Received 16 May 2022
Revised 30 October 2022
1 March 2023
20 April 2023
10 September 2023
9 January 2024
Accepted 10 January 2024

Acceptance of the metaverse: a laboratory experiment on augmented and virtual reality shopping

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Abstract

Purpose – In recent years, there has been significant interest in adopting XR (extended reality) technologies such as VR (virtual reality) and AR (augmented reality), particularly in retail. However, extending activities through reality-mediation is still mostly believed to offer an inferior experience due to their shortcomings in usability, wearability, graphical fidelity, etc. This study aims to address the research gap by experimentally examining the acceptance of metaverse shopping.

Design/methodology/approach – This study conducts a 2 (VR: with vs. without) × 2 (AR: with vs. without) between-subjects laboratory experiment involving 157 participants in simulated daily shopping environments. This study builds a physical brick-and-mortar store at the campus and stocked it with approximately 600

This work has been supported by KAUTE Foundation under Grant No. 20190003 and No. 20200531; OP Ryhmän Tutkimussäätiö under Grant No. 20200040; Liikesivistysrahasto under Grant No. 180386 and No. 210301; Academy of Finland under Grant No. 327241 and Grant No. 337653 and Nasdaq Nordic Foundation (Investigame: Promoting Financial Literacy and Pro-Environmental Choices Using Game-Based Pedagogy and Virtual Reality). This work was carried out with the support of Centre for Immersive Visual Technologies (CIVIT) research infrastructure in Tampere University, Finland. Special thanks to Henrietta Jylhä and Shuo Yang's contribution to the program development, experiment design and implementation. The authors would also like to thank all student participants from Tampere University.

Conflicts of interest: No conflicts of interest have been declared.

Internet Research
Vol. 34 No. 7, 2024
pp. 82-117
Emerald Publishing Limited
1066-2243
DOI 10.1108/INTR-05-2022-0334

products with accompanying product information and pricing. The XR devices and a 3D laser scanner were used in constructing the three XR shopping conditions.

Findings – Results indicate that XR can offer an experience comparable to, or even surpassing, traditional shopping in terms of its instrumental and hedonic aspects, regardless of a slightly reduced perception of usability. AR negatively affected perceived ease of use, while VR significantly increased perceived enjoyment. It is surprising that the lower perceived ease of use appeared to be disconnected from the attitude toward metaverse shopping.

Originality/value – This study provides important experimental evidence on the acceptance of XR shopping, and the finding that low perceived ease of use may not always be detrimental adds to the theory of technology adoption as a whole. Additionally, it provides an important reference point for future randomized controlled studies exploring the effects of technology on adoption.

Keywords Mixed reality, Extended reality, VR, AR, Retail, Technology acceptance

Paper type Research paper

1. Introduction

With the aid of the Internet, consumers can more efficiently browse, search and acquire information about products and services (Grewal *et al.*, 2004). At the same time, shopping became a more cognitively-oriented and information-heavy task, losing some of the multidimensional experientiality of Brick-and-Mortar (B-a-M) shopping (Grewal *et al.*, 2004). However, with the recent progress of XR (extended reality) technologies such as VR (virtual reality) and AR (augmented reality), it is now believed that the experientiality of shopping might be making a comeback as XR may be able to combine the advantages and benefits of digital and physical shopping (Bonetti *et al.*, 2018; Xi and Hamari, 2021), so offering a more optimal mix of experientiality and utility. Such a futuristic-sounding shopping experience can be represented by the concept of "Metaverse Shopping."

