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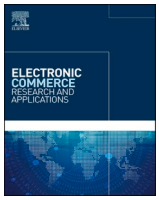

ECRA Executive Article

How extended reality influences e-commerce consumers: A literature review

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ABSTRACT

Extended reality (XR) has attracted the attention of both scholars and practitioners, and the literature addressing XR in the e-commerce context has expanded. Based on the reviewed literature, the current study applied a systematic literature review method to investigate XR use in e-commerce at the individual-consumer level. It aimed to holistically explain how XR use affects individual consumers in B2C e-commerce. The screening of 71 selected peer-reviewed journal articles that had been published since 2000 enabled the current research to identify which factors affect XR use in B2C e-commerce for individual consumers. Specifically, this study analyzed the effects of stimuli on consumers' cognitive, emotional, attitudinal, and behavioral responses to XR-based e-commerce and the interacting effects among technological, consumer, and product-related factors. Based on the literature review's findings, an integrated framework is proposed to explain how XR influences individual e-commerce consumers, and four avenues for future research are recommended. This study provides scholars with a holistic understanding of how XR affects consumers in B2C e-commerce at the individual level. It also provides e-commerce practitioners with useful guidelines concerning consumer experience management in XR-based online shopping.

1. Introduction

E-commerce has become a popular alternative to shopping at offline stores. However, e-commerce companies also face fierce competition in the market. To enhance customer service quality, meet customer needs, and maintain competitive advantages, more and more e-commerce companies are deploying innovative digital technologies such as extended reality (XR), including virtual reality (VR) and augmented reality (AR), in their e-commerce. Such companies include Alibaba, Walmart, and IKEA. This business mode, also called x-commerce, has been defined as the application of immersive XR technologies to e-commerce to offer consumers experiences similar to those of brick-and-mortar stores (Morotti et al., 2021). XR has been proposed to provide individual consumers with realistic, immersive, 3D shopping experiences, such as trying on apparel and accessories and augmenting product or service information to support consumers' online purchasing decisions (Kang et al., 2020; Chiang et al., 2021; Gabriel et al., 2023). For instance, the furniture giant IKEA launched its first version of an AR try-on app that offers consumers vivid try-on experiences and supports their decisions when purchasing IKEA products online (Sohu, 2017). To strengthen XR's application in B2C e-commerce, it is imperative to understand how XR affects individual consumers during their online shopping because consumers' acceptance of XR in this process is vital to the success of XR implementation in e-commerce.

Previous research has investigated XR's impact on individual consumers in a wide range of e-commerce contexts and through many theoretical lenses (Brito et al., 2018; Altarteer and Charissis, 2019; Han et al., 2021; Hsiao and Lin, 2023; Li et al., 2023; Ricci et al., 2023; Lavoye et al., 2023). However, the knowledge concerning XR's impact on individual consumers remains fragmented in the literature. For example, mixed findings concerning XR's influence on individual consumers have been reported (Kang et al., 2020; Smink et al., 2020; Tan et al., 2021). Moreover, a comprehensive understanding of XR's impact on individual consumers in the e-commerce context is needed across the related literature.

Additionally, though the prior literature has featured a couple of literature reviews that sought to explain the role of XR in business (Yung and Khoo Lattimore, 2019; Xi and Hamari, 2021; Akbari et al., 2022), these studies have focused on a specific context, such as tourism (Yung and Khoo Lattimore, 2019), general shopping (Xi and Hamari, 2021), or

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the organizational level (Akbari et al., 2022). Some scholars have also reviewed the literature on AR's role in e-commerce (Kazmi et al., 2021), AR application trends (Riar et al., 2019), and phobias about AR online shopping applications (Kazmi et al., 2021). More than 20 years ago, Howes et al. (2001) conducted a literature review of VR in the e-commerce context at the individual level. This could not explain how XR influenced individual consumers in e-commerce through XR technology's development over the past 20 years. Nonetheless, these prior literature review studies have failed to provide a holistic view of how XR influences individual consumers in the B2C e-commerce context from a multi-facet view and could not provide a deep exploration of how various factors involved in XR-based online shopping affect XR-based e-commerce, such as technological, product-related, or consumer-related factors.

To address the research gaps described above, the current study reviewed the literature on x-commerce since 2000. This study contributes to the literature in three ways. First, it enriches the literature by holistically explaining XR's impact on B2C e-commerce consumers at the individual level, synthesizing empirical findings concerning stimuli, cognitions and emotions, consumer reactions, and moderators based on the stimulus–organism–response (SOR) model. Second, the current research systematically evaluates prior findings at different times and based on different XR technologies, dynamically explaining how XR affects individual consumers in the x-commerce field. Third, this literature review proposes four agendas for future research based on the identified research gaps. This review can also inform x-commerce practitioners about consumer experience management in x-commerce.

The remainder of this paper is organized as follows. Section 2 presents the research background and discusses the definitions of XR, its application in e-commerce, and its impact on B2C e-commerce consumers. Section 3 introduces the literature review procedure, including article search, filtering, and analysis. Section 4 reports the theories, research methods, devices, and contexts included in this review. Next, Section 5 discusses the findings concerning the stimuli, consumer reactions, and moderators studied in the reviewed empirical articles, and analyzes the relationships among these elements. Additionally, Section 5 proposes and summarizes an integrated framework for understanding how XR affects individual consumers via a synthesis of the reviewed empirical studies' findings. Finally, in Section 6, the current study's contributions, suggestions for future research, and limitations are discussed.

2. Research background

Extended reality is an umbrella term describing immersive and spatial computing technologies. XR includes virtual reality (VR) and augmented reality (AR), which facilitate interactions between technologies and the users of computers or wearables in real, virtual, and combined environments to stimulate users' senses (Morotti et al., 2021). Specifically, through the use of mediating technologies, VR provides a 3D environment in which users can interact with virtual goods (Guttentag, 2010; Cowan and Ketron, 2019). In contrast to 2D static image presentations, VR's 3D presentations of products using visual-spatial cues significantly involve users in realistic environments by engaging their visual, audial, and even touch-based senses through virtual head-mounted devices (HMDs; Jin et al., 2021). The 3D virtual environments also allow consumers to escape the real world (Lee and Shafer, 2002). Moreover, VR comprises three types: non-immersive desktop VR (Howes et al., 2001), semi-immersive projection-system VR (Altarteer and Charissis, 2019), and fully immersive HMD VR (Wang et al., 2019). HMDs especially show consumers wide-view and vivid visual presentations with audio and interactive experiences with VR that incorporate vibration and touch senses (Luangrath et al., 2022), while computer-based VR provides the easiest approach to access visual and audio experience (Howes et al., 2001).

AR incorporates virtual components into real-world contexts to allow alternative perceptions of reality (Tan et al., 2021). It is a vital branch of XR (Zhao et al., 2017) that prominently incorporates artificial digital layers into real environments; this process can help ground consumers in the physical world without totally restricting them to reality (Gatter et al., 2022). AR has been argued to engage users more easily than VR because AR does not require any specific HMD (Yoon and Oh, 2022). Similarly, AR can be implemented using computers (Smink et al., 2019) or headsets (Erdmann et al., 2021). Recently, mobile AR has become popular, and it has been said to broaden AR applications, provide the proximity of real shopping experience, increase sales, and improve recommendations (Butt et al., 2022; Poushneh, 2021; Alimamy and Gnoth, 2022).

To enhance online service quality amid fierce e-commerce competition, companies have used the latest advanced technologies, such as VR or AR, to exhibit products, provide multiple-sensory information, and enhance consumers' online shopping experiences (Schaeffer et al., 2018; Hwangbo et al., 2020). Some scholars have also examined how VR or AR influences e-commerce consumers. For example, Jang and Hsieh (2021) compared the features of VR and AR to examine their use in e-commerce, arguing that VR exhibits three notable features: presence, immersion, and interactivity. Meanwhile, AR features ease of use (Butt et al., 2022), synchronous sense of ownership (Huang et al., 2019), and perceived proximity (Poushneh, 2021) characteristics. A body of previous VR and AR literature has examined how VR or AR characteristics influence consumers' attitudes, product evaluations, and purchase intentions at the individual consumer level (Kang et al., 2020; Willems, 2019). For example, the technology acceptance model (TAM) suggests that AR's perceived ease of use and perceived usefulness positively affect consumers' online shopping satisfaction and technology use intentions. Perceived playfulness was found to enhance VR's perceived informativeness, thus affecting consumers' product evaluations and online purchasing intentions (Kang et al., 2020; Chen et al., 2023).

To date, the overall understanding of XR's impact in the e-commerce context remains vague. Mixed findings have been obtained, and little research has attempted to comprehensively explain how XR affects B2C e-commerce consumers at the individual level. These gaps call for a literature review to holistically elaborate on how XR affects individual consumers in the B2C e-commerce context based on the literature's empirical findings.

3. Research procedure

The present literature search and selection method followed systematic review guidelines suggested by Rowe (2014): (1) selecting research questions; (2) determining the dataset sources; (3) choosing the searching keywords; (4) using practical screen criteria such as language, and publication year; (5) applying methodological screen criteria to filter the literature and ensure the adequacy and quality of the study; and analyzing results from articles; (6) doing the reliable and valid review to abstract main findings from articles; (7) synthesizing the results of literature to interpret research findings. The literature review work was conducted in November 2021 and referred to the suggestions of Neumann et al. (2018) to ensure the literature review's quality. The literature selecting and filtering processes are shown in Fig. 1, and the findings in the literature analysis are reported in the following sections.

