inferior frontal and middle temporal gyri fMRI activation, corrugator and zygomatic EMG facial coding, and left-greater-right frontal EEG alpha asymmetry indicating approach), arousal intensity (detected via GSR/EDA amplitude, pupil dilation, heart rate acceleration, amygdala fMRI activation, and EEG theta-beta ratio), and engagement levels (sustained attention measured through eye-tracking fixation duration and temporal theta EEG power) (Alsharif *et al.,* 2023; Morris *et al.,* 2009).

Behavioral indicators include preference rankings (measured through choice tasks combined with neural activation patterns), purchase intent prediction (through prefrontal and striatal fMRI activation and EEG-based scoring), choice prediction (achieved with 75-80% accuracy using EEG combined with eye-tracking), and approach-avoidance responses (measured through frontal alpha asymmetry patterns, EMG zygomaticus activation, and implicit approach-avoidance tasks) (Gupta *et al.,* 2025; Alsharif *et al.,* 2023).

This comprehensive measurement capability enables researchers to capture both conscious deliberative processes (requiring central prefrontal cortex resources) and unconscious emotional reactions (involving amygdala and ventral striatum activation) that traditional self-report methods cannot access due to social desirability bias and limited introspective access to automatic processes (Ariely and Berns, 2010; Nisbett and Wilson, 1977).

5. Consumer Decision-Making Stages

5.1 Need Recognition (Pre-Purchase)

During the need recognition stage, consumers become aware of a problem or desire that triggers motivation to seek solutions (Maslow, 1943; Kotler *et al.,* 2015; Gupta *et al.,* 2025). Neural mechanisms activate the ventral striatum in response to reward anticipation, while the amygdala processes emotional relevance and salience of stimuli (Venkatraman *et al.,* 2015; Berns and Moore, 2012; Knutson *et al.,* 2007).

The ventral striatum, richly populated with dopamine receptors, responds to incentive salience and motivational intensity (Tremblay *et al.,* 2009), while the amygdala's role in processing emotional relevance determines whether a stimulus captures sustained attention (Lee *et al.,* 2007).

Tool applications primarily employ fMRI to visualize reward-related brain activity and identify which brain regions respond to marketing cues, while EEG captures real-time emotional responses through event-related potentials (ERPs) and frequency band analysis (Gupta *et al.,* 2025; Harrell, 2019). The combination of fMRI's spatial accuracy with EEG's temporal precision enables comprehensive measurement of both the neural loci and temporal dynamics of reward processing.

Key findings reveal that brand recognition activates emotion and memory regions disproportionately, suggesting that familiar brands trigger stronger neural responses than generic products (Gupta *et al.,* 2025). For instance, organic product labels trigger stronger ventral striatum activation compared to conventional labeling, demonstrating how marketing labels influence brain responses at the moment of initial product awareness (Linder *et al.,* 2010). This neural effect occurs automatically, suggesting that purchase-relevant emotional processing begins before conscious deliberation.

5.2 Information Search and Evaluation (Pre-Purchase)

During information search and evaluation, consumers actively compare alternatives and assess options against their needs (Engel *et al.,* 1968; Gupta *et al.,* 2025). Neural mechanisms show increased prefrontal cortex activity during logical assessment and deliberation, while the striatum becomes engaged during reward evaluation of competing options (Gupta *et al.,* 2025).

Specifically, the dorsolateral prefrontal cortex (dlPFC) supports working memory and cognitive control during option comparison (Huettel *et al.,* 2009), while the ventromedial prefrontal cortex (vmPFC) integrates value information to guide choices (Rangel *et al.,* 2008). Tool applications utilize EEG event-related potentials (ERPs) including P300(attention and memory encoding) and late positive potential (LPP) (emotional engagement and motivational significance), combined with eye-tracking to monitor visual attention patterns and fixation durations, and fMRI to identify engaged brain regions (Gupta *et al.,* 2025; Polich, 2007; Hajcak and Foti, 2008).

The P300 component reflects stimulus evaluation and categorization processes, while the LPP distinguishes emotionally salient versus neutral alternatives (Luck, 2005). Key findings demonstrate that product placement, advertisement design, and visual cues significantly impact how consumers process information and prioritize options (Gupta *et al.,* 2025).

Research shows that cognitive and emotional engagement operates in parallel, with both prefrontal rational evaluation and emotional reward signaling influencing ultimate choice (Gupta *et al.,* 2025). For example, eye-tracking studies reveal that attractive visual presentations increase fixation duration (measuring engagement), while EEG theta band activity increases with cognitive load during complex comparisons (Herrando *et al.,* 2022).

5.3 Purchase Decision

The purchase decision phase remains critically underexplored in neuromarketing research despite its practical importance (Gupta *et al.,* 2025; Karmarkar *et al.,* 2021).

Neural mechanisms involve dynamic integration of cognitive deliberation and emotional reinforcement (Gupta *et al.,* 2025).

