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A NARRATIVE REVIEW OF NEUROMARKETING TECHNIQUES FOR ELEVATING CONSUMER ENGAGEMENT IN VIRTUAL REALITY SHOPPING ENVIRONMENTS

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Abstract:

In the context of the shift from spatial e-commerce to immersive virtual reality (VR) experiences, the interpreting of non-conscious consumer processes in terms of visual attention distribution, cognitive load, emotional arousal, and behavioral response becomes essential for developing effective strategies in retail. Nevertheless, the present body of knowledge lacks cohesion since the prior review literature fails to propose a continuum between the factors of VR spatial design, neuromarkers of consumer reaction in real-time, decision-making by consumers, and ethical guidelines for managing the latter. To address this multidimensional problem, the following narrative review provides a qualitative synthesis of the empirical and theoretical literature published in the Scopus database during 2021-2025. The literature review is conducted within four principal themes, namely neuromarkers of VR shoppers' reactions, decoding through neuroimaging and biometrics, visual attention and spatial ergonomics through eye-tracking technology, multisensory immersion and social presence, and AI-driven neuro-adaptive retailing. The synthesis reveals that multimodal physiological measurement, such as concurrent electroencephalography, functional near-infrared spectroscopy, and eye-tracking, can offer more complex and possibly more accurate measures of cognitive states changes than traditional self-reports. At the same time, there exists a tension that, while multisensory immersion through high-fidelity cues and virtual touch improves the psychological telepresence of shoppers, uncalibrated environmental complexity may cause extraneous cognitive load. The present paper contributes a

framework that maps out the characteristics of VR rendering and interactions to the intermediate processes and final consumer outcomes, thus providing a structure for development of spatial-ergonomic principles. In addition, the present review tackles the issues of ethics and governance related to neural data privacy, informed consent, data ownership, mental states inference, and reuse of the secondary data.

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Consumer Engagement, Consumer Neuroscience, Immersive Retail, Neuromarketing, Virtual Reality Shopping.



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Introduction

The combination of immersive virtual reality (VR) technology and advanced business methods has dramatically changed the world of modern retail, changing digital storefronts from static platforms to an interactive and spatial environment. Alongside the movement of the world of global commerce to spatial commerce, understanding of consumers' behavior necessitates overcoming limitations of post-hoc self-reporting measures such as surveys and focus groups, which fail to measure fleeting and unconscious psychological processes involved in human actions in the digital environment. As a response to this challenge, consumer neuroscience provides an approach to assess the implicit mental processing of attentional allocation, cognitive workload, arousal, valence, and implicit navigation behaviors. By capturing the physiological and neuroimaging measures of human body, scientists aim to understand better how humans evaluate sensory input, navigate 3D spaces, and make purchasing decisions (Arora, 2024; Singh et al., 2026; Taneja et al., 2024).

Despite rapid advances in commercial VR and physiologically passive biometrics, academic literature on neuro-centered marketing for spatial retail is noticeably fragmented, lacking an overarching theory that would integrate engineering, physiology, psychology and policy perspectives. Existing review papers tend to consider these areas separately: computer engineering focuses on the optics and graphics of headsets and not subconsciously exerted mental effort; psychology of retail considers conventional behavioral responses with the help of retrospective questionnaires; consumer neuroscience explores individual tools of biometry without grounding them into 3D store environment. Besides that, real-life data sampling is unevenly represented in various commercial sectors and tends to be strongly biased towards luxury home furnishing (Bigne et al., 2024) and interaction with the objects (Alipour et al., 2026), leaving other types of retail out of consideration. Moreover, theoretical conceptualization problems exist as well: core concepts like "engagement," "immersion,"

"presence" and "arousal" are often interchangeably used within literature on brain imaging, machine vision and marketing. In addition, methodological implementation is different too – from lab conditions with brain wave measuring and brain optical imaging when performing common tasks (Liu et al., 2025) to automated algorithmic tracking (Bucea-Manea-Țoniș et al., 2026). Therefore, there is an obvious gap in research related to connecting choices made in designing virtual spaces (visual realism, haptic feedback etc.) with real-time brain activity (brain wave band power, eye-tracking) and buyer behavior, as well as mandatory regulations required for ethical governance of such biometric systems (Sujatha et al., 2026).

