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Meta-analysis of augmented reality and virtual reality in marketing

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Abstract

Purpose – Augmented reality (AR) and virtual reality (VR) have revolutionized how firms interact with customers. The purpose of this study is to provide a systematic empirical account of (a) the comparative effects of AR versus VR, (b) their potential negative impacts, (c) the underlying mechanisms, or (d) the role of contextual moderators in the relationship between these technologies and customer responses.

Design/methodology/approach – This meta-analytic review integrates effect sizes from 206 papers, comprising 235 independent studies, to develop a generalizable model of AR and VR. The review tests the comparative effects of these two technologies, explores competing models in each one that incorporate both positive and negative effects, and examines relevant moderators to address inconsistencies in prior research on the two technologies.

Findings – The findings demonstrate that while AR is effective in triggering behavioural responses, VR is more effective in engaging customers through various pathways, including decision fluency, spatial presence theory, experiential approach and technology acceptance model. However, the dark side of these technologies, such as privacy concerns and perceived risk, negatively impacts customer responses to both technologies. Furthermore, the study highlights the significant role of contextual variables, such as technology, customer, product and national factors, in moderating the relationship between AR and VR with customer responses.

Research limitations/implications – This study encourages future research to explore AR and VR technologies in emerging areas like the metaverse.

Practical implications – The study provides recommendations for marketing managers to effectively integrate AR and VR technologies into their marketing strategies, optimizing potential benefits while minimizing adverse outcomes.

Originality/value – Through the development, testing, and identification of an optimal model within the AR and VR technologies literature, this research provides a comprehensive understanding of the underlying theories and establishes a superior model for explaining the impact of AR and VR on consumer responses.

Keywords Augmented reality, virtual reality, meta-analysis

Paper type Literature review

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Introduction

Over the past few decades, technological advancements in both augmented reality (AR) and virtual reality (VR) have emerged as powerful tools for retailers to enhance customer responses and firm performance (Grewal *et al.*, 2017; Hilken, Chylinski *et al.*, 2022). Due to its popularity, major retailers such as Ikea, Zara and Sephora have integrated these technologies in various ways to improve customer experience and their decision-making to boost their sales (Tan *et al.*, 2022). For instance, Ikea has empowered customers to use AR to visualize how a product like a sofa would fit in their homes, while eBay has introduced a VR department store, creating a fully immersive shopping experience (Dwivedi *et al.*, 2021). This differentiation in use cases underscores the diverse applications and strengths of AR and VR in retail. The market for these technologies has also demonstrated significant growth, with the sector valued at US $131.54 billion in 2023 and projected to reach US$1,706.9bn by 2032 (Fortune Business Insights, 2024).

AR and VR technologies offer fundamentally different methods of interaction, each with its potential impact on customers (Rauschnabel *et al.*, 2022). AR enhances the real world by overlaying virtual objects onto physical surroundings, creating an integrated experience (Schultz and Kumar, 2024). In contrast, VR fully immerses users in a virtual world, isolating them from their actual environment (Rauschnabel *et al.*, 2022). While both technologies aim to enhance positive customer responses, some studies suggest that VR offers greater potential for customer engagement (Wedel *et al.*, 2020). Other research indicates that AR may be more effective in driving customer purchases by allowing customers to integrate virtual products into their physical environment, thereby reducing uncertainty (Mishra *et al.*, 2021). Despite these comparative studies on AR and VR (Jayawardena *et al.*, 2023; Mishra *et al.*, 2021; Omran *et al.*, 2024; Wedel *et al.*, 2020), insights into their comparative effects on customer responses, especially engagement and behavioural responses, remain unclear.

While much of the existing research highlights the positive aspects of AR and VR, it is equally important to examine their potential drawbacks (Kim *et al.*, 2023). As with any new technology, AR and VR can sometimes fail to meet customer expectations, leading to negative experiences (Barari *et al.*, 2024). For example, research has shown that customers may be concerned about the potential risks associated with using AR and VR, particularly regarding privacy and data security (Dwivedi *et al.*, 2021). By overlaying virtual elements onto the real world, AR may raise concerns about how personal data is being collected and used in real-world settings, while VR's fully immersive nature may make users feel vulnerable to data tracking and surveillance within virtual spaces. These privacy concerns and perceived risks can lead to negative customer responses, highlighting the need to consider the "dark side" of AR and VR technologies (Feng and Xie, 2019).

A review of the literature on AR and VR reveals significant debates regarding how these technologies influence customer attitudes and behaviours (Dwivedi *et al.*, 2021). Some researchers focus on the decision fluency approach, arguing that these technologies facilitate decision-making by improving mental imagery and increasing decision comfort (Tan *et al.*, 2022). Other scholars rely on spatial presence theory to explain how AR and VR shape customer responses by altering users' perceptions of space, self-location and the perceived integration of virtual elements with the physical environment (Wirth *et al.*, 2007; Hilken *et al.*, 2017). Other scholars adopt an experiential perspective, suggesting that these technologies enhance customer experiences in different ways, thereby driving customer behaviour (Chen *et al.*, 2022). In addition, the technology acceptance model (TAM) has been widely used to study how perceived ease of use and usefulness affect customer responses to AR and VR (Saleem *et al.*, 2021). Although various theoretical frameworks justify the relationship between AR and VR technologies and customer responses, it remains uncertain which framework provides the most accurate explanation for AR vs VR.

Finally, conflicting findings have emerged regarding the effectiveness of AR and VR in triggering customer responses across different contexts (Flavián *et al.*, 2019). This

inconsistency highlights the importance of considering the specific contexts in which these technologies are deployed, as well as the distinct advantages each technology offers to the customer's experience. Several contextual variables have been overlooked in the literature, such as technology (e.g. physical closeness), consumer (e.g. previous experience with these technologies), product (e.g. familiarity) and national level factors (e.g. cultural values), which may influence the effectiveness of AR and VR in different ways. Based on the aforementioned four research gaps identified in the AR and VR literature, the current research questions are as follows:

RQ1. What is the comparative effectiveness of AR versus VR on customer engagement and behavioural response?

RQ2. What are the negative aspects (dark side) of AR versus VR on customer responses?

RQ3. What are the underlying mechanisms through which AR versus VR impacts customer responses?

RQ4. Which contextual factors moderate the relationship between AR versus VR and customer responses?

To address these questions, we synthesized and integrated effect sizes from 150 AR papers, comprising 169 independent studies and 60 VR papers with 70 independent samples, with a total sample size of 59,954. Firstly, our research indicates that AR technologies are more effective in driving behavioural response, while VR technologies are more effective in engaging customers, highlighting the fundamental differences between these technologies.

To answer the second research question, we examined the dark side of these technologies. These included privacy concerns and perceived risk, which can diminish positive customer responses, providing a balanced view of both the positive and negative effects of AR and VR technologies.

To address the third question, we developed a generalizable framework and individually tested AR and VR to explain how these technologies lead to customer responses. Given the divergent views on how these technologies enhance customer engagement and behavioural intentions, we drew on different approaches, including decision fluency, spatial presence theory, experiential theory and the TAM. We also tested the dark side of these technologies (privacy and perceived risk) to illustrate how AR and VR technologies generate positive customer responses. The results indicated that AR outcomes are strongly driven by decision fluency and perceived usefulness, while emotional and experiential responses primarily shaped VR outcomes. The dark side of AR and VR in both models negatively impacted consumer engagement and behavioural responses.

To answer the fourth research question, we selected and tested moderators at four levels: technology (physical closeness and sensory capacity), customer (experience, age, gender), product (familiarity, involvement, benefits) and national (individualism, power distance, masculinity, uncertainty avoidance). This theoretical perspective on moderators enhances our understanding of the contextual factors that influence the role of AR and VR technologies on customer attitudes and behavioural responses. These analyses indicate that AR benefits more from physical presence, high product involvement and prior technology experience, while VR performs better under conditions of product unfamiliarity, hedonic value and among female users. At the national level, individualism and uncertainty avoidance significantly moderate both AR and VR effects, indicating that cultural factors also shape how consumers respond to these technologies.

From a practical standpoint, this study highlights key differences between AR and VR in driving consumer responses, particularly engagement and behavioural outcomes, enabling firms to identify which aspects of each technology are most critical for maximizing the return on their investment.

Augmented reality versus virtual reality

AR and VR are two of the most prominent technologies in marketing, revolutionizing how customers interact with products and services and shaping consumer decision-making (Rauschnabel *et al.*, 2024). These technologies serve distinct functions: AR overlays digital elements onto the physical world, while VR fully immerses users in a simulated environment (Rauschnabel, 2023).

AR enhances real-world environments by overlaying computer-generated content, allowing users to perceive both virtual elements and their physical surroundings simultaneously (Wieland *et al.*, 2024). In contrast, VR creates a fully immersive experience, isolating users from the real world and placing them in a completely simulated digital environment (Abbasi and Ali, 2020). The purpose of AR is to augment reality by helping users make better decisions through digital overlays that interact with physical surroundings (Heller *et al.*, 2021). For instance, AR can aid in tasks like visualizing products within a real-world setting, making it particularly valuable for customer decision-making. On the other hand, VR immerses users in an entirely virtual environment, offering a simulated experience where users are wholly detached from their actual surroundings (Schultz and Kumar, 2024). This distinction makes VR ideal for scenarios requiring complete immersion, such as virtual shopping or simulations.