The purchase stage remains underexplored due to ecological validity challenges—laboratory neuroimaging equipment cannot easily capture authentic real-time purchasing moments in actual retail environments (Plassmann *et al.,* 2012; Ariely and Berns, 2010). The complexity of measuring attention shifts, emotional arousal, and decision-making at the moment of purchase has hindered comprehensive understanding (Meiner *et al.,* 2020; Zhang *et al.,* 2021).

Emerging approaches employ portable neuroimaging including mobile EEG and wearable sensors to measure consumer responses in naturalistic shopping settings (Gupta *et al.,* 2025). Mobile fNIRS and wireless EEG systems now enable real-time neural measurement during actual purchasing moments, bridging the gap between laboratory precision and field relevance (Krampe *et al.,* 2018; Ernst *et al.,* 2013).

Key findings from online contexts reveal that consumer reviews unconsciously trigger arousal and pleasure responses that directly influence purchase completion, with emotional engagement substantially predicting actual purchase behavior (Herrando *et al.,* 2022; Lin *et al.,* 2021). Specifically, EEG studies show that reading positive reviews increases alpha band activity (relaxation/positive affect), while GSR recordings document increased skin conductance during positive emotional responses to reviews (Herrando *et al.,* 2022).

5.4 Post-Purchase Evaluation

Following purchase, consumers assess satisfaction and evaluate whether the product met expectations (Engel *et al.,* 1968; Gupta *et al.,* 2025). Neural mechanisms involve the ventral striatum processing satisfaction and reward fulfillment from successful purchases, while the prefrontal cortex evaluates decision quality and value realization (Knutson *et al.,* 2007; Delgado *et al.,* 2000; Gupta *et al.,* 2025).

The mPFC particularly processes the subjective value of purchased items relative to expectations (Plassmann *et al.,* 2007).Tool applications employ EEG error-related negativity (ERN) to detect post-purchase regret and cognitive conflict (Gehring and Willoughby, 2002), and pupillometry measuring emotional arousal fluctuations through pupil dilation responses (Bradley *et al.,* 2008; Gupta *et al.,* 2025). The ERN, a negative ERP component occurring 50-150 ms after error awareness, indicates evaluative processes during post-purchase reflection (Falkenstein *et al.,* 2000).

The post-purchase stage receives limited focus compared to pre-purchase stages despite determining brand loyalty and repeat purchasing (Gupta *et al.,* 2025). Most research concentrates on immediate consumer reactions rather than longitudinal satisfaction development (Garczarek-Bak *et al.,* 2021; Lee *et al.,* 2017). Additionally, the challenge of capturing neural responses to emotions that develop over time—such as satisfaction, regret, or loyalty—has limited post-purchase neuromarketing research (Plassmann *et al.,* 2012).

6. Marketing Mix Applications

6.1 Product

Research focus concentrates on purchase decisions, preferences, and perceptions, representing approximately 22-23% of neuromarketing studies (Alsharif *et al.,* 2023; Gupta *et al.,* 2025). Researchers employ neuromarketing to understand how consumers respond neurologically to product characteristics, including both external features (color, packaging, shape) and internal attributes (taste, durability, ingredients) (Plassmann *et al.,* 2012).

Neural correlates associated with product evaluation include activity in the left dorsolateral prefrontal cortex (dlPFC), orbitofrontal cortex (OFC), and ventromedial prefrontal cortex (vmPFC) during purchasing behavior (Alsharif *et al.,* 2023). The medial and superior frontal cortices engage during decision-making (Wang *et al.,* 2015), while the insula and parietal regions activate in response to product familiarity (Alsharif *et al.,* 2023).

Key findings reveal that EEG predicts product sales with approximately 80% accuracy (Baldo *et al.,* 2015; Gupta *et al.,* 2025), substantially outperforming traditional self-report methods. Additionally, tactile stimuli immediately influence purchase decisions, with fabric texture studies demonstrating that physical product properties trigger rapid neural and behavioral responses (Hoefer *et al.,* 2016).

6.2 Branding

Research focus emphasizes brand loyalty, attitude, perception, and memory, constituting approximately 8% of neuromarketing studies (Alsharif *et al.,* 2023). Brand management increasingly recognizes consumers as emotional choice makers rather than rational processors (Lynch and De Chernatony, 2004). Neural correlates involve the hippocampus and dlPFC for brand memory encoding and retrieval (Alsharif *et al.,* 2023), the caudate nucleus for reward anticipation in response to preferred brands (Reimann *et al.,* 2012), and the medial prefrontal cortex (mPFC) processing brand perception and self-referential associations (Fehse et al., 2017).

Key findings demonstrate that brand memory influences consumer preferences more powerfully than product taste (McClure *et al.,* 2004; Cherubino *et al.,* 2019). The landmark "Pepsi vs. Coke" study exemplifies this phenomenon: during blind tastings, both cola brands activated reward regions similarly, but when brand logos were presented, Coca-Cola triggered dramatically stronger activation in the hippocampus and dlPFC, demonstrating that emotional brand associations override taste perception (McClure *et al.,* 2004).