It is essential to state that methodological and conceptual fragmentation creates a formidable obstacle for science and commercialization. The lack of synthesis of how different neuromarketing techniques function in a VR environment prevents scientists from validating their findings by comparing them in various environments. For example, although sensory input technologies such as virtual touch may greatly increase immersion and satisfaction (Xionghui et al., 2025), complicated VR environments tend to cause cognitive overload, which results in reduced satisfaction and consumer's inability to make a decision (Alipour et al., 2026). At the same time, although eye-tracking measures provide a detailed mapping of consumers' attention patterns according to intrinsic and extrinsic store stimuli (Bigne et al., 2024), their integration with machine vision algorithms (Cuțitoi, 2022) or quantum AI approaches (Babu et al., 2024) raises the problem of analytical inconsistency. Furthermore, new developments in the field of VR such as multi-user collaboration in VR shopping (Liu et al., 2025) or implicit trait detection through recognition of impulsive behavior in VR (Moghaddasi et al., 2021) stress the need to address these problems.

For addressing these crucial gaps, there is an urgent need for a detailed narrative synthesis for bringing together the present empirical evidence, resolving the terminological inconsistencies and understanding how neuromethodologies could systematically enhance consumer engagement. Thus, the main objective of the present narrative review is to critically evaluate and synthesize the present-day neuromarketing methods including neuroimaging, eye tracking, biometric sensing and advanced data analytics through artificial intelligence that drive consumer engagement in virtual reality retailing.

In order to accomplish this objective, the rest of this paper will be divided into five unique sections. First, the subsequent section outlines the specific neuroimaging and biometrics techniques used in virtual reality applications, highlighting their relevant metrics and psychological indicators. Second, this review summarizes various sensory and environmental factors that motivate consumer engagement, focusing on visual perception, haptic interaction, and social aspects in virtual stores. Then, a critical assessment is provided of the application of artificial intelligence, machine vision, and sensor analytics in order to adapt and recognize behaviors in the virtual environment. After this, a unifying framework is proposed to address the existing disconnect between theory and application in this industry, in addition to discussing the current ethical and methodological issues.

Review Approach

For synthesizing prior empirical and theoretical studies on the use of neuromarketing in VR retail, a narrative synthesis approach has been employed. Narrative synthesis allows for a malleable and conceptually rich framework for combining literature from different disciplines, reconciling methodological differences, and contextualizing new technology paradigms

without having to fulfill the rigorous criteria of systematic meta-analysis (Gupta, 2025). Unlike a meta-analysis, which attempts to provide an extensive coverage of relevant literature, this review hopes to offer an insight into recent trends.

For the purpose of selecting literature, the Scopus database was used to identify peer-reviewed journals from the areas of marketing, computer science, and neuroscience. The period covered by this literature ranged between January 2021 and December 2025 to account for current technological improvements in terms of virtual reality devices and sensors used on consumers. The following Boolean string was employed:

("neuromarketing" OR "consumer neuroscience" OR "brain imaging" OR "neural marketing") AND ("virtual reality" OR "vr" OR "immersive technology" OR "simulated environment") AND ("shopping" OR "retail" OR "consumer behavior" OR "purchase decision") AND ("techniques" OR "strategies" OR "methods" OR "approaches")

Screening process for the relevant studies was qualitative in nature based on their relevance. Eligible studies comprised English language, peer reviewed journal articles and book chapters that used neuro-physiological assessment in commercial VR context. Articles that concentrated solely on non-immersive e-commerce, non-commercial VR application (like medical therapy) or those that did not include any physiological assessment process were discarded. Finally, the selected studies were categorized into four different thematic areas.

Final selection of the literature was critically appraised based on a thematic narrative synthesis. Critical information such as particular neuromarketing techniques (EEG, fNIRS, eye-tracking, galvanic skin response), elements of immersion within the VR system, psychological aspects (visual attention, emotional arousal, cognitive load), as well as behavioral results were identified. This narrative approach made it possible to integrate the fragmented results into a coherent whole despite the differences in equipment used, methodology applied, and business fields.

Table 1: Search Strategy

Element	Description
Database	Scopus
Search String	("neuromarketing" OR "consumer neuroscience" OR "brain imaging" OR "neural marketing") AND ("virtual reality" OR "vr" OR "immersive technology" OR "simulated environment") AND ("shopping" OR "retail" OR "consumer behavior" OR "purchase decision") AND ("techniques" OR "strategies" OR "methods" OR "approaches")
Timeframe	2021-2025
Inclusion Criteria	Peer-reviewed journal articles and scholarly book chapters, Published in the English language between 2021 and 2025, Focus on neuromarketing techniques, neuroimaging tools, or biometric sensing, Application specifically situated within virtual reality (VR) shopping or retail environments, Investigation of consumer engagement, implicit cognitive/emotional reactions, visual attention, or purchasing behavior.