Based on the current work's topic of XR-based e-commerce at the individual level, first, six databases were selected to search for relevant articles: Scopus, Web of Science (WoS), ABI/Inform Collection, EBSCOhost, ACM Digital Library (ACM DL), and Journal Storage (JSTOR), which dominate the business research field and include research on online shopping and the cutting-edge technology application in the business field. Second, the following search terms were applied to identify articles for review: ("extended reality," "XR," "VR," "virtual reality," "AR," "augmented reality," or "mixed reality") *and* ("e-commerce," "online shopping," "online store," "online retail," "online sale," or "online purchase."). Third, articles' abstracts, keywords, and titles

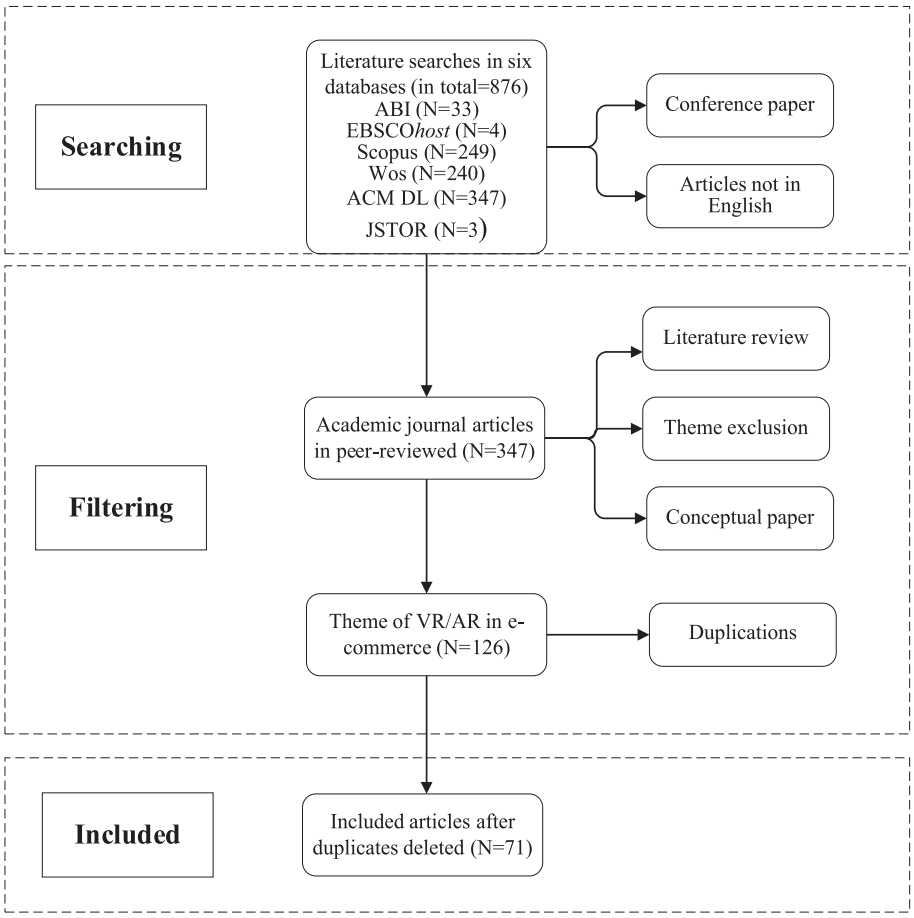

Fig. 1. Literature search steps.

were screened across the six databases based on the above keywords, and articles' publication years were set to any since 2000 because XR has become prevalent during the current millennium.

Fourth, the current study's authors searched 876 publications in total, of which 33 were found in ABI, four in EBSCOhost, 249 in Scopus, 240 in WoS, 347 in ACM Dl, and three in JSTOR. Initially, the results were limited to filtering peer-reviewed journal articles published in English and included articles in the press. Thus, 347 peer-reviewed journal articles were identified, and the remaining 529 publications were excluded either because they were not published in English or because they were conference papers.

Fifth, the further screening of the 347 peer-reviewed journal articles for inclusion and exclusion was based on the inclusion and exclusion criteria in a two-step process. The literature review first screened the title and abstract of these 347 articles to select articles to decide whether they concerned research on VR or AR in e-commerce and then looked through the full articles selected for forward and backward checking. The inclusion criteria included: (1) the research theme is on VR or AR in e-commerce at an individual level (exclude articles not related to VR or AR in e-commerce or articles focused on organization level); (2) empirical studies (exclude literature reviews or non-empirical studies such as conceptual studies or modeling studies without quantifiable data); and (3) duplicate articles (exclude the duplicates of articles in the six databases).

Specifically, the titles and abstracts of the remaining 347 articles were screened to determine whether they concerned research on VR or AR in e-commerce. 151 articles that did not concern VR or AR e-commerce, 12 literature reviews, and nine conceptual papers without any empirical analysis were excluded. Additionally, 49 papers that focused on the organizational level rather than the individual consumer level were excluded. After these two rounds of exclusion, 126 papers remained in the sample set. Finally, after 64 duplicates were excluded across the six databases and 9 articles were added with forward and backward processes, 71 journal articles were selected and stored in the reference management software Zotero for this literature review to conduct further analysis.

The 71 academic journal articles selected for this review were obtained from ABI ($n = 2$, 2.8 %), ACM DL ($n = 1$, 1.4 %), Scopus ($n = 53$, 74.6 %), and WoS ($n = 15$, 21.1 %), and they had all been published between 2000 and 2023. These articles' distribution is presented in Fig. 2. After 2018, studies on VR or AR in e-commerce were increasingly

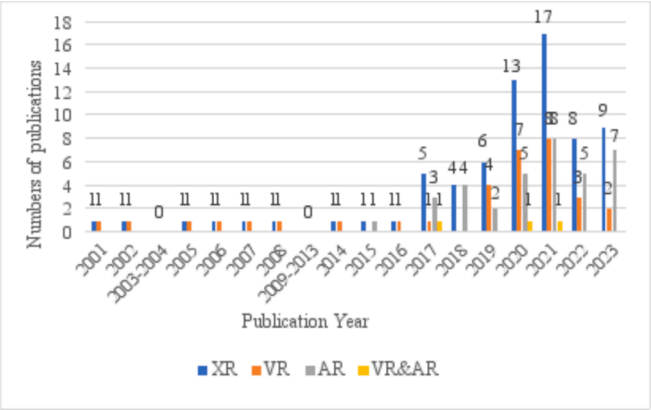

Fig. 2. Reviewed publications' distribution by topic and year from 2000 to 2023.

published. Among the selected articles, 57 were published between 2018 and 2023, and they accounted for more than 75 % of the total sample, indicating the increasing research interest in VR or AR e-commerce applications. AR research was as popular as VR research; about half of the reviewed articles focused on VR ($n = 33$, 46.5 %), while most of the remainder focused on AR ($n = 35$, 49.3 %), and three articles focused on both AR and VR ($n = 3$, 4.2 %). In this review's sample, VR research first appeared in 2001, while AR research first appeared in 2015, and research on AR e-commerce increased since 2017.

Furthermore, 71 articles were read in full and analyzed. Their research methods and theories, studied devices, and research contexts were identified to establish a general understanding of these studies. Additionally, stimuli, moderators, consumers' cognitive, emotional, attitudinal, and behavioral responses, and the relationships among these factors were coded for each paper. A detailed summary of the 71 articles' findings can be found in the Appendix and the related findings are analyzed in the following sections.

4. Literature review: Methods, devices, theories, and contexts

This section presents a descriptive overview of the 71 reviewed empirical studies by summarizing their applied research methods and theories, studied devices, and research contexts.

Research methods. Experiments are the dominantly applied research method among the 71 examined papers ($n = 53$, 74.6 %). This method is suitable for explaining and revealing psychological processes and reactions that are difficult to observe (Jiang et al., 2022). The 53 studies that applied this approach used different experiment methods, including field experiments and quasi-experiments ($n = 8$, 11.3 %), laboratory experiments ($n = 33$, 46.5 %), web experiments ($n = 9$, 12.7 %), and a mix of laboratory and web experiments ($n = 3$, 4.2 %). The other reviewed studies used surveys ($n = 12$, 16.9 %), case studies ($n = 3$, 4.2 %), or interviews ($n = 3$, 4.2 %).

Theories. Various theories across disciplines, such as computer science, information systems, psychology, and marketing, have been used to examine how XR affects e-commerce (Xue et al., 2020; Hwangbo et al., 2020; Phuthong, 2022). Theories on information processing and consumer behavior were the dominant theoretical bases for the reviewed articles. For instance, telepresence theory (Steure, 1993) was used to explain how the technological features of VR or AR, such as vividness, richness, playfulness, enjoyment, and usefulness, enhance consumers' online shopping experiences (Wang et al., 2019; Chen et al., 2023). Meanwhile, construal-level theory (Trope and Liberman, 2010) was used to explore how the technological characteristics of VR or AR, such as interaction, affect consumers' perceptions of technological ease of use and usefulness in online shopping (Chiang et al., 2021). Some theoretical frameworks were also used to explain how VR or AR affects consumers' cognition, affects, and related behaviors, such as TAM (Davis, 1989), the SOR model (Mehrabian and Russell, 1974), and the value-based adoption model (VAM; Erdmann et al., 2021). Table 1 shows the theories used in the reviewed articles.

XR devices. The reviewed VR research has investigated computer-based VR ($n = 17$, 23.9 %), project-based VR ($n = 1$, 1.4 %), mobile-based VR ($n = 1$, 1.4 %), and headset-based VR ($n = 20$, 28.2 %). Computer-based VR and headset-based VR attracted considerably more research attention than mobile-based VR. Meanwhile, the AR research concerned computer-based AR ($n = 9$, 12.7 %), headset-based AR ($n = 2$, 2.8 %), and mobile-based AR ($n = 21$, 29.6 %). Mobile- and computer-based AR attracted more research interest than headset-based AR.

Recent advances have enabled XR devices to engage multiple senses using video, audio, and touch, providing users with deeply immersive experiences. The reviewed articles examined visual ($n = 60$, 84.5 %), audial ($n = 9$, 12.7 %), and haptic ($n = 2$, 2.8 %) stimuli among XR devices using various sensory, input, and output devices. Investigations of various VR and AR devices in e-commerce based on reviewed literature have indicated the diversity of XR devices used in business, as well as the improvement and development of XR devices over the past 20 years.

Table 1
Theories applied in the reviewed articles.

Theory	Articles (No. of the article in the Appendix)	Theory	Articles (No. of the article in the Appendix)
User behavior theory		***Information-processing theory***	
Task–technology fit theory (TTF)	18, 62	Telepresence (presence) theory	34, 53, 58, 63, 69
Product fit uncertainty	60	Media richness theory (MRT)	21
Cognition fit	57	Transfer theory	6
Hedonic and utilitarian value	66	Flow theory	25
Equity theory	44, 62	Theory of Conversation (ToC)	39
Value-based adoption model (VAM)	11	Construal-level theory (CLT)	9, 45
Theory of reasoned action (TRA)	62	Reactance theory	52, 53
Technology acceptance model (TAM)	2, 7, 9, 20, 41, 43, 46, 69	Habituation–tedium theory	68
Stimulus–organism–response model (SOR)	8, 15, 23, 32	Cue-utilization theory	68
Self-evaluation theory	19	Uncertainty reduction theory	59
Self-determination theory	30	Feelings-as-information theory	28
Socially situated cognition theory	16	Memory theory	17
Locus of control	36	***Human traits theory***	
Store atmosphere theory	29	Big five personalities	36, 50
Affective and cognition model	24	Trust literature	12, 42, 64

Note: No. indicates the sequence number of articles in the Appendix.

Contexts. The reviewed articles applied XR to different e-commerce contexts, including fashion, furniture, households, and tourism. Fashion and furniture were the most popular contexts because of consumers' highly individual needs concerning these items. For example, 3D try-on functions based on XR were widely researched ($n = 27$, 38.0 %) in different e-commerce contexts, including daily self-use goods, such as apparel and accessories (Chiang et al., 2021), clothing (Ricci et al., 2023), cosmetics (Butt et al., 2022), glasses (Lavoye et al., 2023), sports shoes (Bonnin, 2020), and watches (Song et al., 2020). Trying out furniture in the home or office surroundings ($n = 11$, 15.5 %) was another popular research context. The reviewed studies applied various product types, such as low- or high-end products (Koontz and Gibson, 2002; Ringler et al., 2021), customized luxury products (Altarteer and Charissis, 2019), and physical or experiential products (Willems, 2019; Morotti et al., 2021).