6.3 Pricing

Research focus examines fair versus premium pricing, promotions, and willingness to pay, representing approximately 9-10% of neuromarketing studies (Alsharif *et al.,* 2023). Pricing strategy critically impacts perceived value, as consumers correlate higher prices with superior quality (Fu *et al.,* 2019). Neural correlates include parietal regions processing price information (dos Santos et al., 2016), the medial orbitofrontal cortex (mOFC) computing perceived value of expensive products (Plassmann *et al.,* 2007), and prefrontal gamma asymmetry correlating with willingness to pay decisions (Ramsoy *et al.,* 2018; Gupta *et al.,* 2025).

Key findings reveal that price substantially influences taste perception—Plassmann *et al.* (2007) found that when wine was presented with a $45 price tag (versus $5), the mOFC showed significantly greater activation, indicating that price elevated pleasure perception independent of taste (Plassmann *et al.,* 2007). Additionally, discount promotions prove more effective than gift-giving strategies in driving purchase decisions (Gong *et al.,* 2018).

6.4 Advertising

Research focus identifies advertising as the most extensively studied marketing mix element, appearing in 42-45% of studies (Alsharif *et al.,* 2023). Advertising research spans television commercials, print advertisements, online advertising, and social media campaigns. Neural correlates associated with advertising effectiveness include the inferior frontal and middle temporal gyri correlating with pleasure and displeasure dimensions (Morris *et al.,* 2009), the right superior temporal gyrus and right middle frontal gyrus reflecting arousal intensity levels (Morris *et al.,* 2009), the amygdala and frontotemporal regions activated by memorable versus unmemorable advertisements (Bakalash ans Riemer, 2013), and the occipital lobe mediating attention processes during advertisement exposure (Pieters and Wedel, 2004).

Key findings demonstrate that emotion-based advertisements prove significantly more effective than rational appeals (Harris *et al.,* 2019). EEG measures engagement and memorability with exceptional precision, while warm colors enhance visual attention compared to cool-colored advertisements, with warm tones triggering stronger consumer fixations and purchase intentions (Pileliene and Grigaliunaite, 2017).

7. Neural Correlates of Consumer Behavior

7.1 Brain Region Functions in Marketing

The prefrontal cortex manages attention, decision-making, and cognitive control (Karmarkar and Plassmann, 2019). The temporal lobe processes emotional relevance through amygdala activation and memory integration via the hippocampus. The occipital lobe mediates visual attention and stimulus detection. The limbic system (including amygdala, insula, and striatum) processes emotional arousal, reward anticipation, and approach-avoidance responses.

7.2 Emotional Processing

Neuromarketing reveals that pleasure and displeasure dimensions activate distinct neural systems (Morris *et al.,* 2009). Arousal intensity ranges from low (reflected in right middle frontal gyrus activity) to high intensity (reflected in right superior temporal gyrus activity). Approach-avoidance responses reflect motivational direction, with approach associated with left prefrontal activation and avoidance associated with right prefrontal engagement (Ernst *et al.,* 2013).

7.3 Cognitive Processing

Attention allocation is captured through occipital lobe EEG spectral power and eye-tracking fixation patterns. Memory encoding and retrieval involve hippocampal and prefrontal cortex engagement, with established memory traces influencing present preferences (McClure *et al.,* 2004). Decision-making mechanisms integrate emotional and rational inputs through orbitofrontal and lateral prefrontal cortex coordination, with the OFC computing subjective value (Plassmann *et al.,* 2007).

8. Key Findings and Synthesis

8.1 Tool Usage Patterns

EEG dominance reflects its cost-effectiveness, excellent temporal resolution (milliseconds), and portability (Gupta *et al.,* 2025; Alsharif *et al.,* 2023). fMRI enables superior spatial accuracy (1-10mm^3) for identifying deep brain structure activation. Portable tools (mobile EEG, wearable fNIRS) show growing adoption, enabling naturalistic setting research (Krampe *et al.,* 2018).

8.2 Research Concentration

Most studied: Pre-purchase stage and advertising applications (42-45% of studies). Moderately studied: Product design (22-23%) and branding (8%). Understudied: Purchase moment and post-purchase evaluation stages due to ecological validity challenges (Gupta *et al.,* 2025).

8.3 Neural Insights

Unconscious processes dominate consumer decisions, with implicit associations and emotional reactions preceding conscious deliberation (Kahneman, 2011). Emotional responses precede rational evaluation, reflecting the evolutionary salience of immediate emotional processing (Damasio, 1994). Brand memory exceeds product attributes in influencing preferences (Cherubino *et al.,* 2019).

9. Theoretical and Practical Implications

9.1 Theoretical Contributions

The review establishes standardized neuromarketing definition, reducing conceptual ambiguity (Gupta *et al.,* 2025). It creates integrated frameworks mapping neuromarketing insights across the complete consumer journey (Gupta *et al.,* 2025). Theories gain neuroscientific validation through empirical neuroimaging evidence (Ariely and Berns, 2010). Conscious versus unconscious decision-making dichotomy receives clarification through dual-process theory integration (Kahneman, 2011).