Exclusion Criteria	Non-peer-reviewed materials, conference abstracts, editorial notes, or opinion pieces, Publications outside the 2021–2025 timeframe, Studies focused exclusively on traditional 2D e-commerce or non-immersive interfaces, Non-commercial VR applications (e.g., clinical therapy, gaming, general navigation), Research lacking explicit neurophysiological, biometric, or sensory data tracking.
Selection Approach	Multi-stage thematic narrative synthesis: initial title/abstract screening, full-text eligibility assessment, and qualitative categorization of neuroimaging tools, engagement metrics, and VR retail applications.

Conceptual Background

Definitions

Understanding the integration of neuroscience within immersive retail contexts requires establishing clear boundary definitions for four foundational concepts: neuromarketing, virtual reality (VR) shopping environments, subconscious consumer processing, and neuroadaptive feedback loops.

Neuromarketing, or consumer neuroscience, refers to the application of neuroimaging and biometric instruments—such as electroencephalography (EEG), functional near-infrared spectroscopy (fNIRS), eye-tracking, and galvanic skin response (GSR)—to evaluate non-conscious consumer reactions to commercial stimuli (Devendran et al., 2024; Taneja et al., 2024). Within this review, subconscious consumer processing is explicitly operationalized across four distinct dimensions: (1) visual attention allocation (measured via gaze fixations and saccades), (2) cognitive workload (indexed by frontal cortical spectral power and mental strain), (3) emotional arousal and affective responses (tracked via autonomic skin conductance and heart rate dynamics), and (4) implicit behavioral responses (manifested in spatial navigation trajectories and interaction speeds) (Agrawal et al., 2025; Varghese & Uthira, 2026).

Within retail, a Virtual Reality (VR) shopping environment refers to a computer-generated, three-dimensional spatial storefront that provides users with a sense of presence and immersion through head-mounted displays (HMDs) and multisensory feedback mechanisms (Arora, 2024; Singh et al., 2025). These environments range from semi-immersive configurations to fully immersive 360-degree digital stores that allow naturalistic spatial navigation, direct product interaction, and simulated tactile touch (Ibrahim & Juhari, 2019; Xionghui et al., 2025).

In this domain, consumer engagement is conceptualized as a multidimensional construct comprising cognitive, emotional, and behavioral dimensions (Arora, 2024; Qiao et al., 2026). Cognitively, engagement reflects focused visual attention and working memory processing; emotionally, it encompasses physiological arousal, positive affect, and valence; behaviorally, it translates into active spatial exploration, dynamic interaction with virtual assets, and elevated purchase intent (Alipour et al., 2026; Sujatha et al., 2026).

Finally, real-time adaptation or neuroadaptive retailing refers to system architectures that continuously ingest real-time biometric and physiological streams to algorithmically modify

virtual environmental parameters such as lighting, product layout, avatar responses, or promotional cues to optimize engagement dynamically (Cuțitoi, 2022; Qiao et al., 2026).

Key Theories and Frameworks

The integration of the neuromarketing concept in VR-based e-commerce is based on four core theoretical concepts, including Cognitive Load Theory, Limited Capacity Model of Motivated Mediated Message Processing (LC4MP), Embodied Cognition Theory, and Technology Acceptance Model in Telepresence Theory.

According to Cognitive Load Theory, working memory has limited processing capability that is further categorized as intrinsic, germane, and extraneous cognitive load. In relation to virtual reality retail stores, high fidelity imagery, complex navigation, and information overkill may cause extraneous cognitive load, resulting in decreased consumer satisfaction and decision-making difficulty (Alipour et al., 2026). Neuromarketing devices like EEG spectral power calculation (particularly frontal theta and alpha) act as objective measures to detect the point where immersion changes into exhaustion (Kaheh et al., 2021; Singh et al., 2026).