In terms of customer experience, AR allows users to engage with both virtual and physical elements, creating what is known as a local presence (Rauschnabel *et al.*, 2024). This means users remain connected to their physical environment while interacting with virtual overlays (Ambika, Shin *et al.*, 2025). In contrast, VR offers telepresence, where users are completely immersed in a virtual world, experiencing the digital environment as though it were real, with no interaction with their physical surroundings (Wieland *et al.*, 2024). The technology behind these experiences also differs significantly (Butt *et al.*, 2022). AR can be accessed through devices like mobile phones, tablets or head-mounted displays equipped with object recognition technology (Rauschnabel *et al.*, 2024). VR, however, requires more specialized tools such as head-mounted displays (HMDs), VR CAVEs or power walls, all of which fully immerse the user in the virtual environment (Ambika, Shin *et al.*, 2025).

For real-world applications, AR is often used to enhance customer interaction with physical products, as demonstrated by IKEA's AR app, which enables users to visualize and customize furniture within their own living spaces (Deep *et al.*, 2025). This approach helps users make informed purchase decisions by integrating virtual elements into real environments (Irshad *et al.*, 2025). On the other hand, VR provides a completely simulated experience, such as eBay's Virtual Reality Department Store, where customers can navigate and shop in an entirely virtual environment without physical constraints (Kowalczuk *et al.*, 2021). The fundamental distinction between AR and VR lies in their levels of immersion and technological requirements (Rauschnabel *et al.*, 2022): AR enhances real-world experiences with virtual overlays, while VR transports users into a fully digital world, offering unique benefits in contexts where full immersion is desired (Rauschnabel *et al.*, 2022).

Different approaches in augmented reality vs virtual reality

Table 1 summarizes the main theoretical approaches used in marketing to study the impact of AR and VR on consumer response. A wide range of theoretical approaches has been studied in this area, but decision fluency, experiential marketing, the TAM and the dark side of these

Table 1. Theoretical approach to AR and VR

Theoretical framework	Explanation	Related variables	Representative research
Decision fluency	Describes how vivid mental images and easy information processing improve decision comfort and influence consumer behaviour	Mental imagery, mental intangibility, processing fluency and decision comfort	Heller *et al.* (2019a), Hilken, Chylinski, *et al.* (2022)
Spatial presence theory	Explains how AR and VR shape users' sense of location. VR creates telepresence (being in the virtual world), while AR creates local presence (virtual objects appearing in the real world), both affecting perceived closeness	Telepresence, local presence, closeness	Wirth *et al.* (2007), Hilken *et al.* (2017), Rauschnabel *et al.* (2024)
Technology acceptance model	Explains how perceived usefulness and ease of use influence users' attitudes and intentions to adopt a technology	Perceived usefulness, ease of use and enjoyment	Manis and Choi (2019), Rese *et al.* (2014), Saleem *et al.* (2021)
Experiential theory	Focuses on how immersive, sensory, and emotional experiences impact customer satisfaction and behavioural responses	Customer experience, flow, immersion	Jung *et al.* (2021), Pizzi *et al.* (2020), Poushneh and Vasquez-Parraga (2017)
Dark side	Examines how perceived risks, privacy concerns, and intrusiveness negatively affect customer trust, satisfaction, and usage	Risk and privacy and loss of autonomy	Alimamy and Gnoth, (2022), Faqih, (2022), Feng and Xie, (2019), Rauschnabel *et al.*, (2018)

Source(s): Developed by the authors

technologies are the primary areas through which researchers have examined how AR and VR technologies shape customer responses.

Decision fluency

The decision fluency approach focuses on how AR and VR technologies aid customer decision-making (Kalantari *et al.*, 2022). AR and VR facilitate the creation of vivid mental images of products in the customer's mind, leading to increased decision comfort, intention and behavioural responses such as purchasing and engagement (Heller *et al.*, 2019a). Mental imagery theory is primarily used to explain how AR and VR technologies enable customers to visualize products and services without direct access to them (Hilken *et al.*, 2022). This theory suggests that mental representations, internal mental images or models of the external world, help consumers process information more fluently, which reduces uncertainty and increases decision comfort (Heller *et al.*, 2019a). This comfort subsequently triggers favourable behavioural responses, such as purchase intention or customer engagement (Heller *et al.*, 2019b). Overall, decision fluency suggests that AR and VR technologies can reduce uncertainty surrounding product fit by providing relevant and timely information, easing decision-making and enhancing customer attitudes and behaviours (Tan *et al.*, 2022).

Spatial presence theory

Spatial presence theory explains how AR and VR technologies shape customer responses by influencing users' perceptions of space and location. According to this approach, individuals form a spatial situation model that integrates real and mediated cues, allowing them to determine where they are and how objects are positioned around them (Wirth *et al.*, 2007). In VR, this process results in telepresence, in which users feel as if they have entered the virtual environment and experience it as their primary spatial reality (Witmer and Singer, 1998). In contrast, AR produces local presence, where virtual objects appear integrated into the user's immediate surroundings, creating the impression that these objects exist in the physical world (Hilken *et al.*, 2017). Both presence states shape perceived closeness: stronger self-location in VR and stronger object-location in AR reduce psychological and spatial distance, making virtual elements feel nearer to the user (Poushneh, 2021; Rauschnabel *et al.*, 2024).

Technology acceptance model. Based on this theory, consumers used AR and VR technologies to gather more information and evaluate it positively, which in turn increases their intention to reuse the technology (Saleem *et al.*, 2021). This positive assessment is influenced by two main factors defined by TAM: perceived usefulness and perceived ease of use (Ha and Stoel, 2009). Perceived usefulness refers to the degree to which a person believes that using a particular technology will enhance their performance (Pavlou, 2003), while perceived ease of use denotes the degree to which a person believes that using the technology will be free of effort (Manis and Choi, 2019). These factors together not only enhance customer attitudes towards AR and VR technologies but also contribute to their engagement and future usage (Rese *et al.*, 2014).

Experiential theory

The second approach to studying AR and VR technologies focuses on customer experience, emphasizing how these technologies can enhance customer responses by providing enriched and enjoyable experiences (Ambika, Jain *et al.*, 2025). This approach views AR and VR technologies as a transformative way to shop, offering customers a deeper, more sensory-driven interaction with products (Ameen *et al.*, 2022). It is rooted in experiential theory literature, suggesting that shoppers are drawn to immersive and emotionally engaging experiences (Alimamy and Al-Imamy, 2021). The overall experience of AR and VR technologies, including both cognitive experiences (such as flow) and emotional responses (such as pleasure and enjoyment), significantly influences customers' intentions to make purchases and interact further with a brand (Flavián *et al.*, 2019). Previous research indicates that these experiences, through customer satisfaction and attitude formation, shape customers' further responses towards marketing activities (Kumar *et al.*, 2021). For instance, Jung *et al.* (2021) demonstrated how AR-based navigation systems not only captivate customers through enhanced entertainment and aesthetic appeal but also create an escapist environment that can significantly boost customer responses.

Dark side of augmented reality and virtual reality

This approach emphasizes the negative roles of AR and VR technologies may play in shaping customer responses (Lombart *et al.*, 2025). While most research highlights the benefits of AR and VR, the "dark side" literature acknowledges that these technologies can also create concerns and barriers (Barari *et al.*, 2024). Specifically, AR and VR technologies can cause adverse responses such as heightened privacy concerns, perceived intrusiveness and an increased sense of loss of autonomy, all of which can reduce customer satisfaction and trust (Alimamy and Gnoth, 2022). These negative effects influence customer attitudes and behavioural intentions in ways that undermine the positive experiences typically associated

with AR and VR (Faqih, 2022; Rauschnabel *et al.*, 2018). For instance, Feng and Xie (2019) found that VR try-on applications can have a detrimental impact on customer attitudes through perceived intrusiveness, thereby limiting technology acceptance despite its functional benefits.

Figure 1 presents the theoretical framework developed to guide our meta-analysis of the impact of AR and VR on consumer responses.

The model in Figure 1 integrates four dominant theoretical perspectives found across AR and VR research: decision fluency, experiential theory, the TAM, and the dark side of AR and VR. Together, these frameworks provide a comprehensive understanding of how AR and VR influence customer outcomes. The decision fluency approach explains how mental imagery enhances processing fluency and decision comfort, ultimately driving engagement and behavioural intention (Heller *et al.*, 2019a, 2019b; Hilken *et al.*, 2022). Experiential theory focuses on how sensory-rich experiences, such as flow and emotional engagement, affect satisfaction and brand-related responses (Jung *et al.*, 2021; Pizzi *et al.*, 2020; Poushneh and Vasquez-Parraga, 2017). TAM highlights the role of perceived usefulness and ease of use in shaping consumer attitudes and intentions towards adopting AR and VR (Manis and Choi, 2019; Rese *et al.*, 2014; Saleem *et al.*, 2021).