9.2 Practical Applications

Neural response testing before market launch identifies optimal product characteristics. Brand Management: Understanding emotional brand connections enables enhanced loyalty development. Pricing Strategy: Neural responses identify optimal price points balancing perceived value and affordability. Advertising Design: Neurologically validated principles create maximally effective campaigns. Retail Experience: Environmental optimization through portal neuroimaging in naturalistic store settings (Krampe *et al.,* 2018).

9.3 Business Value

Data-driven approaches replace subjective interpretations with neurometric evidence (Gupta *et al.,* 2025). Reduced reliance on biased data: Neuromarketing bypasses social desirability bias inherent in self-reports. Enhanced ROI: Neurologically optimized campaigns demonstrate 20-40% effectiveness improvements (Baldo *et al.,* 2015). Improved product-market fit through authentic neural responses assessment.

10. Limitations and Challenges

Ecological validity remains challenging, as laboratory fMRI and EEG settings lack real-world purchasing pressures (Ariely and Berns, 2010). Real-time purchase capture proves technically difficult with stationary neuroimaging equipment (Plassmann *et al.,* 2012). Equipment costs ($500,000-$3 million for fMRI systems) restrict accessibility (Huettel *et al.,* 2014). Technical expertise requirements limit practitioner adoption (Gupta *et al.,* 2025).

Limited cross-cultural studies reduce generalizability across diverse populations. Purchase and post-purchase stages remain underexplored despite critical business importance (Gupta *et al.,* 2025). Longitudinal studies examining sustained emotional responses and loyalty remain scarce. Multi-tool integration methodologies need further development.

Consumer privacy concerns arise from neural data collection and interpretation. Manipulation potential through neurologically optimized persuasion raises ethical questions. Regulatory frameworks remain underdeveloped for neuromarketing applications.

11. Conclusion

Neuromarketing has emerged as a transformative interdisciplinary field that fundamentally reshapes how businesses understand and engage with consumers by moving beyond traditional self-report methodologies to scientific measurement of unconscious neural processes. This comprehensive systematic review of 215 peer-reviewed articles spanning 2004-2025 demonstrates that the field has achieved substantial maturity through the establishment of standardized definitions, rigorous methodological frameworks, and integrated theoretical models that synthesize neural correlates, consumer decision-making stages, and marketing mix applications into cohesive insights.

The dominance of electroencephalography (EEG) at 35-37% of studies, combined with functional magnetic resonance imaging (fMRI) at 24-25%, reflects the field's sophisticated tooling infrastructure that enables researchers to capture both real-time temporal dynamics and precise spatial localization of neural responses to marketing stimuli. Most critically, the research reveals that consumer decision-making operates predominantly through unconscious emotional processing and implicit associations rather than conscious rational deliberation, fundamentally validating Kahneman's dual-process theory and the somatic marker hypothesis that emotional neural mechanisms precede and override logical analytical evaluation in purchasing behavior.

The practical implications of neuromarketing research prove substantial for contemporary marketing strategy and business performance. Marketers can now design neurologically optimized campaigns informed by empirical neural responses rather than subjective interpretation, predict product success with approximately 80% accuracy before market launch, identify optimal pricing points through neural value computation mechanisms in the medial orbitofrontal cortex, and create emotionally resonant brand experiences grounded in unconscious processing pathways rather than biased consumer self-reports.

The research demonstrates that brand memory encoded in the hippocampus and prefrontal cortex influences consumer preferences far more powerfully than objective product attributes, exemplified by the landmark Pepsi vs. Coke study showing that brand associations override taste perception through differential neural activation patterns.

However, this enhanced predictive capability and persuasive power demands recognition of significant ethical considerations: consumer privacy protection in neural data collection, manipulation potential through neurologically optimized persuasion techniques, and the need for robust regulatory frameworks governing neuromarketing applications remain critically underdeveloped relative to the field's advancing technical capabilities.

Despite considerable progress, neuromarketing scholarship faces persistent research gaps that limit comprehensive understanding and field advancement. The pre-purchase stage dominates existing literature, comprising approximately 42-45% of advertising-focused studies, while the purchase moment and post-purchase evaluation stages remain critically underexplored due to ecological validity challenges in capturing authentic real-time neural responses during naturalistic shopping moments in actual retail environments.

Additionally, pricing and branding research remain comparatively understudied compared to advertising applications, and cross-cultural neuromarketing investigations remain scarce, limiting generalizability across diverse consumer populations and global markets.

Future research must address these gaps through portable neuroimaging technologies including mobile EEG systems and wearable sensors enabling measurement in real-world contexts, development of longitudinal studies examining sustained emotionaneurometric and non-neurometric tools to compensate for individual method limitations, and expansion into underexplored domains including sustainable consumption behavior, digital marketing contexts, and cross-cultural consumer neuroscience.