Related to the above is the concept of LC4MP, which states that the processing of mediated virtual environment entails the dynamic distribution of cognitive resources during encoding, storage, and retrieval processes. LC4MP postulates that cues from VR automatically attract attention by way of either appetitive or aversive motivational system (Devendran et al., 2024; Taneja et al., 2024). The process of allocating cognitive resources for the encoding process is operationalized through eye-tracking variables (fixations and gaze paths) as well as physiological arousal (GSR and heart rate variability) of either intrinsic cues (product visual texture) or extrinsic cues (voice assistant avatars and virtual environmental lighting).

According to the Embodied Cognition theory, the enhanced effectiveness of VR retail can be explained because cognition of people is very much dependent on the body and its sensory-motor interactions with the surroundings. In the case of virtual shopping, the use of multisensory cues, especially those of the virtual touch and spatial haptics will help in activating the sensorimotor neural networks (Xionghui et al., 2025). This theoretical perspective explains why interactive, multisensory VR displays elicit stronger subconscious emotional triggers than static or traditional two-dimensional e-commerce interfaces (Sujatha et al., 2026).

Finally, the theoretical synthesis relies on the Technology Acceptance Model (TAM) integrated with Telepresence Theory. Telepresence which refers to the subjective psychological sense of "being there" within a mediated digital space acts as the primary precursor to perceived usefulness and perceived enjoyment in immersive commerce (Arora, 2024; Ibrahim & Juhari, 2019). High level of telepresence amplifies social presence during collaborative VR shopping scenarios (Liu et al., 2025), which can be directly evaluated via hyperscanning techniques (such as concurrent fNIRS) to capture shared neural synchronization between social shoppers (Kaheh et al., 2021; Liu et al., 2025).

Thematic Review of Literature

In order to facilitate a cohesive and well-integrated review of existing research in the area, the literature will be categorized thematically, and not in chronological sequence in terms of

individual studies. In particular, this approach will help bridge the methodological gaps in interdisciplinary research that exists within the areas of consumer neuroscience, human-computer interaction, and virtual retailing. Four interrelated themes have been chosen for the literature synthesis.

Theme 1: Neuroimaging and Biometric Modalities for Decoding VR Shopper Responses

The use of neuroimaging tools and physiological monitoring devices is at the center of consumer neuroscience research in the VR storefront environment. Scientific contributions in this area have shown that EEG, fNIRS, and fMRI generate high-resolution physiological data which enable the measurement of cognitive load, spatial attention, and emotional valence (Kaheh et al., 2021; Singh et al., 2026; Taneja et al., 2024). The combination of the aforementioned neuroimaging technology along with non-invasive biometric measurements of GSR and HRV allows researchers to constantly monitor unconscious physiological arousal evoked by 3D commercial stimuli (Agrawal et al., 2025; Varghese & Uthira, 2026). The combination of the aforementioned neurophysiological parameters allows virtual store interface designers to understand the neural network behind consumers' preferences.

Across empirical investigations, distinct patterns and methodological trade-offs emerge regarding tool selection and deployment within simulated environments. While laboratory-bound fMRI offers deep spatial accuracy regarding neural reward pathways, its rigid physical constraints restrict real-time physical interaction in immersive VR (Agrawal et al., 2025; Devendran et al., 2024; Singh et al., 2026). Consequently, a growing body of work prioritizes portable, non-invasive configurations such as concurrent fNIRS and EEG measurements to observe frontal cortical activity during active product evaluations (Kaheh et al., 2021; Liu et al., 2025). Furthermore, while peripheral biometric indicators like GSR and HRV consistently track emotional intensity, studies note variations in their interpretation, as physiological arousal can signal either positive enthusiasm or cognitive distress depending on the visual density of the virtual store (Agrawal et al., 2025; Taneja et al., 2024).

However, from a critical perspective, the existing literature tends to conduct studies based on the use of isolated laboratory experiments using very limited samples. The issue of ecological validity and generalization of neural activity recordings among different consumer populations is therefore compromised by such an approach. It is important to note that a major empirical gap exists in the field of real-time neuroimaging in differentiating cognitive load from external noises resulting from the use of head-mounted hardware display devices. This gap is very essential in the review topic at hand.