In contrast, the dark side literature draws attention to adverse effects such as privacy concerns, perceived risk and intrusiveness, which can undermine trust and satisfaction (Alimamy and Gnoth, 2022; Faqih, 2022; Feng and Xie, 2019; Rauschnabel *et al.*, 2018). These pathways are linked to key outcome variables such as attitude, satisfaction, engagement and behavioural response, guided conceptually by the theory of planned behaviour (Ajzen, 1991), which posits that attitudes and perceptions shape behavioural intentions and actual behaviour.

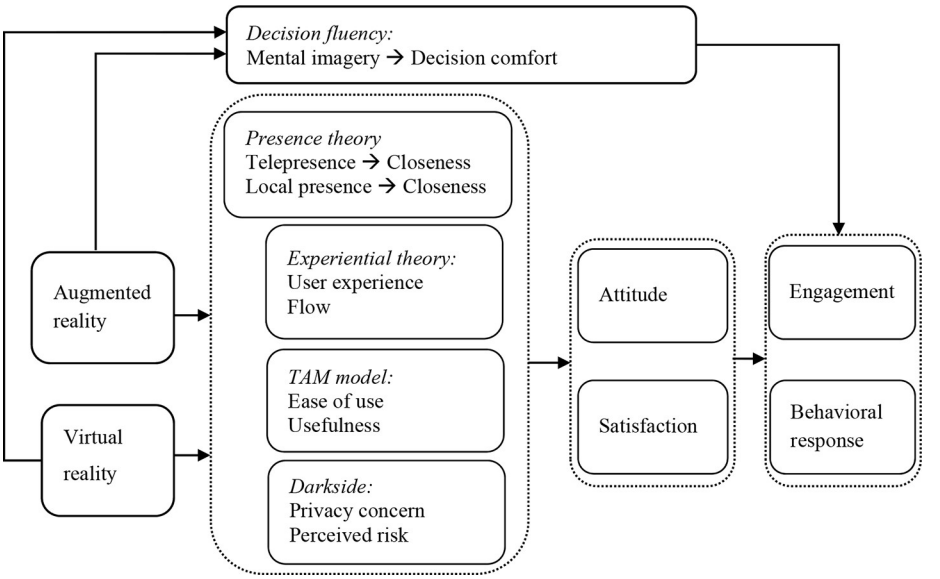

Figure 1. Meta-analysis theoretical framework
Source: Developed by the authors

Importantly, this framework will be separately tested for AR and VR contexts to examine whether these two technologies operate through similar or distinct underlying mechanisms, offering insight into how each shapes customer decision-making and response.

Conceptual framework and hypotheses

Figure 2 illustrates the moderator analysis framework in our meta-analysis, which investigates how different contextual factors influence the effects of AR and VR on two key dependent variables: customer engagement and behavioural response. These two outcomes were selected because they capture the most critical and recurring consumer responses in AR and VR research. Engagement reflects a user's cognitive and emotional connection with the experience, which is particularly relevant for AR and VR, given their goal of delivering rich, interactive environments (Barari *et al.*, 2021). Behavioural response, encompassing intentions or actions such as product choice, purchase or continued use, represents the downstream effect of these experiences and provides a concrete indicator of marketing effectiveness (Arya *et al.*, 2025).

To capture the boundary conditions under which AR and VR influence these outcomes, we focus on four levels of contextual moderators: technology, customer, product and culture, as they offer a comprehensive view of factors that shape the effectiveness of AR and VR. The technology level captures core technological differences across AR and VR experiences such as sensory capacity and spatial proximity that are likely to influence how consumers process the interaction. The customer level includes variables such as experience, age and gender, which reflect individual characteristics shown in research to moderate technology-related responses. The product level accounts for whether the

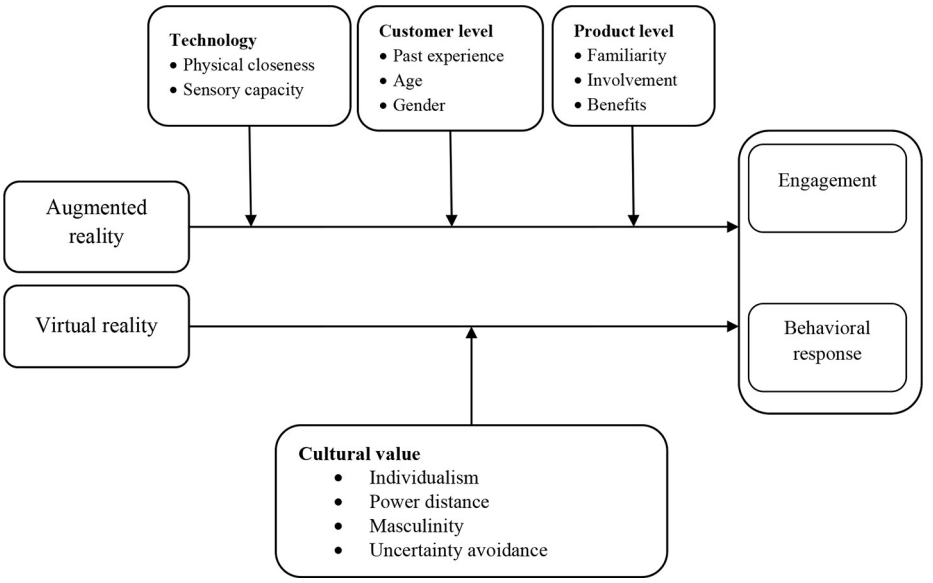

Figure 2. Meta-analysis moderator analysis framework
Source: Developed by the authors

product being marketed is hedonic or utilitarian, familiar or unfamiliar, or high or low involvement, all factors known to affect how technologies facilitate product evaluation. Finally, the culture level includes broad societal values such as individualism or uncertainty avoidance that may influence how consumers respond to novel or tech-mediated encounters.

Technology level

Physical closeness

Physical closeness refers to the user's spatial proximity to the object or environment relevant to the AR or VR experience (Bagozzi *et al.*, 2017). In local conditions, the user is physically present at the focal location, whereas in telepresence conditions, the user experiences the content remotely (Rauschnabel *et al.*, 2024). In AR, digital content is superimposed on the user's real-world environment, and its effectiveness often depends on the alignment between digital elements and the physical context (Poushneh and Vasquez-Parraga, 2017). This spatial alignment enhances users' sense of realism and interactivity (Rauschnabel *et al.*, 2024). In contrast, VR replaces the physical environment with a synthetic one, constructing a self-contained virtual world in which spatial cues are digitally generated (Lombart *et al.*, 2025). Thus, the role of the user's actual physical location is more salient in AR than in VR contexts.

Given that AR content overlays virtual elements onto the user's immediate physical surroundings, local conditions, where users are physically present at the focal location, are likely to enhance the effectiveness of AR by reinforcing spatial congruence and user control (Rauschnabel *et al.*, 2024). This alignment can deepen engagement and strengthen behavioural responses. In contrast, VR is typically experienced through telepresence, where users are immersed in a digitally constructed environment that is independent of their actual location (Sands *et al.*, 2024). Because VR does not rely on the user's real-world context, telepresence plays a more central role than local presence.

H1a. Physical closeness (local vs telepresence) moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for local than telepresence.

H1b. Physical closeness (proximal vs distal) moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for telepresence than local.

Sensory capacity

Sensory capacity refers to the perceived ability of a medium or endorser to convey specific sensory experiences (Krishna *et al.*, 2014). This concept distinguishes between proximal sensory modalities such as touch, smell and taste which rely on close-range stimuli and distal modalities such as sight and sound which function effectively over distance (Zhou *et al.*, 2024). Consumers perceive proximal senses as more embodied and difficult to simulate, especially in virtual environments where the medium or endorser lacks a tangible, physical form (Luangrath *et al.*, 2022). This distinction is critical for AR and VR interfaces, where the mode of sensory communication can influence how messages are processed.

Given that AR overlays virtual content within a user's physical environment, it enables users to simulate or imagine bodily interactions such as touching or tasting more vividly (Ceylan *et al.*, 2024). As such, AR applications are better suited to conveying proximal

sensory experiences, which are highly embodied and contextually grounded (Lowry *et al.*, 2025). In contrast, VR tends to isolate users in a computer-generated environment, prioritizing visual and auditory channels over tactile or olfactory feedback (Ambika, Shin *et al.*, 2025). It is expected that sensory capacity will moderate the effects of AR and VR on customer engagement and behavioural response. Specifically, the benefits of AR will be enhanced under proximal sensory conditions, whereas VR will show greater effects under distal sensory conditions.

H2a. Sensory capacity (proximal vs distal) moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for proximal than telepresence distal.

H2b. Sensory capacity (proximal vs distal) moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for telepresence distal than proximal.

Customer level

Past experience. Past experience with technology refers to a customer's existing familiarity and competence in using a specific technology to support decision-making (Bonnin, 2020). Past experience not only influences future usage intentions but also shapes attitudes and behavioural responses towards technology-enabled interactions with firms (Manis and Choi, 2019). While extant literature does not offer a unified view on the role of prior experience in shaping responses to AR and VR, several studies underscore its significance. For instance, Bonnin (2020) finds that individuals with limited AR experience often lack the procedural knowledge needed to effectively engage with the technology, resulting in diminished outcomes relative to experienced users. Conversely, Hilken *et al.* (2018) suggest that limited exposure can also heighten the novelty and hedonic value of these technologies, potentially enhancing attitudes and purchase intentions in some cases.