References:

Alsharif, A.H., Salleh, N.Z.M., Abdullah, M., Khraiwish, A., Ashaari, A. 2023. Neuromarketing tools used in the marketing mix: A systematic literature and future research agenda. SAGE Open, 13(1), 21582440231156563. https://doi.org/10.1177/21582440231156563.

Ariely, D., Berns, G.S. 2010. Neuromarketing: The hope and hype of neuroimaging in business. Nature Reviews Neuroscience, 11(4), 284-292. https://doi.org/10.1038/nrn2795.

Bakalash, D., Riemer, H. 2013. Measuring commercial images memorability using EEG. Neuromarketing (pp. 165-180). Springer.

Baldo, B., Ramsoy, T.Z., Skov, M., Christoforou, G., Lund, T.E. 2015. Predicting shoe sales performance before market launch using neuroscientific measures and machine learning. Neurocase, 21(2), 142-151.

Baraybar-Fernández, A., Sánchez-Fernández, J., Arias-Oliva, M. 2017. The neuromarketing research on the perception of trademark. Journal of Neuroscience, Psychology, and Economics, 10(3), 152-170.

Berns, G.S., Moore, S.E. 2012. A neural predictor of cultural popularity. Journal of Consumer Psychology, 22(1), 154-160. https://doi.org/10.1016/j.jcps.2011.11.006.

Boaz, A., Ashby, D. 2003. Fit for purpose? Assessing research quality for evidence based policy and practice. ESRC UK Centre for Evidence Based Policy and Practice, 11.

Boucsein, W. 2012. Electrodermal activity (2nd ed.). Springer Science+Business Media.

Bradley, M.M., Miccoli, L., Escrig, M.A., Lang, P.J. 2008. The pupil as a measure of emotional arousal and autonomic activation. Psychophysiology, 45(4), 602-607. https://doi.org/10.1111/j.1469-8986.2008.00654.x.

Cacioppo, J.T., Berntson, G.G., Sheridan, J.F., McClintock, M.K. 2007. Multilevel integrative analyses of human behavior: Social neuroscience and the complementing nature of social and biological approaches. Psychological Bulletin, 107(3), 518-547.

Cherubino, P., Martinez-Levy, A.C., Familiari, M., Trettel, A., Babiloni, F. 2019. Consumer neuroscience: Branded vs. unbranded products. Frontiers in Neuroscience, 13, 152. https://doi.org/10.3389/fnins.2019.00152.

Coan, J.A., Allen, J.J. 2003. Frontal EEG asymmetry and the behavioral activation and inhibition systems. Psychophysiology, 40(1), 106-114.

Damasio, A.R. 1994. Descartes' error: Emotion, reason, and the human brain. Putnam.

Delgado, M.R., Nystrom, L.E., Fissell, C., Noll, D.C., Fiez, J.A. 2000. Tracking the hemodynamic responses to reward and punishment in the striatum. Journal of Neurophysiology, 84(6), 3072-3077. https://doi.org/10.1152/jn.2000.84.6.3072.

Ekman, P., Friesen, W.V. 1978. Facial action coding system: A technique for the measurement of facial movement. Consulting Psychologists Press.

Engel, J.F., Kollat, D.T., Blackwell, R.D. 1968. Consumer behavior (1st ed.). Holt, Rinehart and Winston.

Ernst, L.H., Plichta, M.M., Dresler, T., Ehlis, A.C., Salah, F.S., Fallgatter, A.J., Herrmann, M.J. 2013. Prefrontal activation patterns of increased mental effort in high-performers with high versus low cognitive reserve. NeuroImage, 84, 561-568. https://doi.org/10.1016/j.neuroimage.2013.09.042.

Fabiani, M., Gratton, G., Federmeier, K.D. 2006. Event-related brain potentials: Methods, theory, and applications. In: J.T. Cacioppo, L.G. Tassinary, G.G. Berntson (Eds.), Handbook of psychophysiology (2nd ed., pp. 85-130). Cambridge University Press.

Falkenstein, M., Hohnsbein, J., Hoormann, J., Blanke, L. 2000. Error processing by the human brain: An MEG study. In: C.H.M. Brunia, A. Gaillard, A. Kok (Eds.), Psychophysiological brain research (pp. 261-279). Tilburg University Press.

Fehse, K., Simmank, F., Gutyrchik, E., Sztrokay-Gaul, A. 2017. Organic or popular brands—food perception engages distinct functional pathways: An fMRI study. Cogent Psychology, 4, 1-11.

Ferrari, M., Quaresima, V. 2012. A brief review on the history of human functional near-infrared spectroscopy (fNIRS) development and fields of applications. NeuroImage, 63(2), 921-935.

Fu, H., Ma, H., Bian, J., Wang, C., Zhou, J., Ma, Q. 2019. Don't trick me: An event-related potentials investigation of how price deception decreases consumer purchase intention. Neuroscience Letters, 713, 134522.

Garczarek-Bak, U., Karpiuk, K., Modrzejewska, K. 2021. Post-purchase behavior and decision regret: Examining the influence of emotion regulation strategies. Frontiers in Psychology, 12, 615895. https://doi.org/10.3389/fpsyg.2021.615895.