Theme 2: Visual Attention and Spatial Ergonomics via Eye-Tracking

Eye-tracking techniques have been found to be one of the key tools for the analysis of relationships between spatial environment design and consumer gaze behavior in 3D virtual stores. Existing literature highlights that visual fixations, saccades, and gaze paths demonstrate how attention is allocated, shape the process of visual perception, and determine how information is extracted from both internal and external store stimuli (Bigne et al., 2024; Taneja et al., 2024). Analyzing fixation heatmaps and patterns of visual navigation, scholars use data from eye tracking in order to conduct an analysis of spatial layouts of the store, arrange shelves in the best way possible, and make store promotions more visible (Bigne et al., 2024; Quevedo et al., 2018).

Comparative analyses demonstrate different views on the relationship between visual attention and store complexity or context. According to some studies, clear intrinsic visual cues, including textures of products and 3D representation, always draw people's visual attention for a long time and help to remember the brand name (Alipour et al., 2026; Agrawal et al., 2025). Meanwhile, research investigating interactive store elements like voice assistant avatars or virtual floor indicators prove that extrinsic visual cues can shift visual attention from the main products and sometimes cause visual noise (Bigne et al., 2024; Quevedo et al., 2018). Thus, while visual fixation generally correlates positively with product engagement, excessive visual stimuli risk fragmenting consumer focus across competing spatial anchors (Bigne et al., 2024; Taneja et al., 2024).

However, in the existing eye tracking literature concerning VR shopping environments, there is an important limitation in the sense that existing literature does not take into consideration the dynamics of head movements and depth perception when considering 2D visual gaze vectors in 3D space. Another important gap in the literature is that very little research has been conducted on changes in visual attention dynamics when consumers become accustomed to the virtual store fronts over time. This is important to address since it fulfills the purpose of the review.

Theme 3: Multisensory Immersion, Touch, and Social Presence

The incorporation of multisensory information along with social interactions will lead to greater psychological presence, emotional involvement, and spatial presence in VR commerce. From a synthesis of existing literature, it becomes evident that engaging more than visual sensory modes, that is, simulation of virtual touch, tactile sensation, and realistic environmental sound can increase emotional engagement and perceived value of the product (Arora, 2024; Xionghui et al., 2025). Moreover, adding multi-user features that allow shoppers to shop collaboratively will involve social presence, which will trigger neurofunctional processes between individuals just as in case of physically co-shopping (Ibrahim & Juhari, 2019; Liu et al., 2025).

Differences within literature occur in relation to an appropriate threshold level of sensory stimuli and neurophysiological underpinnings of social presence. Even though there is evidence proving that virtual touch effects positively impact consumer product evaluations and purchasing intentions (Xionghui et al., 2025; Sujatha et al., 2026), there are studies that indicate an increase in unnecessary cognitive load caused by improperly calibrated sensory input, which in turn leads to sensory overload and decreased satisfaction levels (Alipour et al., 2026; Ibrahim & Juhari, 2019). The same applies to the topic of social presence in collaborative shopping. Even though hyperscanning studies prove that collaboration helps synchronize emotions (Liu et al., 2025), it may negatively impact individual consumers' decision-making.

In terms of evaluation of critical studies, there is an evident methodological inconsistency within the area of virtual multisensory integration. While the visual and auditory aspects have been researched quite extensively, the touch and haptic features of the process have not been studied as well as the former ones yet. There are no neurophysiological criteria within the existing models to assess exactly where the line between sensory engagement and cognitive fatigue lies. It is important to solve all the gaps of theory and practice for the review to be done.

Theme 4: AI-Driven Personalization and Neuroadaptive Real-Time Retailing

The integration of AI, machine vision, and real-time sensing of data provides the basis for designing neuro-adaptive retail environments that respond to changes in individual user conditions. Studies related to this topic have revealed that machine learning techniques enable interpretation of continuous streams of data such as neurophysiological, biometric, and behavioral in order to detect implicit states of consumers in terms of emotions, preference, and impulsiveness (Cuțitoi, 2022; Moghaddasi et al., 2021; Qiao et al., 2026). Conversion of real-time neuro-emotional data into a prediction model by means of AI allows for adaptation of environmental parameters such as shop lighting, acoustic environment, recommendation of products, and promotional activities (Bucea-Manea-Țoniș et al., 2026; Qiao et al., 2026).