As AR often requires users to interpret and interact with virtual elements layered on the physical world (Ambika, Shin *et al.*, 2025), higher levels of experience are expected to enable more fluid navigation and enhance both engagement and behavioural response (Deep *et al.*, 2025). Users familiar with AR are typically better able to align digital content with physical cues, interact with features more efficiently and overcome technical or perceptual barriers, thereby fostering more meaningful and effective experiences (Nadeem *et al.*, 2025). In contrast, VR presents consumers with a completely novel and self-contained environment that replaces the physical world, often delivering a sense of uniqueness and escapism that does not depend heavily on past experience (Nadeem *et al.*, 2025). For consumers with little to no exposure to VR, the immersive and unfamiliar nature of the environment may enhance curiosity, enjoyment and stimulation, thereby amplifying engagement and subsequent behavioural intentions (Barta *et al.*, 2025). The sensory novelty and psychological distance offered by VR can contribute to a more memorable and persuasive experience among first-time or infrequent users. Thus, we expect:

H3a. Past experience with AR (low vs high) moderates the relationship between this technology and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for high experience than low experience.

H3b. Past experience with VR (low vs high) moderates the relationship between technology and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for low experience than high experience.

Age. Among customer demographic variables, age is a crucial factor that moderates the effectiveness of customer responses to firm marketing activities. Age is also an essential variable in customer-technology interaction, especially in the TAM, where the younger generation tends to accept and use innovative technologies more than the older generation (Kim, 2016).

With regard to specific technologies, younger consumers are often more responsive to AR applications due to their comfort with real-time digital interaction, spatial awareness and multitasking capabilities (Romano *et al.*, 2022). Their familiarity with mobile interfaces and gamified content allows them to engage more fluidly with AR features, resulting in stronger attitudinal and behavioural outcomes (Smink *et al.*, 2022). Conversely, older consumers may respond more favourably to VR, as it offers guided, immersive experiences that do not require active coordination with the physical environment (de Amorim *et al.*, 2022). The self-contained nature of VR reduces the burden of managing the interplay between digital and real-world elements, making it more accessible and potentially more impactful for older users (Meißner *et al.*, 2020). Therefore, we expect:

H4a. Age moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for younger than for older consumers.

H4b. Age moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for older than for younger consumers.

Gender. Gender is a well-established individual difference factor in the technology adoption and customer experience literature (Richard *et al.*, 2010). It refers to socially constructed roles and psychological attributes associated with being male or female, which can influence how consumers process information and respond to marketing stimuli (Barta *et al.*, 2025). Research indicates that males and females differ in their cognitive styles and decision-making processes: females generally adopt a more comprehensive, detail-oriented information processing approach, while males are more likely to use selective, heuristic-based strategies (Kim *et al.*, 2021). These differences can influence how each gender engages with and evaluates technology-enabled experiences, particularly those involving novel or complex interfaces (Kim *et al.*, 2011).

When considering specific technologies such as AR and VR, these gender-based tendencies may lead to differential outcomes. VR environments offer rich sensory input and extensive information, which align well with females' preference for detailed and immersive content (Chu *et al.*, 2024). As such, females may exhibit stronger engagement and behavioural responses in VR contexts. In contrast, AR applications often require users to control, manipulate and interpret overlaid digital content in real-time, a process that may be more congruent with males' task-oriented and instrumental focus (Sands *et al.*, 2024). Males may also be more drawn to the novelty and technological innovation associated with AR, resulting in heightened engagement and behavioural intention. Thus, we expect:

H5a. Gender (male vs female) moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for males than females.

H5b. Gender (male vs female) moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for females than males.

Product level

Product familiarity

Product familiarity refers to a customer's prior experience and accumulated knowledge about a product, which shapes their expectations, confidence and decision-making processes (Dong *et al.*, 2025). This familiarity often determines how consumers seek and evaluate additional product-related information (Bonnin, 2020). Technologies such as AR and VR are frequently used to deliver product information in a more engaging and informative manner, particularly in retail and advertising contexts (Dong *et al.*, 2025). Prior research suggests that consumers with lower levels of product familiarity are more receptive to enhanced media formats, as these formats help compensate for their lack of knowledge and improve the quality of their purchase decisions (Wedel *et al.*, 2020). In contrast, consumers who are already familiar with the product may gain less incremental value from such experiences (Recalde *et al.*, 2024).

In the context of AR, customers benefit most when the technology enhances known product attributes, reinforcing decision confidence and engagement (Rauschnabel, 2021). Familiar products provide a cognitive foundation upon which AR's features such as 3D views or contextual overlays can add value, making interactions more relevant and efficient (Bonnin, 2020). In contrast, VR is beneficial for unfamiliar products, as it enables consumers to explore and understand new offerings in a fully simulated environment that guides the experience (Dong *et al.*, 2025). The novelty and richness of VR can compensate for limited prior knowledge and encourage exploration, thereby enhancing engagement and behavioural response (Rauschnabel, 2021). Thus, we expect:

H6a. Product familiarity (new vs. familiar) moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for new than familiar.

H6b. Product familiarity (new vs familiar) moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for familiar than new.

Product involvement

Product involvement refers to a customer's perception of a product or service in relation to their personal needs, values and interests (Serravalle *et al.*, 2023). It captures the degree to which the product is viewed as important or risky and thus worthy of cognitive effort and deliberation (Trivedi *et al.*, 2022). Higher product involvement leads consumers to engage in more elaborate information processing and deeper evaluation of product-related content (Nawres *et al.*, 2024). Technologies such as AR and VR are often used to support decision-making when customers require more input to reduce uncertainty and improve decision quality (Wedel *et al.*, 2020). Prior research suggests that these technologies are particularly effective when involvement is high, as they provide rich visual and experiential cues that

help address informational needs and enhance outcomes such as engagement and purchase intentions (Dong *et al.*, 2025).

However, the effectiveness of such technologies may vary depending on the type of experience they offer (Deep *et al.*, 2025). In high-involvement situations, AR allows customers to interact with detailed product information layered in real-world settings, facilitating analytical processing and reinforcing decision confidence (Nadeem *et al.*, 2025). In contrast, AR may be more effective in low involvement contexts, where consumers are less motivated to engage in deliberate evaluation (Barta *et al.*, 2025). In such cases, VR's ability to deliver emotionally rich and self-contained experiences can enhance engagement through affective rather than cognitive pathways (Deep *et al.*, 2025). Therefore, we expect:

H7a. Product involvement (low vs high) moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for high than low involvement products.

H7b. Product involvement (low vs high) moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for low than high-involvement products.

Product benefit

Product benefits are classified into hedonic and utilitarian categories based on the nature of the value they offer to consumers (Dhar and Wertenbroch, 2000). Utilitarian products are practical and functionally oriented, such as household appliances or banking services, whereas hedonic products are experiential, emotional and pleasure-driven, such as theme parks or fashion items (Attri *et al.*, 2024). Although existing research offers mixed findings regarding the moderating role of product benefit in technology based customer experiences, some evidence suggests that enhanced presentation formats can strengthen the perceived value of both product types (Kinzinger *et al.*, 2025). For example, utilitarian products may benefit from digital formats that provide clear, multisensory cues to support decision-making (Wedel *et al.*, 2020). At the same time, hedonic products may benefit from enriched presentation because they often lack concrete evaluative criteria, and consumers rely more on emotional or imaginative cues to form judgments (Xue *et al.*, 2024).

The effects of AR and VR are likely to vary depending on product type. AR, which supports real-time contextual interaction and facilitates feature-based product understanding, is expected to be more effective for utilitarian products (Zhang *et al.*, 2023). The practical orientation of these products aligns thoroughly with AR's capacity to deliver relevant, usage-focused content *in situ* (Lee *et al.*, 2024). Conversely, VR can simulate immersive scenarios and emotionally engaging environments, which aligns more closely with the affective and experiential nature of hedonic products (Xue *et al.*, 2024). By allowing customers to project themselves into a consumption experience mentally, VR enhances the appeal and persuasiveness of hedonic offerings. Thus, we expect:

H8a. Product benefit (hedonic vs utilitarian) moderates the relationship between AR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for utilitarian than hedonic products.

H8b. Product benefit (hedonic vs utilitarian) moderates the relationship between VR and customer (a) engagement and (b) behavioural response, such that these relationships are stronger for hedonic than utilitarian products.

Cultural value

Culture plays a critical role in shaping customer attitudes, expectations, and behaviours in response to marketing activities. It reflects a system of shared values, norms and practices that guide individual and collective behaviour within societies (Hofstede *et al.*, 2010). Cultural values have been shown to influence how consumers evaluate firm actions and interact with marketing channels (Palmatier *et al.*, 2006), making them essential variables in cross-national marketing research and meta-analyses (Barari *et al.*, 2021). Customers from different cultural backgrounds vary in their levels of trust, information-seeking behaviour and decision-making preferences, all of which affect how they respond to firm-driven engagement strategies. Despite growing interest in how culture moderates technology adoption and experience, its role in shaping responses to digitally mediated brand experiences has received limited empirical attention in past studies (Kumar *et al.*, 2021).