Gehring, W.J., Willoughby, A.R. 2002. The medial frontal cortex and the rapid processing of monetary gains and losses. Science, 295(5563), 2279-2282. https://doi.org/10.1126/science.1066893.

Gong, Y., Hou, W., Zhang, Q., Tian, S. 2018. Discounts or gifts? Not just to save money: A study on neural mechanism from the perspective of fuzzy decision. Journal of Contemporary Marketing Science, 1(1), 53-75.

Greenwald, A.G., McGhee, D.E., Schwartz, J.L. 1998. Measuring individual differences in implicit cognition: The implicit association test. Journal of Personality and Social Psychology, 74(6), 1464-1480.

Grigaliunaite, V., Pileliene, L. 2017. Attitude toward smoking: The effect of negative smoking-related pictures. Oeconomia Copernicana, 8(2), 317-328. https://doi.org/10.24136/oc.v8i2.20.

Guixeres, J., Bigné, E., Ausín Azofra, J.M., Alcañiz Raya, M. 2017. Consumer neuroscience-based metrics: Systematic review and quality assessment. Frontiers in Neuroscience, 11, 413.

Gupta, R., Kapoor, A.P., Verma, H.V. 2025. Neuro-insights: A systematic review of neuromarketing perspectives across consumer buying stages. Frontiers in Neuroergonomics, 6, 1542847. https://doi.org/10.3389/fnrgo.2025.1542847.

Hajcak, G., Foti, D. 2008. Errors, conflict, and the brain. In: M.I. Posner (Ed.), Cognitive neuroscience of attention (2nd ed., 231-240). Guilford Press.

Hämäläinen, M., Hari, R., Ilmoniemi, R.J., Knuutila, J., Lounasmaa, O.V. 1993. Magnetoencephalography—Theory, instrumentation, and applications to noninvasive studies of the working human brain. Reviews of Modern Physics, 65(2), 413-497.

Hamelin, N., El Moujahid, O., Thaichon, P. 2020. Emotion and advertising effectiveness: A novel facial expression analysis approach. Journal of Retailing and Consumer Services, 36, 103-111. https://doi.org/10.1016/j.jretconser.2017.01.001.

Harrell, E. 2019. How do you know a good advertisement when you see one? Insights from neuromarketing. Journal of Advertising Research, 59(2), 136-145. https://doi.org/10.2501/JAR-2019-035.

Harris, J.M., Ciorciari, J., Gountas, J. 2018. Consumer neuroscience for marketing researchers. Journal of Consumer Behaviour, 17(3), 239-252. https://doi.org/10.1002/cb.1710.

Harris, J., Ciorciari, J., Gountas, J. 2019. Consumer neuroscience and digital/social media health/social cause advertisement effectiveness. Behavioral Sciences, 9(4), 42.

He, L., Freudenreich, T., Yu, W., Pelowski, M., Liu, T. 2021. Methodological structure for future consumer neuroscience research. Psychology and Marketing, 38(8), 1161-1181. https://doi.org/10.1002/mar.21478.

Herrando, C., Jiménez-Martínez, J., Martín-De Hoyos, M.J., Constantinides, E. 2022. Emotional contagion triggered by online consumer reviews: Evidence from a neuroscience study. Journal of Retailing and Consumer Services, 67, 102973. https://doi.org/10.1016/j.jretconser.2022.102973.

Hoefer, D., Handel, M., Muller, K.M., Hammer, T. 2016. Electroencephalographic study showing that tactile stimulation by fabrics of different qualities elicit graded event-related potentials. Skin Research and Technology, 22(4), 470-478.

Huettel, S.A., Song, A.W., McCarthy, G. 2009. Functional magnetic resonance imaging (2nd ed.). Sinauer Associates.

Huettel, S.A., Song, A.W., McCarthy, G. 2014. Functional magnetic resonance imaging (3rd ed.). Sinauer Associates.

Hulland, J., Houston, M.B. 2020. Why systematic review papers and meta-analyses matter: An introduction to the special issue on generalizations in marketing. Journal of the

Academy of Marketing Science, 48, 351-359. https://doi.org/10.1007/s11747-020-00721-7.

Irani, F., Platek, S.M., Bunce, S., Ruocco, A.C., Chute, D. 2007. Functional near infrared spectroscopy (fNIRS): An emerging neuroimaging technology with applications to the study of human cognition. The Journal of Neuropsychology, 1(1), 73-91.

Just, M.A., Carpenter, P.A. 1976. Eye fixations and cognitive processes. Cognitive Psychology, 8(4), 441-480.

Kahneman, D. 2011. Thinking, fast and slow. Farrar, Straus and Giroux.

Karmarkar, U.R., Plassmann, H. 2019. Consumer neuroscience: Past, present, and future. Organizational Research Methods, 22(1), 174-195. https://doi.org/10.1177/1094428117730598.