Comparative examination reveals contrasting operational paradigms regarding how data-driven personalization should be implemented. One stream of research advocates for fully autonomous, closed-loop neuroadaptive systems that continuously recalibrate VR storefronts based on real-time physiological feedback loops (Cuțitoi, 2022; Qiao et al., 2026). On the other hand, several scholars favor non-intrusive behavioral pattern analysis, arguing that tracking spatial movement vectors, interaction speeds, and navigational impulsivity yields sufficient predictive accuracy without requiring complex, real-time biometric hardware integration (Moghaddasi et al., 2021; Singh et al., 2025). Additionally, studies raise concerns regarding algorithmic latency, noting that delayed environment adaptations can cause cognitive disorientations for the user (Bucea-Manea-Țoniș et al., 2026; Qiao et al., 2026).

More importantly, despite the huge business possibilities of neuroadaptivity through AI applications, the body of research has been limited by the constraints related to the issues of data privacy, ethical uncertainty in the case of emotional manipulation, and a need for validated machine learning models. In most cases, emotion prediction models are based on the use of laboratory-generated datasets which find it difficult to consider the noise in naturalistic behavioral contexts. This is an important aspect in relation to the key research focus of this review.

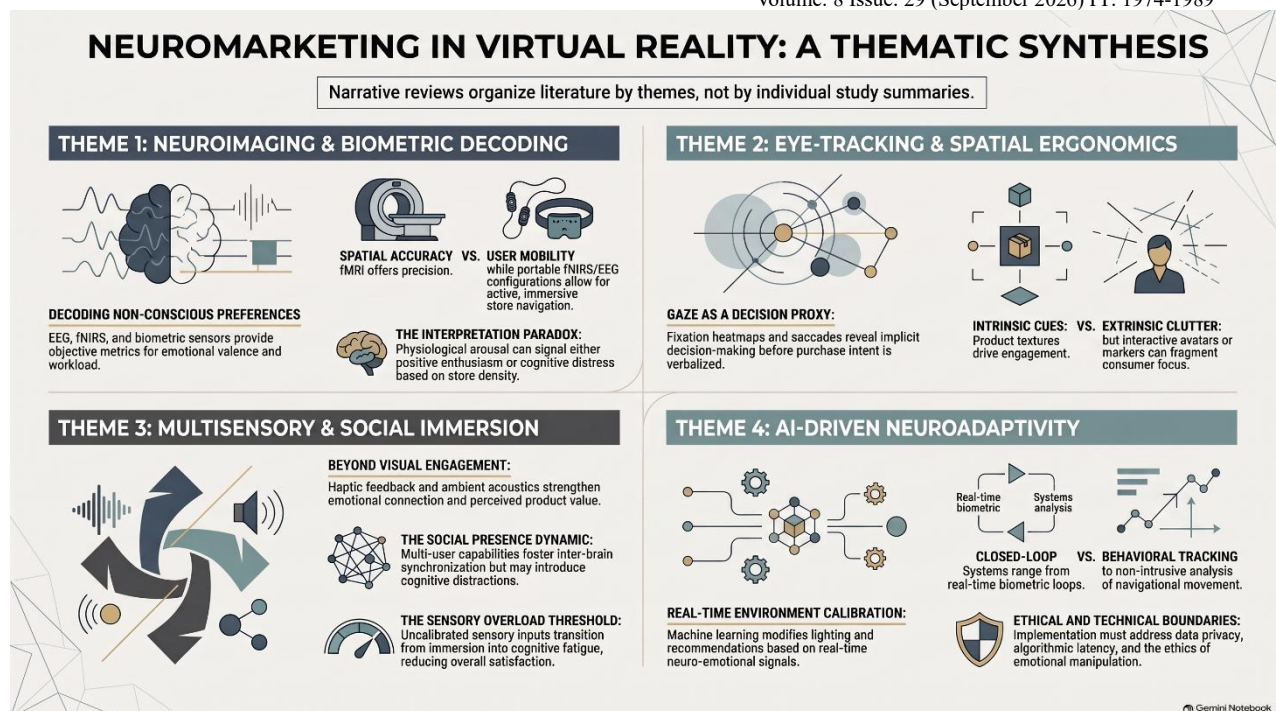


Figure 1: Thematic of Literature

Critical Discussion

In order to progress from narrative analysis and begin a critical examination of the synthesized literature, this section provides an analysis of the intersection of consumer neuroscience and virtual reality retail through four dimensions. These include the identification of major Agreements in the Literature, focusing on areas of consensus both in terms of methodology and theory in relation to multimodal biometrics and immersive engagement. This is followed by a discussion of major Disagreements in the field, including those related to cognitive load and adaptive retail systems. The section then identifies Gaps in the literature, before moving on to consider implications.