It has been felt that these recent technological developments regarding the metaverse may open the door to a new shopping experience (Pizzi *et al.*, 2019; Greenwood *et al.*, 2016). For example, large international retail giants such as IKEA (VR kitchen), Amazon (AR/VR applications) and Walmart (AR scanner) have started to move toward technology-based innovative business, and the global market for VR and AR in retail has been expected to reach USD 1.6 billion by 2025 (Joshi, 2019). However, these "hype" technologies for creating the metaverse have also raised concerns among retailers and consumers that the additional XR modalities might reduce the shopping experience in terms of comfort, information overload, usability, richness, responsiveness and even introduce a change in behavioral norms. Currently, consumers' attitude and willingness to adopt metaverse shopping are still ambiguous, and many retailers have gradually lost confidence and interest in investing in new technologies (Boardman *et al.*, 2020). In academia, there is a growing interest in exploring user experiences within the metaverse, as evidenced by recent literature reviews and conceptual studies (see Barrera and Shah, 2023; Dwivedi *et al.*, 2023; Hadi *et al.*, 2023). This surge in interest is particularly notable in the realm of consumer experiences within the metaverse, specifically within the context of activities such as shopping (see Table 1 in Section 2). However, it is noteworthy that in general, there is only a limited amount of comprehensive empirical studies that focus on the factors and perceptions of the metaverse (Damar, 2021; Shen *et al.*, 2021), which has hindered the development of a deep understanding of the fundamental value and function of the metaverse. First, regarding the concept of metaverse, there is no consensus of prior studies on what the metaverse is and what it actually consists of. Therefore, the representative XR technologies, including AR and VR, have rarely been investigated together and compared. Second, it should be noticed that the majority of extant literature has examined the adoption of existing and available XR applications in the market, based on surveying the users in general. In the fields of Information Systems (IS) and Information Technology (IT), legacy technology acceptance

Table 1.
Extant empirical studies related to the acceptance of metaverse shopping

Sources	Technologies	Devices	Methods	Relevant variables	Sources	Technologies	Devices	Methods	Relevant variables
Altarteer and Charissis (2019)	VR for online luxury products	Projection screen	User evaluation-based questionnaire ($N = 42$)	Perceived presence, usefulness, ease of use, perceived experience value, attitudes	Park and Kim (2022)	Virtual try-on (AR) vs. 3D virtual stores (VR)	Two mock e-commerce websites/PC	Between-subjects experiment ($N = 194$, female students)	Consumption vision, interactivity, image quality issue, novelty, lack of realism, difficult to use, technological limitations
Javornik (2016a)	- IKEA AR app - AR virtual try-on for sunglasses	- Tablet - PC with webcamera	Between-subjects experiment ($N = 60$)	Perceived augmentation, flow, affective responses, cognitive responses	Peukert *et al.* (2019)	VR shopping environment	HTC VIVE	Between-subjects experiment ($N = 257$)	Immersion, perceived product diagnosticity, telepresence, usefulness, enjoyment and intention to reuse shopping environment
Huang and Liao (2015)	ARIT for online fitting	N/A	User evaluation-based questionnaire ($N = 220$)	Presence, ease of use, usefulness, aesthetics, service excellence, playfulness, sustainable relationship, consumer's cognitive innovativeness	Rese *et al.* (2014)	IKEA AR app	Mobile phone	User evaluation-based questionnaire ($N = 275$)	Perceived informativeness, enjoyment, usefulness, ease of use, attitude toward using and behavioral intention to use

(*continued*)

Table 1.

Sources	Technologies	Devices	Methods	Relevant variables	Sources	Technologies	Devices	Methods	Relevant variables
Hwang *et al.* (2023)	Fashion-related (eyewear) AR apps	Mobile phone	Between-subjects experiment (N = 114)	Perceived ease of use, usefulness, privacy priming, behavioral intention to use	Rese *et al.* (2017)	Four different AR apps (marker and markerless)	- Tablet - Smartphone - PC/laptop with webcam	Evaluation-based questionnaires (4 studies, N = 978)	Perceived informativeness, enjoyment, usefulness, ease of use, attitude toward using and behavioral intention to use
Kim and Forsythe (2008)	Virtual Try-on technology	N/A	Five focus groups and an online survey (N = 491)	Usefulness of virtual try-on, ease of use, entertainment value, attitude, technology anxiety, innovativeness, intended use, post-use evaluation	Saleem *et al.* (2022)	Eyeglass-wearing AR apps	Mobile phone	User evaluation-based questionnaire (N = 363)	Vividness, novelty, perceived usefulness, ease of use, enjoyment, attitude toward use, behavioral intention to use

(*continued*)

Table 1.