5. Findings: Stimuli, moderators, and consumer reactions

This section analyzes the findings of the 71 reviewed articles in two streams. First, it identifies stimuli and their effects on consumer cognition, emotions, and behavior responses and deeply clarifies them based on the reviewed literature. Second, the findings concerning technological, product-related, or consumer-related factors' moderating effects are analyzed to explore the boundaries of stimuli's effects on consumer responses. Possible explanations for the mixed results presented in the reviewed articles are provided.

5.1. Stimuli affecting individual consumers

Stimuli can encompass any information transferred during communication—such as text, images, and video—which could trigger

consumers' internal states, including emotional and cognitive reactions and, thus, influence their attitudes and behaviors (Hilken et al., 2020; Zhu et al., 2023). In the e-commerce context, the stimuli studied in the reviewed articles could be divided into three categories. The first category comprised factors related to XR-based online store environments (Meißner et al., 2020; Kim et al., 2022), such as virtual agents embedded in such environments (Moriuchi et al., 2021; Silva and Bonetti, 2021; Wang et al., 2023) and a store's atmosphere (Krasonikolakis et al., 2021; Kim et al., 2022). The second category comprised factors related to XR-based product presentations (Howes et al., 2001; Kang et al., 2020; Bonnin, 2020), such as product presentation methods(including text or images; Suh and Chang, 2006; Willems, 2019; Zhu et al., 2023) and autostereoscopic (Liu and Uang, 2016), static, or dynamic interactions (Hilken et al., 2020). Finally, the third category comprised factors related to multiple-sensory stimulation (Zhao et al., 2017; Huang et al., 2019), such as vision, sound, and touch (Speicher et al., 2017; Ringler et al., 2021; Luangrath et al., 2022; Goel et al., 2023). Table 2 summarizes the stimuli examined in the reviewed literature.

Most of the reviewed studies mainly examined product presentations that used VR or AR (n = 61, 85.9 %) as stimuli. Twelve of the 71 reviewed articles investigated online shopping environments based on VR or AR as stimuli since such environments could affect consumers' cognition, emotions, and behavior when shopping (Krasonikolakis et al., 2021; Kim et al., 2022; Brito and Stoyanova, 2018). The reviewed literature also provided some views on designing online shopping environments in XR-based facilities, such as using humanoid virtual agents in XR-based online shopping environments (Wang et al., 2023). Such usage could constitute a novel innovation that combines artificial intelligence (AI) and XR in online shopping environment design, and it is worth examining in future research.

Additionally, based on XR technology's advances from the reviewed 2000–2023 period, the stimuli provided by various XR technologies were found to dynamically evolve with XR technology's development. In the reviewed articles, studies have applied computer-based VR (n = 17, 23.9 %; mainly before 2015), project-based VR (n = 1, 1.4 %; Altarteer and Charissis, 2019), and headset-based VR (n = 20, 28.2 %). Only one study described an update to mobile-based VR (n = 1, 1.4 %) concerning interactions with avatars in online fitting rooms (Lau et al., 2021). Mobile-based VR facilitates limited virtual product presentation due to the small screen of mobiles.

Before 2015, computer-based VR had normally been used to create stimuli, such as text (Howes et al., 2001) and static pictures (Suh and Lee, 2005), in e-commerce research. The non-immersive VR is the easiest approach for users to access visual and audio shopping content. However, after 2015, the application of VR headsets increased in e-commerce, and multiple-sensory cues could be rendered, isolating consumers from the real outside world and exerting consumers to experience the artificial and virtual world in an enhanced way. For example, visual 3D images for product presentation (Alzayat et al., 2021; Morotti et al., 2021; Luangrath et al., 2022; Chen et al., 2023), the sense of touching virtual products at online stores with haptic devices (Alzayat and Lee, 2021; Luangrath et al., 2022), and audio-visual enhanced environments (Jin et al., 2021; Morotti et al., 2021; Ringler et al., 2021) simulate a realistic online shopping store to provide consumers with a vivid presence and immersive scenario and accurately track consumers' virtual online shopping reactions. Further, some studies have also compared the stimuli in computer-based and headset-based VR to elaborate on the telepresence and vividness of 3D images (Willems, 2019; Kinzinger et al., 2022; Ricci et al., 2023; Kang et al., 2020; Meißner et al., 2020) and audio effects (Speicher et al., 2017). These studies have verified the superior presentation of headset-based VR compared to computer-based VR in the B2C e-commerce context.

Although AR research first appeared in 2015, studies on AR in e-commerce have increased since 2017. Similarly, the articles studying AR devices have evolved from computer-based AR (n = 9, 12.7 %; mainly concentrated around 2017) to headset-based AR (n = 2, 2.8 %) and

Table 2
Stimuli in XR-based online shopping.

Stimulus		Details	Articles (No. of the article in the Appendix)
XR-based online store environment	Virtual agent design	Interactive: chatbot agent vs. AR	39 (mobile-based AR)
		(Non)speech VR vs. PC	40 (headset-based VR)
		Communication with digital agents in VR vs. AR (consumer differences)	51 (headset-based VR and AR)
	Virtual agent service design	– Sale process design – Recommendation service design	12, 42, and 64 (computer-based VR)
	Online store atmosphere	Online store design – First-person telepresence – Graphic style – Precise information content	9 and 19 (computer-based AR)
		–HMD 360° video VR vs. website –Background music –Types of different online store simulations	14, 18, 23, 25, and 29 (headset-based VR)
		(Non)environment-embedded	63 (computer-based VR)
XR-based product presentation	Presentation patterns	Texts	3, 40, and 71 (headset-based VR) 16 and 33 (mobile-based AR) 17, 42, and 63 (computer-based VR) 51 (headset-based VR and AR)
		2D video or pictures	16 (mobile-based AR) 24 and 65 (computer- and headset-based VR) 34 and 37 (headset-based VR) 67 and 69 (computer-based VR)
		360° panoramic pictures or video	23 and 25 (headset-based VR) 65 (computer- and headset-based VR) 32 and 66 (computer-based VR)
		3D images	2 (projection-based VR) 3, 8, 21, 29, 37, and 40 (headset-based VR) 20 (computer-based VR) 24, 26, 38, and 47 (computer- and headset-based VR) 30 (mobile-based VR)

(continued on next page)

Table 2 (*continued*)

Stimulus		Details	Articles (No. of the article in the Appendix)
			13, 31, and 43 (computer- and mobile-based AR)
	Presentation characteristics	Graphic quality	24 (computer- and headset-based VR) 27 (headset-based VR)
		Static or dynamic interaction	57 (computer-based VR)
		Text-only vs. image-enhanced	16 (mobile-based AR)
		Navigation using gestures	9 (computer-based AR) 51 (headset-based AR)
		Avatar (3D model, avatar image with personal pictures, and life-size image model)	30 (mobile-based VR) 67 (computer-based VR) 52 (mobile-based AR)
		Autostereoscopic, stereoscopic, or monocular displays	34 (headset-based VR)
		VR-enhanced (Non) gamification	21 (headset-based VR)
		Gamification process design (e.g., text and feedback)	33 (mobile-based AR)
Multiple-sense engagement	Audio or haptic senses	Audio-visual media	19 (computer-based AR) 23, 25, and 40 (headset-based VR) 39 (mobile-based AR) 70 (computer-based VR and AR)
		The product sounds simulated by mobile- and headset-based XR	46 (mobile-based AR) 48 (headset-based VR) 55 (Computer- and headset-based VR)
		Simulation of holding or touching products using VR headsets	3 and 37 (headset-based VR)

Note: No. indicates the sequence number of articles in the Appendix.

mobile-based AR ($n = 21$, 29.6 %).

Between 2017 and 2019, computer-based AR generated research on the stimuli of online store design, mainly concerning first-person telepresence (Huang et al., 2019). Research on the stimuli provided by mobile-based AR has appeared since 2019, and this focus has also been the main perspective of studies on AR technology in e-commerce because of mobile phones' convenient use for consumers (Chen and Pai, 2018) and embedded layers of the real environment (Gatter et al., 2022). The related research has also widely addressed products' presentation patterns, such as text (Hilken et al., 2020; Liu and Tanaka, 2020), 2D pictures (Hilken et al., 2020), and 3D images (Smink et al., 2019; Lavoye et al., 2023). The interaction and design of virtual agents and avatars (Moriuchi et al., 2021) have been deployed in mobile-based AR, especially in apparel or cosmetic fitting contexts with a highly perceived presence (Smink et al., 2019). However, reviewed studies on headset-based AR have been limited to applications in communication and interactions with digital agents in online stores via audio, gestures, and text (Erdmann et al., 2021; Silva and Bonetti, 2021).

Thus, VR was found to share the most similarities with AR concerning product presentations across the computer-, mobile-, and headset-based types. Moreover, the subtypes of both VR and AR could provide stimuli via text (Howes et al., 2001) and 2D or 3D images (Smink et al., 2019; Kang et al., 2020; Lavoye et al., 2023). However, different XR technological presentations of e-commerce facilitate different application purposes and exhibit different technological advantages. For example, headset-based VR transforms e-commerce, especially in the highly vivid presentation of products (Alzayat and Lee, 2021; Morotti et al., 2021; Luangrath et al., 2022; Chen et al., 2023), but computer-based VR renders consumers the easiest way to access 3D visual or audio contents of products in online shopping. The avatar design in online try-on contexts (Smink et al., 2019) was created specifically for computer- or mobile-based AR, rather than headset-based AR. The AR-based avatar design enhances first-person telepresence (Huang et al., 2019) and personal customization (Smink et al., 2019) because real environments or elements such as self-pictures can be easily embedded in computer- and mobile-based AR applications.

Further, immersive audio and haptic stimulation have been studied for headset-based VR (Alzayat and Lee, 2021; Luangrath et al., 2022), and headset-based AR is expected to provide multiple-sensory cues in future work. This type of AR could also apply gestures to the real world to help users navigate application systems (Erdmann et al., 2021; Silva and Bonetti, 2021). In the business paradigms, headset-based AR could combine the virtual experience with reality proximity by adding a real environment layer or customizing consumers' application environment into the virtual shopping scenario, rendering a realistic consumer experience. It is easy to implement headset-based AR to deeply explore consumers' online shopping experience. This accomplishment might be difficult to mimic using headset-based VR because it isolates consumers from real external environments and requires a high degree of technical investment to mimic and create the reality proximity as well (Van Berlo et al., 2021). Prior literature review studies on XR in e-commerce have focused on the stimuli of VR (Howes et al., 2001) or AR (Riar et al., 2019) in e-commerce. The present literature review enriches the findings on the stimuli of XR in e-commerce by comparing the different stimuli and technical functions of VR and AR applied in e-commerce, including computers, mobile phones, and headsets, which have been rarely discussed in prior literature review work on XR or e-commerce and the current research's findings could provide some research base for future research to refer to.

5.2. *Stimuli's effects on consumer reactions*

The reviewed literature showed that various stimuli in VR- or AR-based e-commerce trigger different cognitions (e.g., perceived informativeness; Kang et al., 2020), emotions (e.g., pleasure; Goel et al., 2023), attitudes (e.g., satisfaction; Gabriel et al., 2023), and behaviors (e.g., purchase intentions or patronage; Bonnin, 2020; Hsiao and Lin, 2023) among consumers.