This study adopts Hofstede *et al.'s* (2010) cultural dimensions including individualism, power distance, masculinity, uncertainty avoidance and long-term orientation to examine how cultural values may moderate the relationship between AR and VR experiences and customer responses (Deep *et al.*, 2025). These dimensions are expected to influence the extent to which customers engage with or act upon digitally delivered brand content (Barta *et al.*, 2025). For example, consumers in individualistic cultures may prefer more autonomous and customized experiences, whereas those in collectivist cultures may prioritize shared or socially reinforced interactions. High power distance cultures may interpret hierarchical or status-enhancing content more favourably, while high uncertainty avoidance cultures may be more responsive to technologies that reduce perceived risk (Sands *et al.*, 2024). These cultural differences are likely to shape how customers engage with AR and VR experiences and translate these interactions into behavioural responses (Barta *et al.*, 2025). Thus, we expect:

H9. Cultural values (i.e. individualism, power distance, masculinity and uncertainty avoidance) moderate the relationship between AR and VR with a customer's (a) engagement and (b) behavioural response.

Method

Data collection and coding

A systematic approach was used to gather all published and unpublished research related to VR, AR and mixed reality to ensure a comprehensive analysis. Various online databases, such as ABI/INFORM Global, Business Source Complete, ProQuest Digital Dissertations, Scopus, SSRN, Emerald, Springer, ISI Web of Science and Taylor and Francis, were searched using relevant keywords. In addition, titles and abstracts of articles published in top marketing journals, such as the *Journal of Marketing, Journal of the Academy of Marketing Science, Journal of Marketing Research, Journal of Retailing, Journal of Consumer Research* and *Journal of Service Research*, were reviewed to ensure all relevant publications were included. The data collection was finalized in March 2025 and resulted in 2,856 publications.

Inclusion and exclusion criteria were then defined to ensure the gathered publications met the study's criteria. Empirical research that provided a correlation coefficient as effect size or enough information to calculate it was included, while review papers or empirical research that did not study at least one relationship in the model were excluded. Only studies in English were included, and empirical research in other languages was excluded. After applying these criteria, 208 papers (AR: 147, VR: 57 and AR/VR: 3) with 235 studies (AR: 165, VR: 66 and AR/VR: 4) total sample size of 59,954 were included in the final data set.

Table 2. Research main variables definitions and aliases

Constructs	Definitions	Aliases/operationalizations	Related research
Closeness	The perceived spatial proximity between the user and virtual content during AR or VR interaction	Closeness, perceived physical closeness; perceived proximity	Poushneh (2021), Rauschnabel *et al.* (2024)
Telepresence	A psychological state in which users feel present inside a computer-generated virtual environment	Telepresence, virtual transportation; VR presence	Lee *et al.* (2024)
Local presence	A psychological state in which users perceive virtual elements as integrated into their immediate physical surroundings	Local presence, presence in physical environment; AR presence	Schein *et al.* (2025)
Mental imagery	Representation of objects, such as products and services, in the customer's mind, is facilitated by AR and VR technologies	Mental intangibility, tangibility	Bogicevic *et al.* (2019), Heller *et al.* (2019a)
Decision comfort	The effectiveness of retailers in simplifying customer decision-making for choosing specific products via AR and VR technologies	Decision ease, decision-making comfort	Heller *et al.* (2019a, 2019b)
User experience	The unique and enjoyable experience customers have during their interaction with AR and VR technologies	Unique experience, enjoyment, excitement	Alimamy and Nadeem (2021), Batat (2021)
Flow	The state of being completely involved in an activity through AR and VR technologies leads to optimal experience	Flow, immersion, cognitive absorption	Arghashi and Yuksel, (2022), Brannon Barhorst *et al.* (2021)
Perceived ease of use	The degree to which a person believes that using a specific system or technology would be effortless	Ease of use, perceived ease	Arghashi and Yuksel, (2022), Plotkina and Saurel (2019)
Perceived usefulness	The extent to which a user believes that using a particular system or technology will enhance their performance	Usefulness, enhancing performance	Arghashi and Yuksel (2022); Plotkina and Saurel (2019)
Privacy concern	Concerns about how personal information is collected, accessed, used and protected by AR and VR technologies	Privacy issues, data protection	Feng and Xie, (2019), Poushneh, (2018)
Perceived risk	The uncertainty and potential negative consequences associated with the use of a retailer, product or technology	Financial risk, psychological risk, social risk, risk beliefs, risk perceptions	Feng and Xie, (2019), Poushneh, (2018)
Satisfaction	The emotional response or affective state resulting from the technology experience	User satisfaction, emotional reaction	Butt *et al.* (2022), Chiu *et al.* (2021)
Attitude	The predisposed emotional response or feelings toward objects, attributes or interests associated with AR and VR technologies	Attitude toward AR and VR technologies	Alimamy and Al-Imamy (2021), Holdack *et al.* (2022)
Engagement	The non-financial investment customers make in maintaining a relationship with a brand beyond mere transactions	Consumer engagement, behavioural engagement, WOM	Arghashi and Yuksel, (2022), Cuomo *et al.* (2015)
Behavioural response	The actions and intentions of customers toward AR and VR technologies, ranging from purchase to active participation	Purchase intention, usage, reuse, loyalty, co-creation of value, resource integration	Bonnin, (2020), He *et al.* (2018)

Source(s): Developed by the author

Table 3. Research moderator variables definitions and operationalizations

Moderator	Definition	Operationalizations
Perceived physical closeness	The extent to which the customer is physically present at the location where the AR or VR experience occurs	Local = 1 vs Telepresence = 0
Sensory capacity	The type of sensory modality emphasized in the AR or VR experience. Proximal senses require bodily proximity (e.g. touch), while distal senses operate over distance (e.g. sight, sound)	Proximal =1 vs Distal = 1
Experience	The extent of the customer's exposure to AR or VR technologies before participating in the study	Low past experience = 1 vs High past experience = 0
Customer age	The average age of participants in the study sample	Average age of participants, expressed in years
Customer gender	The gender composition of the study sample	Proportion of female participants in the sample
Product familiarity	The customer's prior knowledge or experience with the product featured in the AR or VR environment	New product = 1 vs Familiar Product = 0
Product involvement	The perceived relevance and importance of the product featured in the AR or VR experience	Low Involvement = 1 vs High involvement = 0
Product benefits	The type of benefits the product offers when presented through AR or VR – either experiential or functional	Hedonic product = 1 vs Utilitarian product = 0
Cultural value	National cultural dimensions that influence customer responses to AR or VR experiences, based on Hofstede *et al*'s (2010) framework	Scores for individualism, power distance, uncertainty avoidance, masculinity and long-term orientation, each ranging from 0 to 100

Source(s): Developed by the authors

A coding manual was developed to clarify the details of all variables in the model to ensure the quality of the coding process (see Tables 2 and 3). Two coders, one of whom was an independent coder not involved in the research team, were used to code the studies in the meta-analysis process. Both coders independently coded the studies to enhance the quality of the coding process. The inter-coder agreement was 96%, indicating high coding quality. In case of any discrepancies, differences in the coding process were resolved through discussion.

Effect size preparation

Similar to previous meta-analyses, we used a random-effect meta-analysis method to combine effect sizes separately from AR and VR obtained from the coding process (Hunter and Schmidt, 2004). As most of the publications included in our final data set reported correlation coefficients, this metric was chosen as the basis for the effect size. However, some studies did not report correlation coefficients, and for these publications, we used available data, such as standardized regression coefficients, to calculate the correlation coefficient. Subsequently, the correlation coefficients were adjusted for variable reliabilities to correct for measurement error (Hunter and Schmidt, 2004), and these reliability adjusted correlations were weighted by their respective sample sizes. In addition, we used the Q statistic test to assess the homogeneity of effect sizes. To mitigate the file drawer issue, we

followed a systematic process to include all relevant publications in our analysis. Furthermore, we calculated fail-safe Ns to ensure that the file drawer issue did not pose a potential problem in our meta-analysis.

Main model and moderator analysis

To test the main model separately for AR and VR, two-stage structural equation modelling (TSSEM) was used to investigate the relationships among variables. The first stage involved pooling the correlation matrices obtained from individual studies separately for AR and VR to create a composite correlation matrix. This correlation matrix was then used as input to test AR and VR conceptual frameworks.

As for moderator analysis and to account for dependencies between effect sizes extracted from each sample, we used hierarchical linear models (HLM) to examine the impact of moderators on conceptual models for AR and VR. Following Hox's (2010) approach, we specified effect size as the dependent variable and mediators and dependent variables as predictors at level 1, while moderators were included at level 2 of both AR and VR models.

We included the outcome variable at level 1 and all moderators at level 2. This approach allowed us to examine the potential moderating effects of these factors on the relationship between the predictors and the outcome variable. Because HLM does not provide direct statistics for assessing multicollinearity among predictor variables, we used variance inflation factors (VIFs) to detect its presence in our data. The VIFs indicated that multicollinearity was not a significant issue and did not substantially impact our findings. These results suggest that our analysis is robust and reliable, and that multicollinearity is unlikely to have biased our results.