Sources	Technologies	Devices	Methods	Relevant variables	Sources	Technologies	Devices	Methods	Relevant variables
Lee *et al.* (2022)	AR-enhanced virtual try-ons	Mobile phone	User evaluation-based questionnaire (N = 352)	Perceived interactivity, augmentation, telepresence, utilitarian value, hedonic value, adoption intention, sensation-seeking tendency, technology anxiety	Shah Alam *et al.* (2022)	AR applications for online buying	N/A	Online questionnaire (N = 265)	Social identity, perceived usefulness, ease of use, personal innovativeness, self-efficacy, enjoyment, attitude, intention to use
McLean and Wilson (2019)	Three AR apps: ASOS, Amazon and IKEA	N/A	Online questionnaire from users of AR apps (N = 441)	AR novelty, interactivity and vividness, ease of use, usefulness, enjoyment, subjective norms, brand engagement, satisfaction and brand usage intention	Sikström *et al.* (2016)	VR shelf	Oculus Rift DK2	Within-subjects experiment (N = 22)	Presence, body ownership, awareness of movements, usability and enjoyment
Ohta *et al.* (2015)	AR and VR for electronic product	- Oculus Rift DK1-VR - Desktop PC-AR	User evaluation-based questionnaire (N = 11)	Usefulness and ease of use	Spreer and Kallweit (2014)	AR application for books	Tablet	Experimental field study (N = 96)	Perceived ease of use, usefulness, enjoyment and intention to reuse

(continued)

Table 1.

Sources	Technologies	Devices	Methods	Relevant variables	Sources	Technologies	Devices	Methods	Relevant variables
Oyman *et al.* (2022)	AR apps virtually trying-on cosmetic products	Mobile phone	User evaluation-based questionnaire (N = 278, all females)	Novelty seeking, perceived augmented reality, enjoyment, usefulness, informativeness and ease of use, behavioral intention to use	Van Kerrebroeck *et al.* (2017)	VR Christmas experience	Oculus Rift DK2	Between-subjects experiment (N = 183)	Attitude toward the mall, approach behavior, mall satisfaction and loyalty intention
Pantano and Servidio (2012)	VR clothing store	Large screen with polarized glasses	User evaluation-based questionnaire (N = 150)	Ease of use, enjoyment, store perception and consumer satisfaction	Verhulst *et al.* (2016)	VR supermarket	Full HD 3D 1080p Projector	Between-subjects experiment (N = 80)	Performance (task completion time and the traveled distance) and NASA Task Load Index
Pantano *et al.* (2017)	Virtual try-on system for sunglasses	PC with webcamera	User evaluation-based questionnaire (n = 150, Italy; n = 168, Germany)	Aesthetic quality, interactivity, response time, quality of information, ease of use, enjoyment, usefulness, attitude and behavioral intention	The current study	AR, VR and AV (AR + VR) shops compared to self-built physical shop	Valve Index VR headset & Microsoft HoloLens AR headset; allow body movement and interaction	Between-subjects experiment (N = 157)	Perceived enjoyment, perceived ease of use (NASA Task Load Index), perceived usefulness, attitude and intention to visit

Source(s): Author's own creation/work research has started to face resistance as it often provides only iterative additions to the literature and especially disregards methodological ambition. Consequently, it is especially important to investigate its adoption through experimental settings where users have the opportunity to acquire a first-hand experience of the technology. Furthermore, synthesizing findings from previous studies is quite challenging due to the fact that prior research has either focused on the effects of single- or multiple-specific attributes of AR/VR on adoption or has examined different shopping contexts involving various interactions. Therefore, it is still unknown whether consumers are generally willing to adopt XR in general for shopping (rather than any specific features) and what factors would influence the adoption.