5.2.1. *Stimuli's effects on cognitive reactions*

Cognition can be defined as mental actions and perceptions concerning products and environments based on related information conveyed through products or environmental cues (Laroche et al., 2022). Consumer cognitive processes are the main mechanisms that explain XR stimuli's effects on attitudinal and behavioral responses when consumers use VR or AR in B2C e-commerce. The reviewed articles mainly examined positive cognitive reactions from the four following perspectives. The information-processing view comprises perceived telepresence and flow (Willems, 2019; Hsiao and Lin, 2023; Kim et al., 2022), perceived informativeness (Kang et al., 2020), and perceived media richness (Jang and Hsieh, 2021). The technology usability view encompasses perceived ease of use (Pantano et al., 2017),

usefulness or usability (Rese et al., 2017; Brito and Stoyanova, 2018), and perceived convenience and fit (Liu et al., 2020). The hedonic values view involves perceived enjoyment (Pantano et al., 2017; Ricci et al., 2023), perceived playfulness (Kang et al., 2020; Chen et al., 2023), perceived attractiveness (Bonnin, 2020; Han et al., 2021), and perceived immersion (Yim et al., 2017, Song et al., 2020, Erdmann et al., 2021; Hsiao and Lin, 2023). Finally, the interactivity view comprises perceived control, ownership, empowerment, or autonomy in VR- or AR-based online shopping (Brito and Stoyanova, 2018; Hilken et al., 2020; Lau et al., 2021), perceived experience value (Altarteer and Charissis, 2019), perceived engagement (Moriuchi et al., 2021; Lavoye et al., 2023), and interactivity (Jiang et al., 2022). However, negative evaluations and behavioral responses from consumers should be considered when personal intrusiveness (Smink et al., 2019) and perceived risk (Bonnin, 2020) are aroused in XR-based e-commerce. For instance, Yang (2019) argued that a personalized virtual fitting room (VFR) might not increase sales when model avatars are used because the self-discrepancy between consumers and model avatars becomes salient, impeding consumers from choosing virtual clothes in AR.

Previous research on XR-based online shopping has also evidenced stimuli's effects on consumer cognitive responses in three regards: product presentation, multisensory engagement, and shopping environments. A series of prior findings have indicated that XR can be used to present product information to consumers in e-commerce better than traditional product presentations with text or static 2D pictures. Compared to online shopping presentations' static 2D pictures or text, XR-based product presentations' stimuli—especially vivid 3D images rendered through VR (Chen et al., 2023) or AR (Phuthong, 2022)—trigger more positive cognitive experiences among consumers. For example, Phuthong (2022) applied AR to online retailing to present products with 3D images. Two positive cognitive perceptions of utilitarian and hedonic values were generated, spurring high consumer engagement in AR-based online shopping due to the AR's perceived ease of use. Chen et al. (2023) also confirmed that highly immersive sensory experiences and interactivity in VR-based online shopping enable a strong product presence, playfulness, and diagnostics, encouraging consumers to impulsively buy from VR-based online stores.

Multisensory experiences triggered by visual, audial, and haptic cues in x-commerce could promote positive consumer perceptions of products or shopping experiences. Some of the reviewed studies (n = 60, 84.5 %) indicated that visual cues have attracted significant attention among scholars, while only a few studies considered audial (n = 9, 12.7 %) and haptic (n = 2, 2.8 %) cues as stimuli for consumer perceptions of VR- or AR-based e-commerce. However, compared with visual cues, multisensory cues involving audial or haptic senses are likely to trigger greater perceived informativeness (Ringler et al., 2021) and favorable perceptions among consumers in XR-based online shopping (Jin et al., 2021; Ringler et al., 2021). For instance, Ringler et al. (2021) suggested that sound amplitude triggers inferences about products' functions, where consumers are more willing to pay for a louder sports utility vehicle (SUV). Alzayat and Lee (2021) and Luangrath et al. (2022) added to the evidence of touch senses' superior status in XR-based online shopping sensory experiences. The scholars verified that, compared with images of hands in ads, a vicarious touch sense improved consumers' purchase intentions and willingness to pay for products in VR-based online shopping by satisfying their touch needs (Alzayat and Lee, 2021) and enhancing perceived product ownership (Luangrath et al., 2022).

Prior literature has verified that the visual complexity of online retail stores affects consumers' information processing (Jang et al., 2018), and a couple of the reviewed studies addressed VR- or AR-based online stores' environmental factors influence consumers' cognitive reactions, including XR-based online stores' layouts (Krasonikolakis et al., 2021) and embedded virtual agents (Moriuchi et al., 2021; Wang et al., 2023). Shopping environments, including realistic online store layouts combined with different store types such as simulation of fashion stores or supermarkets via 360° video or 3D images in XR-based B2C e-commerce, were found to affect consumers' product knowledge and intentions to engage in online shopping (Kim et al., 2022; Hsiao and Lin, 2023) via atmosphere theory (Krasonikolakis et al., 2021). Meanwhile, Jin et al. (2021) found that audio-enhanced online stores with background music simulating vivid and realistic store atmospheres in VR-based online stores improve consumers' perceptions of virtual stores' attractiveness and their preferences for such stores. Moreover, Kim et al. (2022) clarified that VR- or AR-based online store presentations enhance consumers' intentions to visit physical stores when consumers have a high flow experience in XR-based online stores.

In addition, the image- and audio-enhanced virtual agents embedded in VR online shopping provide novel views to enhance interactivity in online shopping, thereby leading to higher consumer satisfaction than virtual chatbots using text-based communication (Moriuchi et al., 2021). Similarly, Morotti et al. (2021) confirmed that VR agents' speech input induces higher technology acceptance and more favorable perceptions of VR-based fashion shopping than nonspeech-input VR or website-based chatbots. Recently, Wang et al. (2023) provided more insights into humanoid virtual agents embedded in VR-based online shopping. The authors verified that humanoid features—such as perceived integrity, ability, benevolence, and perceived similarity—enhance virtual agents' presence and perceived trust for consumers.

Thus, consumers' cognitive responses—especially positive ones—dominated the reviewed literature, serving as a holistic theoretical lens for scholars in their research. The finding is consistent with prior findings on consumers' cognitive responses to XR in business (Riar et al., 2019; Xi and Hamari, 2021), however, research should not ignore the drawbacks of XR technologies in triggering negative cognitive responses such as perceived intrusiveness of too close distance from AR presentation (Smink et al., 2019) and perceived risk in VR-based online shopping (Bonnin, 2020). Meanwhile, compared to conventional online 2D shopping, XR's application enhances e-commerce experiences, especially with ample multiple-sensory experiences. The previous literature has demonstrated that multiple-sensory cues—especially audial and haptic—surpass visual cues in triggering XR-based e-commerce consumers' positive cognitive processes. Different effects of visual, audio, and haptic cues on consumers' cognitive responses will be interesting to examine. In addition, less attention has been paid to the cues of XR-based online store design on consumers' cognitive responses than multiple-sensory cues. Such as online stores' atmosphere and virtual agents have been rarely examined in the existing e-commerce research. Realistic simulation of XR-based online store design based on multiple senses such as background elements or music inserted in the online store could engage consumers in a virtual shopping atmosphere, reminding scholars to explore more factors associated with online store design to enhance consumers' XR-based e-commerce experience. Meanwhile, given the emergence of novel virtual agent applications in XR-based e-commerce, future works should investigate the combined AI and XR-based e-commerce to enhance consumer's cognitive experiences in XR-based e-commerce.

5.2.2. *Stimuli's effects on emotional reactions*

Lindquist (2013) defined *emotion* as a psychological process controlled by the nervous system that generates a series of specific physiological expressions. The little reviewed literature focused on emotions as a mechanism explaining how VR or AR influences consumers in an e-commerce context. Only six of the reviewed empirical studies explored positive emotional experiences generated in XR-based e-commerce. For instance, positive emotions such as excitement (Brito et al., 2018) were found to promote consumers' positive evaluations of brands and increase purchase intentions in marker-based AR. Meanwhile, pleasure was found to result from sensory experiences in mobile-based AR (Goel et al., 2023), and the interaction of VR displays (Jin et al., 2021; Li et al., 2023) was also observed to lead to positive

evaluations of VR-based online stores or increase purchase intentions in VR-based online shopping. Other positive discrete emotions—such as surprise and joy—were found to arise when consumers applied the interactive system of gesture-based e-commerce AR, increasing their intentions to recommend the brand (Brito and Stoyanova, 2018).

The research on consumers' emotions in XR-based e-commerce has been less focused than the research on consumers' cognitions, and deep examinations of various emotional experience aspects in this field are lacking. Positive emotional responses are dominant in XR-based e-commerce in the reviewed literature (Jin et al., 2021; Li et al., 2023; Brito and Stoyanova, 2018), which is consistent with other scholar's findings on consumers' positive emotions in XR use in business (Huang et al., 2013; Cadet and Chainay, 2020; Yung et al., 2021). There is a lack of studies on the possible negative or mixed emotional experiences among consumers though prior literature has argued that consumers could have negative emotional experiences in using AR or VR in business (Kazmi et al., 2021; Bender and Sung, 2021). Prior literature has identified negative emotional experiences among users in other VR technology usages, including loneliness, anxiety, or boredom (Bender and Sung, 2021; Liu and Uang, 2016; Brito et al., 2018). Thus, there is a need for a deep and further exploration of negative emotional experiences in XR-based online shopping and their impacts on customers' purchasing and XR-based online shopping usage behavior, which could provide insights into customer experience management via mitigating their negative shopping experiences.

Moreover, the relationships between emotions and cognitions in VR- or AR-based online shopping remain vague. Research on these relationships might help explain the impact of VR or AR on consumers' attitudinal and behavioral responses to XR use in e-commerce. However, according to Fedorikhin and Shiv (2014), decision-making relies more on cognition than emotions when tasks require more cognitive resources, and vice versa when the resources needed to process tasks are constrained. This finding might provide insight into the mixed explanations for stimuli's effects on consumer responses to XR-based online shopping through cognitions and emotions.

5.2.3. Stimuli's effects on attitudinal and behavioral reactions

Concerning XR use in B2C e-commerce, over 90 % of the reviewed articles' results affirmed that VR or AR positively affects consumer responses. For example, the previous research demonstrated that VR and AR benefit consumers' thoughts, such as attitudes toward products, and their engagement in online shopping (Sun et al., 2022; Elboudali et al., 2020; Phuthong, 2022). Additionally, consumer satisfaction and attitudes concerning products were the main attitudinal responses examined in these studies (Moriuchi et al., 2021; Kinzinger et al., 2022; Gabriel et al., 2023).