Data analysis

Descriptive analysis

Table 4 presents the results of the descriptive analysis of our effect size integration calculated separately for AR and VR across various consumer response variables. Both technologies exhibit significant positive effects across a wide range of constructs. VR outperforms AR in several areas, including mental imagery ($r_{AR} = 0.40$ vs $r_{VR} = 0.49$; $\Delta = -0.09$; $p < 0.001$), user experience ($r_{AR} = 0.41$ vs $r_{VR} = 0.52$; $\Delta = -0.11$; $p < 0.001$) and flow ($r_{AR} = 0.37$ vs $r_{VR} = 0.51$; $\Delta = -0.14$; $p < 0.001$). On the other hand, AR shows significantly stronger effects in decision comfort ($r_{AR} = 0.48$ vs $r_{VR} = 0.36$; $\Delta = 0.12$; $p < 0.001$), ease of use ($r_{AR} = 0.51$ vs $r_{VR} = 0.39$; $\Delta = 0.12$; $p < 0.001$), and usefulness ($r_{AR} = 0.49$ vs $r_{VR} = 0.40$; $\Delta = 0.09$; $p < 0.001$).

Among the key outcome variables, behavioural response and engagement show distinctive patterns. AR has a more substantial effect on behavioural response ($r = 0.48$) compared to VR ($r = 0.42$; $\Delta = 0.06$; $p < 0.001$), suggesting AR is more effective in driving consumer action. In contrast, VR significantly outperforms AR in enhancing engagement ($r_{VR} = 0.51$ vs $r_{AR} = 0.40$; $\Delta = -0.11$; $p < 0.001$), indicating that VR offers a more involving experience.

Finally, regarding negative consumer responses, both AR and VR show significant adverse effects on privacy concerns ($r_{AR} = -0.28$; $r_{VR} = -0.26$) and perceived risk ($r_{AR} = -0.32$; $r_{VR} = -0.30$), although the differences between the two technologies on these variables are not statistically significant ($p > 0.05$).

Results of structural equation modelling

The result of testing our conceptual models using TSMETA separately for AR and VR is provided in Table 5. Model fit indices for AR (CFI = 0.910, RMSEA = 0.040, TLI = 0.883) and VR (CFI = 0.910, RMSEA = 0.041, TLI = 0.886) indicate good fit across both conditions.

Table 4. Average effect of AR versus VR on consumer response

	AR					VR					
Relationship	K	N	r_{cw}	Q	FSN	K	N	r_{cw}	Q	FSN	AR vs VR
Mental imagery	16	4,010	0.40*	421*	341	6	1,560	0.49*	198*	101	VR > AR
Decision comfort	11	2,850	0.48*	282*	211	5	1,490	0.36*	121*	89	VR < AR
User experience	41	10,250	0.41*	459*	1,478	10	2,960	0.52*	241*	196	VR > AR
Flow	28	7,121	0.37*	301*	629	9	2,650	0.51*	211*	214	VR > AR
Ease of use	19	4,860	0.51*	348*	467	9	2,560	0.39*	231*	201	VR < AR
Usefulness	14	3,580	0.49*	263*	295	7	1,561	0.40*	165*	109	VR < AR
Privacy concern	11	2,650	−0.28*	209*	198	4	890	−0.26*	84*	36	No significant difference
Perceived risk	16	4,110	−0.32*	379*	356	6	1,211	−0.30*	98*	42	No significant difference
Attitude	32	8,220	0.39*	858*	602	12	1,890	0.42*	312*	211	No significant difference
Satisfaction	41	10,890	0.47*	701*	1,321	13	1,991	0.50*	341*	245	No significant difference
Engagement	16	4,121	0.40*	308*	398	7	1,012	0.51*	210*	106	VR > AR
Behavioural response	67	16,589	0.48*	998*	1,058	22	3,210	0.42*	698*	612	VR< AR

Note(s): K is number of effect sizes; N is cumulative sample size; r_{cw} is reliability adjusted and sample size weighted correlation; Q is Q statistic; FSN is fail-safe N. $^{*}p < 0.01$
Source(s): Developed by the authors

Table 5. Result of different model testing

Relationships	AR integrated model			VR integrated model		
	β	Sd	R^2(%)	β	Sd	R^2(%)
Technology → mental imagery	0.40*	0.06	16	0.49*	0.07	24
Technology → telepresence	–	–	–	0.48*	0.07	23
Technology → local presence	0.46*	0.07	21	–	–	–
Technology → user experience	0.41*	0.06	17	0.52*	0.08	27
Technology → flow	0.37*	0.06	14	0.51*	0.08	26
Technology → perceived ease of use	0.51*	0.08	26	0.39*	0.06	15
Technology → perceived usefulness	0.49*	0.07	24	0.40*	0.06	16
Technology → privacy concern	−0.28*	0.04	8	−0.26*	0.04	7
Technology → perceived risk	−0.32*	0.05	10	−0.30*	0.04	9
Technology → decision comfort	0.48*	0.07	23	0.36*	0.05	13
Telepresence→ attitude	–	–	–	0.38*	0.07	15
Telepresence→ satisfaction	–	–	–	0.41*	0.07	17
Local presence→ attitude	0.33*	0.06	12	–	–	–
Local presence→ satisfaction	0.36*	0.06	13	–	–	–
User experience → attitude	0.41*	0.06	17	0.52*	0.08	27
Flow → attitude	0.37*	0.06	14	0.51*	0.08	26
User experience → satisfaction	0.41*	0.06	17	0.52*	0.08	27
Flow → satisfaction	0.37*	0.06	14	0.51*	0.08	26
Perceived ease of use → attitude	0.51*	0.08	26	0.39*	0.06	15
Perceived usefulness → attitude	0.49*	0.07	24	0.40*	0.06	16
Perceived ease of use → satisfaction	0.51*	0.08	26	0.39*	0.06	15
Perceived usefulness → satisfaction	0.49*	0.07	24	0.40*	0.06	16
Privacy concern → attitude	−0.28*	0.04	8	−0.26*	0.04	7
Perceived risk → attitude	−0.32*	0.05	10	−0.30*	0.04	9
Privacy concern → satisfaction	−0.28*	0.04	8	−0.26*	0.04	7
Perceived risk → satisfaction	−0.32*	0.05	10	−0.30*	0.04	9
Decision comfort → engagement	0.48*	0.07	23	0.36*	0.05	13
Decision comfort → behavioural response	0.48*	0.07	23	0.36*	0.05	13
Attitude → engagement	0.39*	0.06	15	0.42*	0.06	18
Attitude → behavioural response	0.39*	0.06	15	0.42*	0.06	18
Satisfaction → engagement	0.47*	0.07	22	0.50*	0.07	25
Satisfaction → behavioural response	0.47*	0.07	22	0.50*	0.07	25
CFI	0.909			0.910		
RMSEA	0.039			0.040		
TLI	0.882			0.885		

Source(s): Developed by the author

Importantly, the pattern of relationships was broadly consistent: in both models, the core technology construct significantly influenced cognitive (perceived usefulness, ease of use), affective (user experience, flow) and evaluative (decision comfort, privacy concern, perceived risk) responses. These intermediate variables, in turn, predicted key outcomes such as attitude, satisfaction, engagement and behavioural response. Across both models, decision comfort, satisfaction and attitude consistently emerged as critical drivers of customer engagement and behavioural response.

In line with spatial presence theory, the two models also demonstrated distinct presence-based mechanisms. In the AR model, technology significantly predicted local presence, which in turn enhanced both attitude and satisfaction. In the VR model, technology strongly predicted telepresence, and telepresence significantly improved attitudinal and satisfaction-related responses. These results indicate that each technology activates its characteristic

presence state, local presence for AR and telepresence for VR, which then shapes downstream evaluations.

Despite these similarities, the results also reveal meaningful differences in the strength of effects across the two technologies. In the VR model, technology had a stronger impact on user experience and flow, which in turn led to higher levels of engagement. This outcome suggests that the emotionally rich and effective nature of VR makes it particularly effective in stimulating user involvement. The VR model also showed a strong effect of telepresence on both attitude and satisfaction, indicating that being immersed "in" the virtual environment enhances users' affective evaluations and contributes to this heightened engagement response.

In contrast, the AR model showed relatively stronger effects on behavioural response, primarily driven by cognitive and evaluative components such as perceived ease of use, perceived usefulness, decision comfort and, thereby, behavioural response. Consistent with this pattern, the AR model also demonstrated that local presence significantly improved attitude and satisfaction, reinforcing AR's ability to integrate virtual content into the physical environment and support more deliberate, task-focused decision-making. This effect indicates that AR supports more deliberate, task-focused processing, enabling customers to act on their intentions more readily.

Results of moderator analysis

Table 6 presents the results of the moderator analysis, exploring the influence of moderator variables on the relationships between AR and VR technologies and customer outcomes.