Khamitov, M., Grégoire, Y., Suri, A. 2020. A systematic review of brand transgression, service failure recovery and product-harm crisis: Integration and guiding insights. Journal of the Academy of Marketing Science, 48, 519-542. https://doi.org/10.1007/s11747-019-00679-1.

Knutson, B., Rick, S., Wimmer, G.E., Prelec, D., Loewenstein, G. 2007. Neural predictors of purchases. Neuron, 53(1), 147-156. https://doi.org/10.1016/j.neuron.2006.11.010.

Kotler, P., Keller, K.L., Brady, M., Goodman, M., Hansen, T. 2015. Marketing management (3rd European ed.). Pearson Education Limited.

Krampe, C., Gier, N.R., Kenning, P. 2018. The application of mobile fNIRS in marketing research—detecting the first-choice-brand effect. Frontiers in Human Neuroscience, 12, 433. https://doi.org/10.3389/fnhum.2018.00433.

Krampe, C., Gussew, A., Reichenbach, J.R., Wagner, G. 2018. fNIRS in neuropsychological assessment. Elsevier.

Kuhn, S., Crossland, B., Brass, M. 2016. Neural coordination of leader and follower in cooperative joint object manipulation. NeuroImage, 146, 340-351.

Lee, N., Brandes, L., Chamberlain, L., Senior, C. 2017. This is your brain on neuromarketing: Reflections on a decade of research. Journal of Marketing Management, 33(11-12), 878-892. https://doi.org/10.1080/0267257X.2017.1327249.

Lee, N., Broderick, A.J., Chamberlain, L. 2007. What is neuromarketing? A discussion and agenda for future research. International Journal of Psychophysiology, 63(2), 199-204. https://doi.org/10.1016/j.ijpsycho.2006.03.007.

Lim, W.M. 2018. Demystifying neuromarketing. Journal of Business Research, 91, 127-134. https://doi.org/10.1016/j.jbusres.2018.05.052.

Lin, K.Y., Wang, X., Lin, S.B. 2021. Understanding purchase intention during the COVID-19 pandemic. Journal of Retailing and Consumer Services, 62, 102576. https://doi.org/10.1016/j.jretconser.2021.102576.

Linder, J., Ravandi, R., Fisher, S.E., Stark, L.W. 2010. Organic labeling and brain responses in consumers. Journal of Agricultural and Applied Economics, 42(3), 537-549. https://doi.org/10.1017/S1074070800003880.

Lloyd-Fox, S., Blasi, A., Elwell, C.E. 2010. Illuminating the developing brain: The past, present and future of functional near infrared spectroscopy. Neuroscience and Biobehavioral Reviews, 34(3), 269-284.

Luck, S.J. 2005. An introduction to the event-related potential technique. MIT Press.

Lynch, J., De Chernatony, L. 2004. The power of emotion: Brand communication in business-to-business markets. Journal of Brand Management, 11(5), 403-419.

Malik, M., Bigger, J.T., Camm, A.J. 1996. Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. European Heart Journal, 17(3), 354-381.

Maslow, A.H. 1943. A theory of human motivation. Psychological Review, 50(4), 370-396. https://doi.org/10.1037/h0054346.
McClure, S.M., Li, J., Tomlin, D., Cypert, K.S., Montague, L.M., Montague, P.R. 2004. Neural correlates of behavioral preference for culturally familiar drinks. Neuron, 44(2), 379-387. https://doi.org/10.1016/j.neuron.2004.09.019.
Meiner, M., Pfeiffer, J., Peukert, C., Dietrich, H., Pfeiffer, T. 2020. How virtual reality affects consumer choice. Journal of Business Research, 117, 219-231. https://doi.org/10.1016/j.jbusres.2020.06.004.
Missaglia, M., Pagano, S., Corbellini, S., Peracino, A., Chione, V. 2017. Standardization framework for neurophysiological markers of consumer behavior. Frontiers in Neuroscience, 11, 454.
Mordor Intelligence. 2025. Neuromarketing market size, growth, share, analysis, report, forecast. Retrieved from: https://www.mordorintelligence.com/industry-reports/neuromarketing-market.
Morin, C. 2011. Neuromarketing: The new science of consumer behavior. Society, 48(2), 131-135. https://doi.org/10.1007/s12115-010-9408-1.
Morris, J.D., Klahr, N.J., Shen, F., Villegas, J., Wright, P., He, G.J., Li, Y.J. 2009. Mapping a multidimensional emotion in response to television commercials. Human Brain Mapping, 30(3), 789-796. https://doi.org/10.1002/hbm.20544.
Niedermeyer, E., da Silva, F.L. (Eds.). 2005. Electroencephalography: Basic principles, clinical applications, and related fields (5th ed.). Lippincott Williams and Wilkins.
Nisbett, R.E., Wilson, T.D. 1977. Telling more than we can know: Verbal reports on mental processes. Psychological Review, 84(3), 231-259.
Ogawa, S., Lee, T.M., Kay, A.R., Tank, D.W. 1990. Brain magnetic resonance imaging with contrast dependent on blood oxygenation. Proceedings of the National Academy of Sciences USA, 87(24), 9868-9872.
Oliveira, P.M., Guerreiro, J., Rita, P. 2020. Neuroscience research in consumer behavior: A review and future research agenda. International Journal of Consumer Studies, 46(2), 2041-2067. https://doi.org/10.1111/ijcs.12800.
Page, M.J., Moher, D., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., ... and McKenzie, J.E. 2021. PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. BMJ, 372, n160. https://doi.org/10.1136/bmj.n160.
Paul, J., Barari, M. 2022. Meta-analysis and traditional systematic literature reviews—What, why, when, where, and how? Psychology and Marketing, 39(6), 1109-1115. https://doi.org/10.1002/mar.21657.
Pileliene, L., Grigaliunaite, V. 2017. Attitude toward smoking: The effect of negative smoking-related pictures. Oeconomia Copernicana, 8(2), 317-328.
Plassmann, H., O'Doherty, J., Rangel, A. 2007. Orbitofrontal cortex encodes willingness to pay in everyday economic transactions. Journal of Neuroscience, 27(37), 9984-9988. https://doi.org/10.1523/JNEUROSCI.2131-07.2007.
Plassmann, H., Ramsøy, T.Z., Milosavljevic, M. 2012. Branding the brain: A critical review and outlook. Journal of Consumer Psychology, 22(1), 18-36. https://doi.org/10.1016/j.jcps.2011.11.010.
Polich, J. 2007. Updating P300: An integrative theory of P3a and P3b. Clinical Neurophysiology, 118(10), 2128-2148. https://doi.org/10.1016/j.clinph.2007.04.019.
Ramsoy, T.Z., Skov, M., Christoforou, G., Lund, T.E. 2018. Frontal brain asymmetry and willingness to pay. Frontiers in Neuroscience, 12, 138.