Agreements in the Literature

There is considerable consensus among all the reviewed literature that the combination of neuroimaging and biometrics through VR technology has a higher capability than conventional self-reports in understanding the consumer's unconscious reaction (Devendran et al., 2024; Taneja et al., 2024). The empirical evidence shows that the combination of eye-tracking and EEG or GSR gives accurate results for the determination of visual focus, workload, and physiological stimulation (Agrawal et al., 2025; Bigne et al., 2024; Varghese & Uthira, 2026). Moreover, the role of multi-sensory stimuli, especially virtual touch and spatial interaction, in enhancing presence and immersing the consumer emotionally is unanimously accepted (Arora, 2024; Xionghui et al., 2025).

From a theoretical perspective, this broad convergence reinforces Embodied Cognition and Telepresence frameworks, proving that immersive spatial experiences trigger genuine sensorimotor and emotional neural networks (Arora, 2024; Xionghui et al., 2025).

Mechanistically, the agreement on multimodal data collection highlights a major shift in consumer research: moving from static post-purchase surveys toward real-time cognitive state tracking. Methodologically, this consensus establishes that evaluating consumer engagement in virtual spaces requires capturing simultaneous cognitive (EEG/fNIRS) and affective (GSR/HRV) signals to obtain an accurate profile of subconscious consumer behavior (Kaheh et al., 2021; Singh et al., 2026).

Disagreements in the Literature

While there is a general agreement on the benefits of biometrics, there are substantial differences of opinion among scholars about the ideal degree of sensory complexity and the precise process of real-time adaptation through AI. One view is that very realistic multi-sensory VR shops with dynamic avatars and ambient triggers will keep on enhancing consumer engagement and association with the brand (Bucea-Manea-Țoniș et al., 2026; Singh et al., 2025). On the other hand, the results of empirical studies based on Cognitive Load Theory indicate that complex visuals and tactile inputs tend to cause cognitive overload and visual fatigue, thereby making consumers feel confused and dissatisfied about their purchases (Alipour et al., 2026; Bigne et al., 2024). There is also an ongoing discussion on whether the adaptation process should be automatic through physiological feedback loop or behavioral motion tracking (Cuțitoi, 2022; Moghaddasi et al., 2021; Qiao et al., 2026).

These conflicting perspectives expose a fundamental tension in immersive retail design between maximizing sensory richness and preserving human cognitive capacity. The disagreement over adaptive implementation underscores an unresolved trade-off between algorithmic control and user agency. If real-time neuroadaptive algorithms adjust virtual store parameters too aggressively, consumers may experience loss of autonomy or spatial disorientation (Qiao et al., 2026). Resolving these theoretical contradictions requires establishing baseline thresholds where environmental richness enhances telepresence without triggering extraneous cognitive fatigue.

Gaps in the Literature

From critical evaluation of the existing literature base, it becomes quite evident that there are numerous empirical and theoretical shortcomings in the current literature base. Empirically, the most common flaw found in empirical literature is small homogenous samples analyzed through tightly controlled lab experiments, thus restricting the practical application of the findings in actual shopping scenarios (Agrawal et al., 2025; Kaheh et al., 2021). In addition, the literature has a pronounced sector bias in the sense that high involvement products such as furniture and clothing are given much emphasis whereas fast moving consumer goods and services are ignored (Alipour et al., 2026; Bigne et al., 2024). Moreover, no literature exists in relation to longitudinal studies on habituation.

Addressing these gaps is essential for advancing the scientific maturity of consumer neuroscience in spatial commerce. The over-reliance on cross-sectional laboratory designs leaves researchers uncertain whether observed neural activations reflect genuine commercial interest or merely a temporary novel technology effect. Moreover, the lack of standardized protocols for filtering physical noise (e.g., motion artifacts from head-mounted displays) during continuous biometric tracking impedes the development of scalable, commercial-grade neuroadaptive platforms (Singh et al., 2026).

Implications

The theoretical and practical implications of the integration of this theory go beyond academia, extending into the realms of retail architecture and policy in consumer protection. This theoretical review emphasizes that there is a necessity for incorporating the theory of cognitive load and telepresence model into one comprehensive model which can incorporate non-conscious cognitive processes in three-dimensional space (Alipour et al., 2026; Arora, 2024). From the practical standpoint, for retail professionals, this study provides several practical recommendations, focusing on the importance of the connection between visual anchors and multisensory touch cues in virtual shopping stores (Bigne et al., 2024; Xionghui et al., 2025).