Table 6 also presents the results of the moderator analysis examining how various contextual and individual-level variables shape the relationships between AR and VR and customer outcomes. Overall, the findings align with our previous findings, confirming that the effects of AR and VR on engagement and behavioural response are not uniform but depend on specific conditions. Several moderators showed significant effects, reinforcing the theoretical rationale that different mechanisms are activated depending on the technology type, user profile, product characteristics and cultural context.

At the technology level, physical closeness (H_1) significantly moderated the effects of AR but not VR, with local conditions enhancing both engagement and behavioural responses in the AR model. This result supports the idea that AR works better when users are physically present, reinforcing spatial alignment and contextual relevance. Sensory capacity (H_2) also showed contrasting effects: while proximal modalities improved outcomes for AR, distal modalities were more effective for VR, supporting the sensory fit logic outlined earlier.

At the customer level, experience (H_3) strengthened the effect of AR but had no significant impact on VR, indicating that familiarity helps users navigate AR features more efficiently, while the novelty of VR can still engage users without prior experience. Age (H_4) does not have any significant moderating effect but gender (H_5) played a differential role: females responded more favourably to VR but less so to AR in terms of behavioural response, aligning with prior evidence that females may find emotionally rich and guided environments more engaging, while AR requires more self-directed interaction.

At the product level, product familiarity (H_6) significantly enhanced the impact of VR but not AR, particularly for engagement, supporting the notion that VR can help consumers explore unfamiliar products more vividly. Involvement (H_7) had the opposite pattern, low involvement dampened AR outcomes but had no significant effect on VR, suggesting that AR is more effective for high-involvement decisions where users are motivated to process detailed information. Product benefit (H_8) moderated behavioural responses in both models but in opposite directions hedonic products reduced AR impact but boosted VR outcomes, reinforcing the idea that VR aligns better with emotional and experiential consumption.

Table 6. Results of moderator analysis

		Augmented reality (a)				Virtual reality (b)			
		Engagement		Behavioural response		Engagement		Behavioural response	
	Moderators	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
	Intercept	0.18	0.92	0.20	0.89	0.20	0.83	0.22	0.88
	Technology level								
H_1	Local (vs telepresence)	0.42*	0.21	0.38*	0.19	−0.19	0.29	−0.18	0.11
H_2	Proximal (vs distal)	0.30*	0.13	0.26*	0.12	−0.36*	0.64	−0.32*	0.16
	Customer level								
H_3	High experience (vs low)	0.38*	0.18	0.34*	0.16	−0.28	0.18	−0.26	0.18
H_4	Age	0.14	0.96	0.16	0.94	0.18	0.92	0.20	0.9
H_5	Female (vs Male)	−0.10	0.2	−0.32*	0.16	0.28*	0.13	0.32*	0.16
	Product level								
H_6	Low familiarity (vs high)	0.18	0.28	−0.20	0.30	0.65*	0.31	0.36*	0.16
H_7	Low involvement (vs high)	−0.36*	0.16	−0.27*	0.13	0.10	0.21	0.12	0.18
H_8	Hedonic benefit (vs utilitarian)	−0.28	0.38	−0.30*	0.14	0.36*	0.16	0.25	0.30
	National level								
H_9	Individualism	0.29*	0.14	0.35*	0.16	0.29*	0.14	0.18	0.36
	Power distance	−0.08	0.18	−0.10	0.21	−0.12	0.22	−0.14	0.24
	Masculinity	0.20	0.17	0.09	0.16	0.12	0.36	0.10	0.26
	Uncertainty avoidance	0.22	0.88	0.42*	0.16	0.36*	0.14	0.16	0.36

Source(s): Developed by the author

At the national level, individualism (H_9) strengthened engagement effects across both technologies, suggesting that individualist consumers may appreciate the personalized control offered by these experiences. Uncertainty avoidance significantly moderated behavioural responses for both AR and VR, suggesting that such technologies can be particularly persuasive in cultures that value risk reduction.

Discussion

This meta-analysis reveals clear distinctions between AR and VR in shaping customer responses. While both technologies enhance consumer decision-making and experience, they do so through different psychological mechanisms and produce different outcome patterns. Overall, AR is more effective in driving behavioural responses, whereas VR is more effective in generating customer engagement. These findings underscore the importance of analysing AR and VR separately rather than treating them as interchangeable technologies. By proposing and testing integrated structural models for each technology, this study offers a more precise explanation of how AR and VR influence consumers through distinct underlying processes.

Building on previous research, we developed a model that incorporates both positive and negative mediation pathways, including decision comfort, user experience, flow, technology acceptance variables (perceived usefulness and ease of use), privacy concerns and perceived risk. The results confirm that these mechanisms significantly explain the ways in which AR and VR shape engagement and behavioural responses. Importantly, the findings clarify that AR effects are primarily driven by cognitive and evaluative mechanisms such as perceived ease of use, perceived usefulness, and decision comfort which support goal-directed and task-focused behaviour. In contrast, VR operates more strongly through affective and experiential mechanisms particularly user experience, flow and telepresence which create immersive emotional experiences that promote deeper engagement.

The inclusion of spatial presence theory further strengthens this distinction. In AR, local presence (the integration of virtual objects into the physical environment) improved attitude and satisfaction, highlighting AR's ability to support situated, context-dependent decision-making. In VR, telepresence (the sense of being "inside" the virtual environment) significantly enhanced affective evaluations, reinforcing VR's capacity to generate fully immersive and emotionally rich experiences. These presence-based pathways provide a coherent explanation for the divergent effects of AR and VR and represent a novel contribution to the literature.

To explain variation across prior studies, we also examined moderators across four levels: technology, customer, product and national. The results show that AR is more effective when consumers have physical proximity to the context, high product involvement, or prior experience with the technology. VR performs better under conditions of product unfamiliarity, hedonic value and among female users. At the national level, cultural dimensions such as individualism and uncertainty avoidance significantly moderate both AR and VR effects, suggesting that cultural context shapes how consumers interpret and respond to immersive technologies. Collectively, these findings offer a comprehensive explanation for heterogeneity in prior research and clarify the conditions under which each technology is more likely to succeed.

Theoretical contributions

Augmented reality drives behavioural response, while virtual reality enhances customer engagement

This study advances AR and VR research by offering a clearer explanation of how these technologies differ in *shaping* customer responses. Previous work has compared AR and VR but often treats them as functionally similar or places them on a single immersive continuum (Flavián *et al.*, 2019; Hilken *et al.*, 2022; Orús *et al.*, 2021). Our findings show a distinct

pattern: AR is more effective in driving customer behavioural responses, whereas VR is more effective in generating engagement. This distinction reflects the underlying mechanisms of each technology. AR supports task-focused, goal-driven behaviour by increasing decision confidence and integrating virtual elements into the real environment, which reduces uncertainty and facilitates action (Rauschnabel *et al.*, 2022). VR, in contrast, generates deeper emotional and experiential involvement, as users enter self-contained virtual environments that stimulate affective reactions and immersive attention (Rauschnabel *et al.*, 2022). Importantly, this study extends existing theory by incorporating spatial presence theory to explain these differences. AR strengthens local presence, supporting evaluation and decision-making, whereas VR strengthens telepresence, intensifying emotional engagement. This theoretical integration provides a more complete explanation of why AR leads to behaviour and VR leads to engagement.

Integrated mediation explains augmented reality and virtual reality responses better than single-path models

Our integrated structural model demonstrates that customer reactions to AR and VR arise from multiple complementary mechanisms: decision fluency, experiential processing, technology acceptance and spatial presence. Each mechanism contributes differently for AR and VR. Decision fluency enhances mental imagery and decision comfort by making product information more vivid (Heller *et al.*, 2019b). Experiential processing explains how enjoyment, user experience and flow drive affective evaluations (Jung *et al.*, 2021). The TAM (Saleem *et al.*, 2021) highlights how perceived usefulness and ease of use shape attitudes and satisfaction. Spatial presence theory clarifies how telepresence and local presence affect users' cognitive and emotional states. Our results show that AR is more strongly driven by decision fluency and perceived usefulness, supporting cognitive and evaluative pathways. VR is more strongly driven by emotional and experiential mechanisms, supporting immersive and affective pathways. This multi-path approach shows that similar outcomes (i.e. behaviour or engagement) arise through different processes depending on the technology, offering a more nuanced theoretical explanation for AR–VR differences.

Augmented reality and virtual reality create both positive and negative customer responses

By modelling both positive and negative mediation pathways, this study contributes a more balanced theoretical view of immersive technology effects. While AR and VR enhance confidence, enjoyment and involvement, they can also increase privacy concerns and perceived risk, which diminish attitudes and satisfaction and suppress behavioural and engagement intentions (Lim *et al.*, 2025). Prior work often emphasizes the benefits of immersive technologies, but our findings show that these tools can simultaneously support and hinder consumer response, particularly when users feel overwhelmed, lack control or question data privacy (Rauschnabel *et al.*, 2022). This dual-pathway perspective extends customer–technology interaction theory by recognizing that immersive systems can trigger both facilitating and inhibiting processes.