Meanwhile, various behavioral responses by consumers were identified and summarized from the four perspectives in the reviewed literature. The usage activity view included mouse manipulation, browsing time, page visit frequency, and shopping dwell time (Wang et al., 2019; Howes et al., 2001; Liu and Tanaka, 2020; Schnack et al., 2021). The behavioral intention view examines intentions to interact with virtual avatars (Silva and Bonetti, 2021), the willingness to share personal data (Smink et al., 2019), and intentions to use VR or AR in decision-making, such as purchase or patronage intentions (Bonnin, 2020; Li et al., 2023). The consumption behavior view considers product choice (Schaeffer et al., 2018; Krasonikolakis et al., 2021), the willingness to pay (Ringler et al., 2021; Luangrath et al., 2022), product returns (Yang, 2019; Hwangbo et al., 2020), and post-purchase recommendation behaviors (Hilken et al., 2020; Jang and Hsieh, 2021; Alimamy and Gnoth, 2022). The continuous behavior view considered reuse (Kowalczuk et al., 2021) and revisits (Hwangbo et al., 2020; Moriuchi et al., 2021).

A couple of the reviewed articles suggested that stimuli have negative or mixed effects on consumers' behavioral responses. Kang et al. (2020) found VR headset presentation exerts a limited effect on consumer purchasing intentions due to much focus on the playfulness of the virtual environment but a lack of informativeness of virtual product presentation. Smink et al. (2019) discovered that AR use's perceived intrusiveness against consumers' expectations in online shopping triggers consumers' reluctance to apply AR to online makeup purchases. Thus, scholars and practitioners should be cautious of the elements that impair XR-based online shopping behaviors (Smink et al., 2019; Kang et al., 2020).

5.3. Moderation effect

Although most of the reviewed research on consumer reactions to XR use verified that XR presentations consistently surpass non-XR presentations on consumer intention to purchase and online sales (Bonnin, 2020; Kim et al., 2022; Tan et al., 2021), mixed effects of VR and AR on consumer responses such as consumer recommendation, brand attitude and interaction with virtual agents were observed in e-commerce context (Hilken et al., 2020; Smink et al., 2020; Silva and Bonetti, 2021), requiring a deep exploration of moderators' boundary effects. In the reviewed literature, technological, product-related, and consumer-related factors were found to moderate the effects of the stimuli on VR or AR on consumers' cognitions, emotions, attitudes, and behaviors.

5.3.1. Technology types' moderating effect

As Table 3 shows, most of the reviewed papers focused on comparing the effects of different technologies, such as VR, AR, and PC, when products were exhibited to consumers. Scholars stated that compared with the 2D website presentation, VR or AR achieved consistently superior vividness (Chen et al., 2023), interactivity (Gabriel et al., 2023), and multiple-sense engagement (Ringler et al., 2021; Luangrath et al., 2022; Goel et al., 2023).

Moreover, the reviewed research mainly examined either VR or AR subtypes' use in different e-commerce contexts. In XR-based online shopping, computer-based, and mobile-based AR facilitates the perceived ease of use and usefulness (Liu et al., 2020), especially self-customization for consumers to involve AR applications (Bonnin, 2020). Compared with computer-based VR, headset-based VR can especially assist consumers to experience immersion (Speicher et al., 2017) and further provide consumers with vivid spatial presence in the scenario (Chen et al., 2023). Further, headset-based VR renders consumers full embodiment in the virtual shopping environment, facilitating the freedom for consumers to interact with the surrounding environments and thereby enhancing immersion and presence (Luangrath et al., 2022).

Nevertheless, recent studies' authors have argued that VR or AR might have limited effects on consumers' responses in some e-commerce contexts. For example, Kang et al. (2020) suggested that VR presentations' graphical quality insignificantly influences consumers' preferences for products presented via computer- or headset-based VR.

Table 3
Technological factors' moderating roles.

	Specific factors	Articles (No. of the article in the Appendix)
Technological factors	VR sub-types:	
	Non-VR vs. VR	26, 38, 40, 55, 65, and 47
	Computer- vs. headset-based VR	
	AR sub-types:	
	Non-AR vs. AR	1, 15, 28, and 43
	Computer- vs. mobile-based AR	6, 45, and 46
	Marker-based vs. markerless AR	
	VR vs. AR	35, 51, 70

Note: No. indicates the sequence number of articles in the Appendix.

The reason is that the two VR presentations' graphical quality could not provide consumers with enough cognitive resources to differentiate these presentations in computer- or headset-based VR. Bonnin (2020) verified that AR does not equally influence consumers' perceptions of hedonic and utilitarian values in AR-based online shopping. This finding indicates that AR-rendered products' presence can only increase hedonic evaluations (such as those concerning the attractiveness of AR-based product presentations), rather than utilitarian evaluations (such as reduced perceived purchase risk).

Mixed results were also examined concerning some negative cognitive responses to individual XR-based e-commerce. For instance, Smink et al. (2019) investigated AR persuasion in e-commerce and noted that consumers perceive the intrusiveness of mobile-based AR rendering 3D images to be higher than that of traditional 2D websites. This perception impedes consumers from using AR in their online shopping. However, Phuthong (2022) found that personal intrusiveness does not affect consumer perceptions of AR's utilitarian value or further reduce consumers' engagement in smartphone-based AR shopping.

Of the reviewed articles, only three compared the impacts of VR and AR on consumer perceptions and behaviors in B2C e-commerce, revealing some mixed findings (Zhao et al., 2017; Liu et al., 2020; Silva and Bonetti, 2021). For instance, Zhao et al. (2017) observed a visual and mental difference between field-independent and field-dependent consumers in an audio-visual VR context, and this visual-mental difference increased in audio-visual AR shopping. This finding indicates that AR allows online consumers to perceive more accurate commodity information and helps consumers shorten their involvement time by alleviating their mental workloads in AR-based online shopping. Liu et al. (2020) found that an AR 3D try-on application visualizes clothing quality better than VR by triggering a high sense of self, stimulating consumers' involvement in self-references to virtual avatars trying on virtual clothes. However, Silva and Bonetti (2021) investigated consumers' preference for technology devices to communicate with digital humans, suggesting stronger usage intentions for VR than AR when interacting with digital humans, especially in the Americas, Europe, the Middle East, and Africa (EMEA), and the United Kingdom.

To sum up, prior research provides evidence that compared to the 2D presentation, VR or AR renders consumers a 3D vivid and immersive experience or first-person presence in e-commerce while some mixed results existed concerning XR's impacts on consumers in XR-based e-commerce. For instance, in the reviewed literature, consumers do not perceive a better presentation effect of high-quality graphics on headset-based VR than computer-based VR (Kang et al., 2020). And AR enhances more hedonic than utilitarian evaluation of products, instead of an equal influence on the presentation of products' values (Bonnin, 2020). Some scholars examined that mobile-based AR might induce a negative effect such as perceived intrusiveness to impede the usage of AR-based e-commerce as well. Thus, a further and deeper exploration of a variety of technological factors affecting XR-based e-commerce is needed to provide explanations for the varied effects of XR technologies on e-commerce. Besides, VR and AR differently affected consumers' responses in some e-commerce contexts when both technologies were examined in the same online shopping context. This result indicates that some VR features, especially headset-based VR presentation such as high vividness and interactivity (Silva and Bonetti, 2021), or AR features such as proper information loads (Zhao et al., 2017) and proximity (Liu et al., 2020), are likely to differentiate the effects of VR or AR on consumer responses. To date, studies on technological features and differences between VR and AR have been rather scarce in the e-commerce context. Such differences are worth exploring in future works.

5.3.2. *Product-related factors' moderating effect*

When discussing research contexts, products presented in VR- and AR-based B2C e-commerce were found to significantly moderate the effects of XR on consumers' reactions. Some of the reviewed articles explored the extent to which XR affected consumers by comparing different product types and brand reputations in XR-based online shopping contexts (Brito and Stoyanova, 2018; Tan et al., 2021). For instance, Alzayat and Lee (2021) suggested that VR retail environments are more suitable for exhibiting products perceived as bodily extensions (e.g., tools) than as bodily presentations (e.g., clothes) because experiencing bodily extension products through VR online retail produces greater hedonic value for consumers.

Distinct product features could also exert mixed effects on how XR influences consumers. Some studies (n = 6, 8.5 %) examined, for example, how product features, such as geometrics (visual cues), material cues (touch cues), and mechanical cues (experience function qualities), could affect consumers' perceptions of VR product presentations (Wang et al., 2019). Similarly, Smink et al. (2020) compared cosmetics and furniture in mobile-based AR. They found that, when applications augment users' faces with virtual cosmetics products, perceived personalization enhances consumers' purchase intentions, while perceived intrusiveness dissuades such intentions. However, such negative effects of perceived intrusiveness on purchase intentions disappear in online mobile-based AR shopping for furniture.

A few reviewed studies explored and compared high- or low-end (Altarteer and Charissis, 2019) or more experiential versus less experiential products (Koontz and Gibson, 2002) to enrich the research on product types. For instance, Suh and Lee (2005) suggested that VR enhances consumers' product knowledge, especially for high virtual experiential (VHE) products with visual and audio attributes compared to low virtual experiential products. The reason is that VR's media richness, interactivity, and presence could provide many visual and audio cues for consumers' evaluations of VHE products.

Moreover, some of the reviewed studies (n = 3, 4.2 %) discussed how brand-related features—such as popularity, awareness, and connections—moderated the effects of VR or AR on individual consumers. These effects included emotional experiences (Brito and Stoyanova, 2018), online sales (Tan et al., 2021), and product attitudes (Sun et al., 2022). Table 4 summarizes the product-related factors discussed in the reviewed literature.

Reviewed studies have mainly examined product-related factors as moderators, such as high- or low-value or experiential products (Koontz and Gibson, 2002; Suh and Lee, 2005). Recent research has centered on the necessities such as make-up and furniture (Smink et al., 2020) and product features that affect sensory experiences (Wang et al., 2019). Meanwhile, recent studies have also provided some evidence of brand features as moderators, such as brand popularity, awareness, and familiarity, which affect consumers' responses to XR-based online shopping (Tan et al., 2021; Brito and Stoyanova, 2018; Sun et al., 2022). The role of product-related features in XR-based e-commerce has attracted scholars' attention in recent years.

5.3.3. *Consumer-related factors' moderating effect*

Some of the reviewed studies discussed consumer-related factors

Table 4
Product-related factors' moderating roles.

	Specific factors	Articles (No. of the article in the Appendix)
Product Attributes	Organicness (geometric vs. material vs. mechanical)	63
	More vs. less experiential	57
	Self-usage (cosmetics) vs. surroundings (furniture)	53
	Luxury and customization	2
	Involvement	59 and 14
	Price	60
Brand attributes	Awareness	5
	Connection	55
	Popularity and familiarity	60

Note: No. indicates the sequence number of articles in the Appendix.

when explaining how VR or AR use affected B2C e-commerce contexts via antecedents (Schnack et al., 2021) or moderators (Kinzinger et al., 2022). Table 5 presents the different consumer-related factors extracted from the reviewed papers. They included the following categories: (i) human traits (e.g., characters; Schnack et al., 2021), demographic traits (Zhao et al., 2017; Silva and Bonetti, 2021), and abilities (Howes et al., 2001; Wang et al., 2023); (ii) previous experiences using a technology (e.g., familiarity with an online channel; Brito and Stoyanova, 2018; Smink et al., 2020), advanced experiences using a technology (Yim et al., 2017; Song et al., 2020), and familiarity with an online atmosphere (Jin et al., 2021); (iii) preference bias, including technophilia (Han et al., 2021), fashion consciousness (Huang et al., 2019), self-image consciousness (Huang et al., 2019), information control (Poushneh, 2018), and mindset bias (Zhao et al., 2017; Ringler et al., 2021); and (iv) social factors: social cues from recommendations (Hilken et al., 2020) and competitors (Liu and Tanaka, 2020).