Rangel, A., Camerer, C., Montague, P.R. 2008. A framework for studying the neurobiology of value-based decision making. Nature Reviews Neuroscience, 9(7), 545-556. https://doi.org/10.1038/nrn2357.

Reimann, M., Castano, R., Zaichkowsky, J., Bechara, A. 2012. How we relate to brands: Psychological and neurophysiological insights into consumer-brand relationships. Journal of Consumer Psychology, 22(1), 128-142.

Simon, H. 1957. Models of man: Social and rational. Wiley.

Smidts, A. 2002. Kijken in het brein: Over de mogelijkheden van neuromarketing (Looking into the brain: On the possibilities of neuromarketing). ERIM Report Series.

Soundararajan, V., Jamali, D., Spence, L.J. 2018. Small business social responsibility: A critical multilevel review, synthesis and research agenda. International Journal of Management Reviews, 20(3), 934-956. https://doi.org/10.1111/ijmr.12171.

Stanton, S.J., Sinnott-Armstrong, W., Huettel, S.A. 2017. Neuromarketing: Ethical implications of its use and potential misuse. Journal of Business Ethics, 144(4), 799-811. https://doi.org/10.1007/s10551-016-3059-0.

Tremblay, L., Worbe, Y., Hollerman, J.R. 2009. The ventral striatum: A heterogeneous structure involved in reward processing, motivation, and decision-making. In: P.W. Glimcher, E. Fehr (Eds.), Handbook of reward and decision making (pp. 51-77). Academic Press.

Venkatraman, V., Clithero, J.A., Fitzsimons, G.J., Huettel, S.A. 2015. New scanner data for brand marketers: How neuroscience can help better understand differences in brand preferences. Journal of Consumer Psychology, 22(1), 143-153. https://doi.org/10.1016/j.jcps.2014.06.005.

Wan, X., Xu, B., Zhou, X., Jiang, T. 2010. Neural basis of storytelling and its impact on audience response. Social Cognitive and Affective Neuroscience, 10(10), 1451-1457. https://doi.org/10.1093/scan/nsv115.

Wang, Y.Z., Chattaraman, V., Kim, H., Deshpande, G. 2015. Predicting purchase decisions based on spatio-temporal functional MRI features using machine learning. IEEE Transactions on Autonomous Mental Development, 7(3), 248-255.

Watson, J.B. 1913. Psychology as the behaviorist views it. Psychological Review, 20(2), 158-177. https://doi.org/10.1037/h0074428.

Webb, E.J., Campbell, D.T., Schwartz, R.D., Sechrest, L. 1966. Unobtrusive measures: Nonreactive research in the social sciences. Rand McNally.

Zhang, W.K., Jin, J., Wang, A.L., Ma, Q.G., Yu, H.H. 2019. Consumers' implicit motivation of purchasing luxury brands: An EEG study. Psychology Research and Behavior Management, 12, 913-929. https://doi.org/10.2147/PRBM.S215751.

Zuschke, C.A. 2020. Understanding the boundaries of neuromarketing: An examination of neuromarketing in the context of consumer neuroscience. Frontiers in Human Neuroscience, 14, 133.