Context shapes the effectiveness of augmented reality and virtual reality

Our moderator analysis clarifies the contextual conditions under which each technology performs best. At the technology level, AR is more effective in local, physically co-present settings and when experiences rely on proximal sensory cues, whereas VR performs better when distal cues and full immersion dominate (Rauschnabel *et al.*, 2024). At the customer level, prior technology experience enhances AR outcomes by improving processing fluency, while VR appears less dependent on prior exposure. Gender also shapes VR responses, with

female users showing stronger engagement, consistent with research on emotional responsiveness. At the product level, AR is more effective for high-involvement and evaluation-heavy products, whereas VR is more effective for hedonic and unfamiliar products where emotional stimulation is valuable. At the national level, cultural values such as individualism and uncertainty avoidance moderate both AR and VR effects, suggesting that cultural context plays a critical role in how consumers interpret immersive experiences.

Managerial implications

AR and VR have become central tools in marketing strategies across retail, tourism, entertainment and service industries (Dwivedi *et al.*, 2021), yet many managers still lack clarity on how these technologies differ in their influence on customer responses. This research provides a unified framework and empirical evidence to help marketing managers better align technology choices with strategic goals.

Firstly, managers should select the appropriate technology based on the desired outcome. Our findings show that VR is more effective for enhancing customer engagement, while AR is more effective for influencing behavioural responses such as purchase intention. These results echo earlier findings that VR excels in creating immersive, emotionally rich experiences suited to storytelling, brand building and exploration (Flavián *et al.*, 2019). In contrast, AR's strength lies in supporting evaluation and decision-making by overlaying relevant information onto the physical environment, which reduces uncertainty and increases confidence (Hilken *et al.*, 2017; Rauschnabel *et al.*, 2022). Managers can therefore use VR for deep engagement such as virtual tours, fashion runways, or product demonstrations and AR for decision support applications such as try-ons, feature comparison, or contextual product placement.

Secondly, marketing strategies should reflect the psychological mechanisms through which each technology operates. VR relies more on emotional involvement, telepresence and immersive flow to create engagement (Witmer and Singer, 1998). This makes VR ideal for categories where emotional stimulation is critical, such as entertainment, travel, luxury or hedonic goods. AR, however, operates more through cognitive and evaluative pathways, including perceived usefulness, ease of use and decision comfort (Heller *et al.*, 2019b; Poushneh, 2021). AR is therefore better suited for contexts requiring clarity, product comparison and real-time information such as common in retail, utilities and home improvement. Managers should design VR content that heightens immersion and narrative richness, whereas AR content should prioritise accuracy, usability and contextual relevance.

Thirdly, managers must recognise that AR and VR carry risks that can undermine trust and reduce adoption. Privacy concerns, surveillance anxiety and loss of control can negatively shape attitudes and behavioural responses, particularly when personal data is captured through sensors, cameras or biometric inputs (Rauschnabel *et al.*, 2018). Past cases such as Google Glass illustrate how privacy mismanagement can derail even technologically advanced solutions. Firms should therefore adopt transparent data practices, provide clear consent options, communicate safeguards and emphasize ethical data use to reduce perceived risk and increase customer confidence.

Fourthly, the moderator analysis offers practical guidance for targeting different customer segments. At the customer level, AR works better among users with prior technology experience, who can easily navigate interactive interfaces (Ameen *et al.*, 2022). VR, however, generates strong engagement even among inexperienced users due to its intuitive immersive properties (Jung *et al.*, 2021). Gender also plays a role: women tend to respond more positively to VR, consistent with research linking female consumers to higher emotional involvement in immersive environments (Poushneh, 2021), whereas AR responses are more favourable among male users who prefer task-oriented, information-rich

interaction. Although younger consumers engage readily with both technologies, older consumers may benefit from low-stakes, hedonic VR applications such as virtual travel experiences to ease adoption barriers.

Fifthly, product characteristics should guide the selection of AR or VR. VR is particularly effective for unfamiliar, experiential and hedonic products, allowing customers to explore offerings in depth and form emotional connections (Hilken *et al.*, 2017). AR is more effective for high-involvement or risk-sensitive products, where consumers need accurate information and context to support decision-making. For example, AR furniture apps, home renovation tools and cosmetics try-on platforms can simplify and accelerate the path to purchase by demonstrating product fit in real contexts.

Finally, managers operating across cultures should consider national differences in consumer responses to AR and VR. The findings show that outcomes are stronger in individualistic cultures and in markets with higher uncertainty avoidance, aligning with research that suggests immersive technologies reduce ambiguity and support personal control (Schein *et al.*, 2025). In contrast, markets with high power distance or low digital maturity may require additional onboarding, education and framing that emphasizes simplicity and reassurance. Tailoring AR and VR experiences to cultural expectations can therefore improve adoption and customer satisfaction.

Future research directions

Like previous meta-analyses, this study has limitations that provide promising avenues for further research. Table 7 outlines areas that require additional theoretical and empirical attention to advance the understanding of AR and VR applications in consumer contexts.

Table 7. Summary of future research directions

Research areas	Future research directions
AR and VR technologies and data privacy	• What theoretical frameworks can explain how AR and VR influence consumer perceptions of data privacy? • How do users, developers, and policymakers prioritize privacy concerns in AR and VR contexts? • How can tools like blockchain or differential privacy be used to strengthen data protection in AR and VR applications?
AR and VR technologies through customer journey	• How can models such as the customer journey map or service-dominant logic explain the role of AR and VR in shaping retail experiences? • How can user-centred design principles improve AR and VR usability and alignment with customer expectations?
Advancements in AR and VR technologies	• What are the most promising innovations in AR and VR for retail and marketing? • How can new developments be effectively integrated into existing commerce platforms to enhance consumer experience and operational outcomes?
AR and VR technologies as a marketing insight tool	• What is the potential of AR and VR to provide deeper behavioural and attitudinal insights for consumer research? • How can these technologies be integrated into marketing strategies for experimentation and diagnostics?

Source(s): Developed by the authors

Augmented reality and virtual reality technologies and data privacy

Our meta-analysis review indicates that there is a lack of research on how data privacy concerns impact customer interaction with AR and VR technologies in the retail context. Therefore, future research should explore this area in more depth. One area that could be explored further is the application of theoretical frameworks, such as the privacy calculus model or the social shaping of technology framework, to understand this relationship better. In addition, research could investigate how different stakeholder groups, including customers, retailers and policymakers, perceive and prioritize data privacy concerns in the context of AR and VR technologies. This examination could involve conducting surveys or focus groups to gain insights into stakeholders' attitudes and beliefs about data privacy in AR and VR technologies. Finally, emerging technologies such as blockchain and differential privacy have the potential to enhance data privacy protections in AR and VR technologies applications. Future research could explore how these technologies can be leveraged to address data privacy concerns in the retail context and what theoretical frameworks can be used to guide their implementation.

Augmented reality and virtual reality technologies and customer journey

Our meta-analysis review has identified a gap in the research on the role of AR and VR technologies in shaping customer experiences throughout the retail journey. One potential avenue for research is to apply theoretical models, such as the retail journey map or the service-dominant logic framework, to more thoroughly understand the role of AR and VR technologies in shaping customer experiences in the retail context. In addition, user-centred design principles can be applied to create AR and VR technologies experiences that are intuitive, engaging and aligned with customer needs and preferences in retail. These occurrences could involve conducting user research, prototyping, and iterative testing to ensure that AR and VR technologies experiences meet customer expectations and contribute positively to the retail journey. Furthermore, research could investigate how the integration of AR and VR technologies into existing touchpoints in the retail journey, such as product discovery or post-purchase support, can enhance the overall customer experience.

New advancements in augmented reality and virtual reality technologies

Our meta-analysis review indicates that the field of AR and VR technologies is rapidly advancing, with new technologies and applications emerging on a regular basis. Therefore, future research in this area could focus on identifying the most promising new advancements in AR and VR technologies and investigating their potential applications in online retailing. One potential area of research could be exploring the use of AR and VR technologies, such as virtual try-on and AR, to enhance the online shopping experience and improve customer engagement. Another area of research could be investigating the use of AR and VR technologies for showrooming, allowing customers to view and interact with products in a virtual space before making a purchase decision. In addition, research could focus on the development of new AR and VR technologies hardware and software platforms that are designed explicitly for e-tailing and investigate their potential applications for improving the efficiency and effectiveness of online retail operations.

Furthermore, future research could study how these new advancements in AR and VR technologies can be effectively integrated into existing e-tailing platforms and applications. This combination could involve exploring the challenges and opportunities associated with integrating new technologies into existing e-commerce systems, as well as investigating how these advancements can be leveraged to improve the user experience and create new opportunities for growth and profitability.

Augmented reality and virtual reality technologies as a marketing insight tool

Based on our meta-analysis, there is currently a lack of research on the implications of AR and VR technologies as a marketing insight tool for consumer behaviour research and understanding. This critical gap in our knowledge is demonstrated in the potential that AR and VR technologies should provide new and innovative ways to understand consumer behaviour, preferences and decision-making processes. Future research in this area could focus on identifying the most effective use cases for AR and VR technologies as a marketing insight tool and exploring how these tools can be integrated into existing research methods to provide new insights and perspectives on consumer behaviour. In addition, research could investigate the potential impact of AR and VR technologies on consumer attitudes and perceptions, and the implications of these findings for marketing strategies and tactics.

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