Regarding consumer-related factors' moderating roles on VR or AR's effect on consumers in B2C e-commerce, the research focused mainly on human traits (Wang et al., 2023). For example, gender differentiates the effect of XR-based online shopping for consumers. Zhao et al. (2017) found that in VR-based online shopping, the high value of products would generate more influence for male consumers than female ones because male consumers focus on the practical functions of products and VR presents the products' details to help them evaluate products' value. Also, male Americans are more likely than female ones to use digital agents in VR-based online shopping since male ones have a higher acceptance of novel digital technology (Silva and Bonetti, 2021). Other consumer-related factors examined in the existing research such as consumer previous media experiences (Brito and Stoyanova, 2018) and preference bias (Han et al., 2021) also remind future XR-based e-commerce researchers to consider consumer types. For instance, Brito and Stoyanova (2018) clarified that markerless AR offers more stimulation for consumers to recommend the products than marker-based AR

Table 5
Consumer-related factors' moderating roles.

	Specific factors	Articles (No. of the article in the Appendix)
Human traits	Big five traits: agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience	36 and 50
	A product's absence from consumer consideration sets (absent vs. present)	45
	Memory ability: target or incidental	17
	Perceived integrity, ability, benevolence, and perceived similarity	64
	Demographic traits: age, gender, income, and position	51 and 70
Previous experiences	Familiarity with an online channel, website visits, and prior experience	5, 26, and 53
	Prior experience using advanced technology	54 and 68
	Familiarity with advanced technology	4
	Familiarity with online stores	23
Preference bias	Technophilia vs. technophobia	15
	Preference for various stimulations	37 and 59
	Fashion innovativeness or fashion consciousness	19
	Subjective innovation level	11
	Body surveillance	19
	Information privacy and protection concerns	44
	Mindset bias: independent vs. field dependent or process vs. outcome	48 and 70
Social factors	Managing recommendation-based impressions and persuasive goals	16
	Social cues (e.g., competition vs. non-competition)	33

Note: No. indicates the sequence number of articles in the Appendix.

presentation, especially for consumers who are more prone to adopt innovative technology and are unfamiliar with the websites of online stores. Wang et al. (2023) explored the human features, such as perceived integrity, ability, and benevolence, ascribed to virtual agents in XR-based e-commerce and these features' effects on such agents' effectiveness and found that these features of virtual agents enhance consumers' perceived trust and, therefore, improve their purchase intentions.

Another stream of scholars has considered the impact of social cues related to consumers on XR-based e-commerce, such as social norms (Hilken et al., 2020; Liu and Tanaka, 2020). For instance, Hilken et al. (2020) suggested that a strong impression of management concerns among recommenders weakens social empowerment's effect on recommendation trust. The stronger a recommendation's persuasion goal, the less likely a decision-maker is to use that recommendation in consumer choices when using an AR-based recommendation system in online shopping.

Summarily, the recent research not only focused on consumer characters' effects on XR-based e-commerce but also initially explored humanoid virtual agents embedded in XR-based online shopping. This trend might broaden the research scope concerning AI and XR. Moreover, social norm cues such as impression management and peer norms could be applied to design VR-based online shopping environments, and they are worth researching.

5.4. Synthesizing the reviewed empirical studies' findings

In the current study, a literature review was conducted based on prior research concerning XR-based online shopping at the individual level. Seventy-one peer-reviewed journal articles that had been published since 2000 were systematically screened from the six databases: ABI, EBSCOhost, Scopus, WoS, ACM Dl, and JSTOR. These articles' findings were analyzed and further synthesized to elaborate on how XR influences individual e-commerce consumers according to the SOR model with stimuli (S), organisms including emotion and cognition (O), and consumer response (R). Specifically, the synthesized framework (see Fig. 3) holistically mapped the different stimuli derived from XR, their effects on consumers' responses via the mechanisms of both consumer cognitions and emotions, and the moderating effects of product-, technology-, and consumer-related factors in the B2C e-commerce context. In other words, x-commerce's stimuli (S), including VR- or AR-based online store environments, product presentations, and multiple senses, could trigger consumers' perceptions and emotions (O) during XR-based online shopping. In turn, consumers' attitudes and behaviors concerning a product or brand, as well as their online purchasing behaviors (R), would be driven. A series of theoretical perspectives, such as information-processing theory and user behavior theories, were used to derive insights into consumers' responses and online shopping experiences in XR-based e-commerce. Some moderators that incorporated product-related (Suh and Lee, 2005), consumer-related (Wang et al., 2023), and technology-related factors (Zhao et al., 2017; Liu et al., 2020; Silva and Bonetti, 2021) helped explain the variation in stimuli's effects on consumer responses across e-commerce contexts. Fig. 3. illustrates how XR influences individual consumers in B2C commerce based on the SOR framework.

6. Future research agenda, contributions, and limitations

6.1. Future research agenda

This subsection identifies research gaps and proposes four agendas for future research based on the reviewed articles' findings.

Research agenda 1: Exploring online store environments' senses and features in XR-based e-commerce. This study's analysis of the themes addressed in the reviewed articles indicated that product presentations were the stimuli that had been mainly studied. Less attention has been

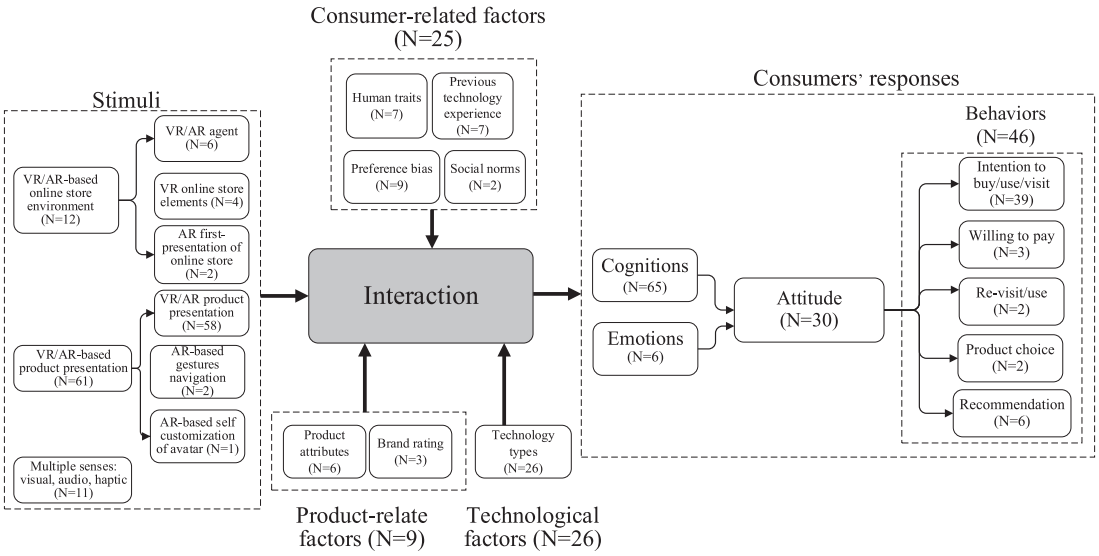

Fig. 3. Integrative framework of how XR influences individual consumers in B2C e-commerce. *Note:* N *indicates the number of articles in the reviewed database.*

paid to environmental cues' effects on XR-based online shopping. For instance, although elements of online store design such as realistic stimulation of various store types based on multiple senses and virtual agents in XR-based online stores are verified to engage consumers in XR-based online shopping, only a couple of studies have touched on these themes. Thus, three themes for future research on XR in e-commerce are proposed: how multisensory interactions can enhance consumers' XR-based online shopping experiences (especially audio and haptic cues, which have barely been tested in prior research); how AI could be integrated into XR-based online shopping to enhance consumers' experiences (for example, humanoid virtual agents embedded in XR-based online shopping have significant potential to enhance interactivity and simulate realistic online environments); and the negative elements of online store design to hinder XR use among e-commerce users.

Research agenda 2: Considering emotion as a mechanism explaining consumers' responses. Various theories have been used to explain how XR affects e-commerce consumers. Cognitive theories were mostly used in the reviewed studies to explain the processes governing consumers' internal states in VR- or AR-based online shopping. However, emotion is another important mechanism that explains human behavior (Schwarz, 2010). So far, existing literature has mainly examined the dominant positive emotions such as pleasure and joy in the XR-based online shopping field. Thus, negative emotions or mixed-emotional experiences should be examined in future research because potential mental health problems such as cyber sickness, loneliness, or anxiety in XR technology usage might arouse negative emotional experiences to hinder XR-based online shopping. Moreover, the relationship between cognition and emotion in XR-based online shopping has not been sufficiently investigated in the current research. Therefore, future research could combine cognitive and emotional theories to explain how XR affects e-commerce consumers.

Research agenda 3: Examining the boundary effect. The reviewed studies expressed some mixed findings, which indicates limited research validity because some moderators such as technological, product-related, and consumer-related factors vary the effect of XR-based e-commerce for individual consumers (Smink et al., 2019; Phuthong, 2022). First, prior research rarely examined product types and brand familiarity and limited studies examined mixed effects of consumer features and social norms such as the management concerns from recommenders in the virtual shopping world (Hilken et al., 2020; Liu and Tanaka, 2020), where the boundary effect of age, gender, previous media experiences and preference bias on XR-based e-commerce also lacks a deep exploration. Therefore, product-related, and consumer-related factors could be deeply identified and examined in related works to enrich XR-based online shopping research and improve its validity.

Second, XR's consistent superiority compared to static-presentation modes has been verified by most of the prior research, interpreting multiple senses, vivid and immersive 3D presentation via headset-based VR, or a first-person presentation of mobile-based AR in e-commerce. However, some negative effects or limitations of XR technologies in online shopping due to consumers' limited perception of presentation quality in headset-based VR or the proximity and self-discrepancy in mobile-based AR presentation and the differences between the effects of VR and AR remain unclear, given mixed findings. Accordingly, a deep exploration of sub-types of XR technology presentation and studies that compare VR and AR to explore these two XR technologies' unique value in e-commerce could be conducted in future work.

Research agenda 4: Employing various research methods to examine XR's effects on consumers. The reviewed studies employed different methods to examine how different forms of XR in B2C e-commerce can affect consumers according to various theories. However, quantitative research methods—including surveys and experiments—dominated the reviewed studies, which were often conducted in laboratory environments and vulnerable to subjective bias. Future research could apply qualitative or mixed methods to explain XR's impact on individual e-commerce consumers while considering second-hand data analysis.