From the perspective of ethics and policy, the practicality of closed loop neuro adaptive shopping presents some major issues related to data privacy, subliminal manipulation and informed consent (Sujatha et al., 2026). Appropriate regulatory measures need to be created to prevent the misuse of consumers' neural data by businesses in any way (Qiao et al., 2026; Sujatha et al., 2026). Research in the future needs to focus on longitudinal studies for creating guidelines for ethically sound neuro adaptive VR shopping experiences.

Recommendations and Future Directions

Recommendations for Practice

Retailers and VR space designers should prioritize cognitive-ergonomic principles over pure visual density. To prevent extraneous mental fatigue, practitioners can adopt progressive-disclosure interfaces where complex product specifications remain hidden until triggered by intentional consumer gaze or proximity. Furthermore, store architects can utilize eye-tracking fixations to design intuitive visual corridors that guide shoppers toward primary merchandise without cluttering the spatial field. Interactive elements, such as conversational avatars or collaborative social features, should be calibrated to support decision-making rather than serving as visual distractions.

Recommendations for Policy or Organizational Use

On the organizational and regulatory front, industry bodies and policymaking institutions need to put in place formalized ethical governance structures to specifically cover non-conscious collection of biometric data within the spatial context. Business organizations that make use of real-time biometric sensors (in-built eye-tracking devices, galvanic skin response handhelds, or neural helmets) need to incorporate strict "Privacy by Design" guidelines. Such guidelines need to be strict on consent for data collection, limited data storage period, and no use of the collected data to take advantage of consumers' vulnerability through manipulation of price tags or urgency signals once heightened emotional states are detected. Standards organizations need to provide hardware-software interoperability guidelines.

Future Research Directions

Future academic research must address current methodological limitations by transitioning from cross-sectional, laboratory-bound experiments to field-validated, longitudinal study designs. Researchers should prioritize investigating the habituation effect such as examining how non-conscious cognitive workload, visual fixation patterns, and emotional arousal evolve

over repeated VR shopping exposures once the novel technology effect dissipates. Methodologically, future studies must refine real-time signal-processing algorithms to isolate and filter physical motion artifacts caused by head-mounted displays during active spatial navigation. Finally, scholarly inquiry should expand beyond high-involvement retail goods into fast-moving consumer goods and collaborative social environments, leveraging fNIRS-based hyperscanning to explore inter-brain neural synchronization and shared decision-making during multi-user VR commerce.

Limitations

However, while this narrative review offers an extensive analysis of consumer neuroscience in the context of VR commerce, there are some methodological and structural limitations that have to be considered. Firstly, the selection of sources has been performed through the single Scopus bibliographic database only, even though it encompasses an extensive and multidisciplinary index of articles but can still miss niche research papers published in specialized regional databases and in computer science. Secondly, the period of publication was limited only to the range of 2021 to 2025, thus neglecting any seminal publications and real-time research studies published outside the stated five-year period. Thirdly, the set of sources has a notable imbalance by sectors, being predominantly focused on the high involvement consumer goods markets (furniture, high fashion) while failing to include fast-moving consumer goods and digital services sector. Lastly, the existing body of literature is characterized by conceptual overlap and confusion with terminology, as terms such as "immersion," "presence," and "engagement" are often applied interchangeably in the fields of neuroimaging, human-computer interaction and retail design.

Conclusion

This review provides a systematic approach to address the issue of fragmented knowledge in consumer neuroscience in terms of its use in virtual reality shopping. By combining insights from various methods related to neuroimaging approaches, measurements of visual attention, techniques used for multisensory immersion, and adaptive neurotechnology based on AI systems, this paper aims to provide an integrated model of how implicit physiological signals dictate the behavior of consumers in 3D digital stores. The main contribution of this review consists in creating a bridge between technical computer science criteria and consumer psychology results in terms of the dominance of biometric monitoring over self-reporting techniques.

In addition, the paper highlights the fine line that needs to be drawn between sensory immersion and cognitive ergonomics, providing design guidelines in order to avoid unnecessary cognitive burden on users of spatial commerce. With the continuous advancements in immersive technologies, the development of responsive real-time spatial experiences will demand neurophysiological findings to be in harmony with transparent ethical governance.

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