6.2. Contributions

The current study contributes to the literature in the three following ways. First, it enriches the literature by comprehensively explaining how XR influences consumers at the individual level in the B2C e-commerce context and proposing a framework demonstrating XR's effects on consumers according to the SOR model. Specifically, this study identified different stimuli, cognitions, or emotions as organisms, and consumer responses to XR use in e-commerce according to the SOR. This study also identified the moderating effects of technology-, product-, and consumer-related factors. The holistic framework of XR's impact on consumers might provide insights into XR-based e-commerce research ranging from a technological focus to products, services, and consumer characters.

Second, the current study revealed how the stimuli of XR-based e-commerce have evolved over time and alongside technologies. Specifically, this study identified diverse stimuli for computer-, headset-, or mobile-based VR or AR, offering new insights into improving

consumers' online shopping experiences by applying XR technologies to e-commerce. For instance, VR largely resembles AR in providing stimuli as text and visual elements to computer-, headset-, and mobile-based XR devices. Additionally, headset-based VR improves virtual presentation quality through vivid 3D images and multiple-sensory stimulation, including audio and touch senses. Headset-based VR also enriches online shopping experiences through high immersion, multiple senses, and dynamic interactions with products, virtual agents, and virtual shopping environments compared to computer-based online VR shopping. Because of mobile phones' convenience and the embedding the of real world in AR environments, mobile-based AR expands AR's online shopping applications, providing realistic experiences that resemble those of brick-and-mortar stores. Compared to VR-based online store presentations, AR is likely to employ more customized virtual avatars to establish a presence and gesture navigations in e-commerce.

Third, four future research avenues concerning XR use in B2C e-commerce were proposed to address gaps in the literature identified through this literature review. These avenues spanned the following themes based on the reviewed literature's findings and potential research gaps: (i) exploring the multiple senses and features of online store environments; (ii) considering various emotions as mechanisms; (iii) deeply exploring the boundary effect; and (iv) applying various research methods to examine XR's effects on consumers. These suggestions can serve as topic guidelines for x-commerce scholars' and practitioners' future work.

6.3. Limitations

The current study's limitations should be acknowledged. First, its literature review was conducted based on a sample of six databases, and it only included journal articles. Future research could include conference articles and more databases when reviewing XR's impact on individual consumers in the e-commerce context. Second, this study was restricted to the e-commerce context, so caution should be taken when generalizing its findings to other contexts. Accordingly, in the future, researchers could review the literature on other business contexts, such as tourism, entertainment, and real estate, to generate further insights into VR or AR use. Third, the current study considered VR- and AR-based online shopping at the individual level, excluding organizational-level research, such as the sales and marketing literature. Researchers could review the literature on the e-commerce context across the individual and organizational levels to explain VR and AR use in e-commerce more broadly. Fourth, although major key terms such as *VR*, *AR*, *mixed reality*, and *extended reality* were used in this study's database search, some articles might have been overlooked if they did not include these terms in their titles, abstracts, or keywords. Fifth, most of the reviewed articles on headset-based XR in e-commerce focused on VR, perhaps due to VR headsets' technological maturity. Future exploration of headset-based AR in the e-commerce context would require persistent attention to AR technological development.

CRediT authorship contribution statement

Hong Chen: Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Formal analysis, Conceptualization. **Hongxiu Li:** Writing – review & editing, Supervision, Formal analysis, Conceptualization. **Henri Pirkkalainen:** Writing – review & editing.

Declaration of competing interest

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

Data availability

No data was used for the research described in the article.

Appendix:. A list of the reviewed 71 articles

No.	Authors	VR/AR	Context	Theory	Research method(s)	Stimuli	Consumers' response (s)	Moderator(s)
1	(Alimamy and Gnoth, 2022)	Mobile-based AR	Furniture	/	Experiment	– 3D images	CR: Perceived trust and perceived riskBR: Product recommendation intention	– Perceived value
2	(Altarteer and Charissis, 2019)	Projection-based VR	Luxury suitcase	TAM	Experiment	– Life-sized 3D images	CR: Perceived experience valueAR: Attitude towards systems	– Product customization– Personalization features
3	(Alzayat and Lee, 2021)	Headset-based VR	Hammers andclothes	/	Experiment	– Texts– Touch sense by VR headsets– 3D images	CR: Perceived telepresence and need for touchBR: Purchase intention	– Autotelic– Instrumental
4	(Bonnin, 2020)	Computer-based AR	3D try-on: sports shoes and sunglasses	/	Experiment	– Texts– 2D pictures	CR: Utilitarian evaluation, hedonic evaluation, perceived risk, and attractiveness of the online storeBR: Patronage intention	– Familiarity with AR
5	(Brito and Stoyanova, 2018)	Computer-based AR	3D try-on: sports shoes	/	Experiment	– 3D images	CR: Perceived ease of control and usabilityER: Emotional expression and interactive experienceBR: Recommendation intention	– Website visit– Brand awareness of the target category– Innovativeness– Emotional intensity
6	(Brito et al., 2018)	Computer-based AR	3D try-on: sports shoes	Transfer theory	Experiment	– 3D images	CR: Brand familiarity, perceived risk, opinion	

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No.	Authors	VR/AR	Context	Theory	Research method(s)	Stimuli	Consumers' response (s)	Moderator(s)
							leadership, and perceived interactivityER: Positive and negative emotionsAR: Attitude towards brand relationship	
7	(Butt et al., 2022)	Mobile-based AR	3D try-on: cosmetics	/	Case study	− 3D images	CR: Perceived ease of use, and immersionBR: Mobile AR use intention	
8	(Chen et al., 2023)	Headset-based VR	Furniture	SOR	Experiment	− 3D images	CR: Telepresence, perceived diagnostic, and playfulnessBR: Purchase intention	
9	(Chiang et al., 2021)	Computer-based AR	3D try-on: apparel and accessories	− TAM − CLT	Survey	− Online store design− Navigation structure using gestures− Information content with different colors	CR: Perceived ease of use and usefulnessBR: Intention to use AR	
10	(Elboudali et al., 2020)	Headset-based VR	Customized luxury bag	/	Case study	− Texts− 2D pictures	CR: Perceived interactivityBR: Product browse time and purchase intention	
11	(Erdmann et al., 2021)	Headset-based AR	3D try-on: cloth	The value-based adoption model	Experiment	− Texts− 3D images	CR: Perceived immersion, AR-tech complexity, and valueBR: Purchase intention	− Subjective norm: social pressure
12	(Fang et al., 2014)	Computer-based VR	Virtual agent	Trust	Survey	−Virtual agent services− 3D images	CR: Trust	
13	(Gabriel et al., 2023)	Mobile-based AR	Fashion and beauty products	SOR	Survey	− 3D images	CR: Interactivity, novelty, and hedonic valueAR: SatisfactionBR: Purchase intention	
14	(Goel et al., 2023)	Mobile-based AR	Glasses	/	Survey	−3D images−Background music	ER: Emotional states (arousal, pleasure)BR: Purchase intention	− Product involvement
15	(Han et al., 2021)	Mobile-based AR	3D try-on: glasses	SOR	Experiment	− 2D pictures− 3D images	CR: Perceived enjoyment, attractiveness, immersion, and product riskAR: Satisfaction with recommendationBR: Patronage intention	− Technophilia
16	(Hilken et al., 2020)	Mobile-based AR	Paints	Social cognition theory	Experiment	− Texts− 2D pictures/ video− Static/ dynamic interaction	CR: Perceived social empowerment, and recommendation comfortBR: Intention to use recommended products− Recommendation intentions	− Recommender's impression management concerns− Strength of a recommender's persuasion goal
17	(Howes et al., 2001)	Computer-based VR	Books/household items	Memory theory	Experiment	− Texts− 2D pictures	CR: Perceived target items recalledBR: User visit behavior	− Memory ability: target or incidental− Type of product retrieved (household is easy to memory vs. homologous books are hard to memory)
18	(Hsiao and Lin, 2023)	Computer-based VR	Supermarket	TTF	Survey	−360-degree-VR-images	CR: Spatial presence, perceived needs-technology fitBR: Purchase intention	− Immersiveness of VR
19	(Huang et al., 2019)	Computer-based AR	3D try-on: cloth	Self-evaluation theory	Experiment	− Online store design (background music)− 3D images	CR: Perceived enjoyable interaction, personal and interactive system connection, and rapport experience	− Body surveillance− Fashion consciousness

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No.	Authors	VR/AR	Context	Theory	Research method(s)	Stimuli	Consumers' response (s)	Moderator(s)
20	(Hwangbo et al., 2020)	Computer-based VR	3D try-on: cloth	TAM	Interview	− 3D images	CR: Perceived confidence in apparel fit, model self-congruity, and perceived convenience of virtual tryBR: Revisit behavior, online shopping behavior, sales and return behavior	
21	(Jang and Hsieh, 2021)	Headset-based VR	Tourism	Media richness theory	Experiment	− 3D images− Gamification	CR: Perceived media richness, usefulness, ease of use, and valueAR: Satisfaction towards travel experience in VRBR: Visit intention to travel destination in VR and recommendation of travel destination in VR	
22	(Jiang et al., 2022)	Mobile-based AR	3D try-on: sports shoes	/	Experiment	− 3D images	CR: Perceived interactivityBR: Intention to use AR	
23	(Jin et al., 2021)	Headset-based VR	Fashion store (boutique)	SOR	Experiment	− Online store design− 360-degree-VR-video	CR: Perceived store attractivenessER: Pleasure in technology use	− Customers' store familiarity
24	(Kang et al., 2020)	Computer- and headset-based VR	Furniture	Affective cognition model	Experiment	− 2D pictures− 3D images	CR: Perceived playfulness and informativenessAR: Hedonic attributes preferenceBR: Purchase intention	− Graphics quality
25	(Kim et al., 2022)	Headset-based VR	Fashion store (boutique)	Flow theory	Experiment	− Online store design− 360-degree-VR-video	CR: Perceived flow stateAR: Interest in the online storeBR: Intention to visit offline store	
26	(Kinzinger et al., 2022)	Computer- and headset-based VR	Kitchen appliance	− Cue summation theory− Self-diagnosticity	Experiment	− 3D images	CR: Perceived presence and diagnosticityAR: Attitude towards technologyBR: Purchase intention	− Online shopping frequency
27	(Koontz and Gibson, 2002)	Headset-based VR	High-end products	/	Interview	− 3D images− Graphic quality	AR: Interest in productsBR: Technology use intention	
28	(Kowalczuk et al., 2021)	Mobile-based AR	Furniture	Feelings-as-information theory	Experiment	− 3D images	CR: Perceived immersion, enjoyment, usefulness, and choice confidenceAR: Product likingBR: AR reuse and purchase intention	
29	(Krasonikolakis et al., 2021)	Headset-based VR	Fashion store	Store atmosphere theory	Experiment	− Online store design− 3D images	CR: Perceived ease of use and usefulnessBR: VR-based online store choice	− Shopping motivation (hedonic vs. utilitarian orientation)
30	(Lau et al., 2021)	Mobile-based VR	3D avatar: fashion	Self-determination theory	Survey	− 3D images	CR: Perceived competence and autonomy needsBR: App use intention and continuance intention to make in-app purchases	
31	(Lavoye et al., 2023)	Mobile-based AR	Sunglasses and makeup	Extended self-theory	Quasi-experiment	−3D images	CR: Presence, self-explorative engagement, and brand cognitive processingAR: Brand attitude	

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No.	Authors	VR/AR	Context	Theory	Research method(s)	Stimuli	Consumers' response (s)	Moderator(s)
32	(Li et al., 2023)	Computer-based VR	Tourism	−Cognitive emotional theory− SOR	Survey	−360-degree-VR-images−Texts	CR: Perceived usefulness and playfulnessER: Interactive pleasureBR: Purchase intention	− Interactive comparison (Times of product comparison)
33	(Liu and Tanaka, 2020)	Mobile-based AR	Food	/	Experiment	− Texts− Gamification− 3D images	AR: Interest to join in activitiesBR: Time spent on the website	− Social cue (competitive/non-competitive interactions)
34	(Liu and Uang, 2016)	Headset-based VR	Stationery	/	Experiment	− 2D pictures− 3D images− Display pattern	CR: Perceived sense of presence and cybersickness	− Type of display (autostereoscopic, stereoscopic and monocular displays)
35	(Liu et al., 2020)	Computer- and mobile-based AR	3D try-on: cloth	/	Experiment	− 3D images	CR: Perceived enjoyment, usefulness, convenience, and fitBR: Purchase intention	
36	(Lixăndroiu et al., 2021)	Computer-based AR	3D try-on: cloth	− Big Five trait-Locus of control	Experiment	− 3D images	CR: Perceived impulsivenessBR: Purchase intention	
37	(Luangrath et al., 2022)	Headset-based VR	− Cloth− blanket− coffee− knitting− electronics	− Body ownership and psychological ownership− Sensory stimuli	Experiment	− 2D pictures− 3D images− Product holding sense via VR headsets	CR: Perceived sense of psychological ownershipAR: Product likingBR: Purchase intention and willingness to pay	− Hand types (disembodied hand vs. human hand)− Hands quality (dark vs. lighthand depiction) ×continuous (participant skin tone)− Mindset (diagnostic vs. non-diagnostic)− Hand movement types (typical vs. atypical movement)
38	(Meißner et al., 2020)	Computer- and headset-based VR	Virtual agent	/	Experiment	− 3D images	CR: Perceived price-sensitivityAR: Satisfaction with choice	
39	(Moriuchi et al., 2021)	Mobile-based AR	Virtual agent	− The theory of conversation − ECT	Experiment	− Virtual agent design− Texts− 2D pictures	CR: Perceived technology engagementAR: Satisfaction with technologies usedBR: Revisit and purchase intention	
40	(Morotti et al., 2021)	Headset-based VR	Cloth		Experiment	− Virtual agent design− Texts− 3D images	CR: Perceived ease of use, enjoyment, and voice gainAR: Attitude towards VRBR: Purchase intention	
41	(Pantano et al., 2017)	Computer-based AR	3D try-on: glasses	TAM	Experiment	− 3D images	CR: Perceived enjoyment, ease of use, and usefulnessBR: Purchase intention	
42	(Papadopoulou, 2007)	Computer-based VR	Virtual agent	Trust	Survey	− Virtual agent services design− Texts− 3D images	CR: TrustAR: Preference for the virtual real store environment	
43	(Phuthong, 2022)	Computer- and mobile-based AR	Furniture	TAM	Survey	− 3D images	CR: Perceived hedonic-utilitarian need and customer engagement	
44	(Poushneh, 2018)	Computer- and mobile-based AR	3D try-on: cloth	Equity theory	Experiment	− 3D images	CR: Perceived sense of privacyAR: Satisfaction with technology use	
45	(Poushneh, 2021)	Mobile-based AR	3D try-on: glasses	CLT	Experiment	− 3D images	CR: Perceived measurement feedback and generalityBR: Purchase intention	− Product in/out consumers' consideration set

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No.	Authors	VR/AR	Context	Theory	Research method(s)	Stimuli	Consumers' response (s)	Moderator(s)
46	(Rese et al., 2017)	Mobile-based AR	– Furniture– 3D try-on: glasses– Auto	TAM	Experiment	– Products' sound simulated by mobile-based AR– 3D images	CR: Perceived usefulnessAR: Attitude towards technologyBR: Intention to use and recommend AR	
47	(Ricci et al., 2023)	Computer-based and Headset-based VR	Fashion industry: clothes and accessories	/	Experiment	– 3D images	CR: Hedonic value, utilitarian value, and cognitive loadBR: Time duration spent in the VR store	
48	(Ringler et al., 2021)	Headset-based VR	– Furniture–Sports utility vehicle (SUV)	Cue Diagnosticity and Power	Experiment	– Products' sound simulated by headset-based VR	CR: Perceived powerBR: Willingness to pay	
49	(Schaeffer et al., 2018)	Headset-based AR	Green productagent	/	Survey	– 3D images	CR: Perceived cognition processing burdenBR: Willing to pay for products and product choice frequency	
50	(Schnack et al., 2021)	Headset-based VR	Snacks	Big five trait	Experiment	– 3D images	CR: Perceived product knowledgeBR: Purchase intention and shopping dwell time	
51	(Silva and Bonetti, 2021)	Headset-based AR and VR	Virtual agent	Human-computer interaction	Survey	– Virtual agent– Texts	BR: Intention to interact with the digital agent	– Consumer demographics: age, country of residence, gender, employment status, income, and current primary mobile device
52	(Smink et al., 2019)	Mobile-based AR	3D try-on: cosmetics	Reactance theory	Experiment	– 3D images	CR: Perceived enjoyment, informativeness, and intrusivenessAR: Attitude towards brandBR: Purchase intention and willingness to share personal data	
53	(Smink et al., 2020)	Mobile-based AR	Furniture and make-up	– Presence theory– Reactance theory	Experiment	– 3D images	CR: Perceived spatial presence, personalization, and intrusivenessAR: Attitude towards AR and brandBR: Purchase intention	– Product types (make-up (face) vs. furniture (surroundings))
54	(Song et al., 2020)	Mobile-based AR	3D try-on: watch	Habituation-tedium theory	Experiment	– 3D images	CR: Perceived immersion, ownership, and decision comfort	– Consumers' prior AR try-on experience
55	(Speicher et al., 2017)	Computer- and headset-based VR	Grocery	/	Survey	– Products' sound simulated by headset-based VR– Texts– 2D pictures– 3D images	CR: Perceived motion sicknessAR: Consumer satisfaction with technologies	
56	(Su et al., 2020)	Headset-based VR	Household: kitchen	/	Interview	– 3D images	AR: Satisfaction with systems	– Consumers' prior VR experience
57	(Suh and Lee, 2005)	Computer-based VR	Furniture	Cognitive fit	Experiment	– 3D images	CR: Perceived learning of product knowledgeAR: Attitude towards productsBR: Purchase intention	– Product types (virtually high experiential vs. low)
58	(Suh and Chang, 2006)	Computer-based VR	Furniture	– Telepresence – Negativity theory	Experiment	– Texts– 2D pictures– 3D images	CR: Perceived telepresence and product knowledgeAR: Attitudes towards productsBR: Purchase intention	
59	(Sun et al., 2022)	Mobile-based AR	Necessary (Suitcase, glasses, Bluetooth and desk lamp)	Uncertainty reduction theory	Experiment	– 3D images	CR: Perceived informativeness, presence, mental imagery, and product	– Product involvement– Need for sensory

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No.	Authors	VR/AR	Context	Theory	Research method(s)	Stimuli	Consumers' response (s)	Moderator(s)
							quality fitAR: Attitude toward products	richness– Self-brand connection
60	(Tan et al., 2021)	Mobile-based AR	3D try-on: cosmetics	Product fit uncertainty	Experiment	– 3D images	CR: Perceived uncertaintyBR: Purchase intention	– Product characteristics (Brand popularity, product appeal, ratings, price)– Consumers' familiarity with online channels and product category
61	(Wang et al., 2015)	Computer-based AR	3D try-on: cloth	/	Experiment	– 3D images	BR: Task completion time and paging frequency	
62	(Wang et al., 2020)	Computer-based VR	3D try-on: cosmetics	– TTF – TRA	Case-study	– 3D images	CR: Perceived goodness of fit of task and technologyBR: Technology use intention	
63	(Wang et al., 2019)	Computer-based VR	Cat products	Telepresence theory	Experiment	– Online store design– Texts– 3D images	CR: Perceived product knowledgeBR: Purchase intention	– Product types: geometric, material, and mechanical
64	(Wang et al., 2023)	Computer-based VR	Virtual agent	Trust theory	Survey	– 3D images	CR: Presence and customers' trustBR: Purchase intention	– Streamers' type: Perceived integrity, ability, and benevolence, perceived similarity
65	(Willems, 2019)	Computer- and headsets-based VR	Tourism	Customer engagement	Experiment	– 2D pictures– 360 panoramic video–3D images	CR: Perceived enjoyment and telepresenceBR: Travel product purchase intention	
66	(Xue et al., 2020)	Computer-based VR	3D try-on: cosmetics	Hedonic and utilitarian value	Interview	– 360 panoramic video– 3D images	CR: Perceived ease of use, usefulness, enjoyment, trust, utilitarian and hedonic value	
67	(Yang, 2019)	Computer-based VR	3D try-on: cloth	/	Experiment	– 2D pictures– 3D images	AR: Post-sale satisfactionBR: Product return	– Presence vs. absence of CVD– Virtual display: appealing promotional photos featuring fashion models
68	(Yim et al., 2017)	Computer-based AR	3D try-on: watch	– The habituation–tedium theory- Cue-utilization theory	Experiment	– 3D images	CR: Perceived immersionAR: Consumer attitude toward technologiesBR: Purchase intention	– Precious media experiences
69	(Yoon et al., 2008)	Computer-based VR	Furniture	– Presence– TAM	Experiment	– 2D pictures– 3D images	CR: Perceived confidence in using technologyAR: Satisfaction with VR use	
70	(Zhao et al., 2017)	Computer-based VR and AR	Furniture	/	Experiment	– Online store design (background music)– 3D images	CR: Perceived mental load	– Sensory channel: visual sound vs. visual– Cognitive style: field-independent vs. field-dependent– Gender: male vs. female
71	(Zhu et al., 2023)	Headset-based VR	Supermarket	/	Experiment	–3D images–Texts	CR: Perceived warmth, trust, comfortAR: Satisfaction	

Note: CR: Cognitive response; ER: Emotional response; AR: Attitudinal responses; BR: Behavioral responses; TAM: Technology acceptance model; CLT: Construal-level theory; SOR: Stimuli-organism-response; TRA: Theory of reasoned action; TTF: Task-technology-fit theory; ECT: Expectation confirmation theory.

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