To address the research gap, we experimentally examine the acceptance of metaverse shopping using the technology acceptance model, aiming at answering the research questions of *whether and how AR and VR technology differently affect consumers' perceived usefulness and perceived enjoyment, perceived ease of use, attitude, as well as their future intention to re-experience XR shopping*. We conducted a 2 (VR: with vs. without) × 2 (AR: with vs. without) between-subjects laboratory experiment with 157 participants in real-life daily shopping environments, combined with a psychometric questionnaire. The cutting-edge research question, important findings and experiment-based empirical approach offer considerable empirical, theoretical and methodological research contributions. In addition, they provide valuable practical implications for practitioners who seek to utilize virtual technologies for retail transformation, as well as for developers and designers of metaverse platforms.

This study is structured as follows. Section 2 describes the theoretical background and hypothesis development. The experimental method and implementation are detailed in Section 3, including laboratory experiment design, participants, materials, measures and procedure. Section 4 analyzes the structural equation model and Section 5 provides a detailed discussion of the results, theoretical contributions and practical implications of the work. Section 6 presents the conclusions, and the Section 7 points out future research directions based on the limitations that are acknowledged.

2. Background and hypothesis

2.1 Theoretical background

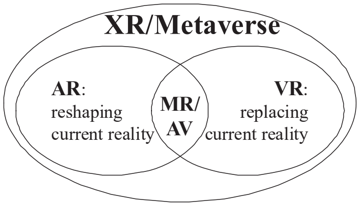
2.1.1 Metaverse: AR and VR. Metaverse broadly represents artificially generated, modified, diverse and extended realities that are built on the convergence of virtual technologies and multimodalities (Dwivedi *et al.*, 2022; Pamucar *et al.*, 2022; Rauschnabel *et al.*, 2022). The term "Metaverse" was first coined by Neal Stephenson in his 1992 science-fiction novel *Snow Crash* and refers to the dystopian virtual world. Nowadays, this concept is no longer limited to the imagination; it is becoming a futuristic reality that provides full-scale, persistent and interactive experiences (Kozinets, 2022). Even though there is a lack of an accurate definition as to what Metaverse is, it has been considered as interchangeable with the concept of XR (extended reality), which forms an umbrella term for AR (augmented reality), VR (virtual reality) and MR/AV (mixed reality/augmented virtuality). XR or Metaverse is a generic expression that covers all digitalized, replaced, duplicated, alternative, augmented and new realities (Çöltekin *et al.*, 2020; Rauschnabel *et al.*, 2022), and these reshaped realities could be fully or partially virtual (Hwang and Chien, 2022). Figure 1 describes different realities in the metaverse.

VR is one of the core technologies employed in the metaverse. The understanding of VR has deepened over the past 30 years, from being loosely used to refer to things such as the Internet as a whole (Climo, 2001), digital worlds (Lee and Chung, 2008) and virtual games (Zyda, 2005), to describing computer-based 3D virtual environments (Brooks, 1999). This also applies in relation to VR shopping literature where VR has described the web 3D technology used for producing an online store (e.g. web-based applications: see Wang and Datta, 2010;

Second Life retail store: see Vrechopoulos *et al.*, 2009). However, these descriptions usually refer to the provided digital content, while today VR refers to human-computer interfaces and most commonly to stereoscopic head-mounted displays (HMD). It should be acknowledged that the creation of a VR environment usually relies on what is known as presence-inducing or immersive computing technology (Berg and Vance, 2016) that more or less fully covers the field of view of the user through the use of large screens or HMD (Zikic, 2007). Thus, VR is touted to block out the real world (Manis and Choi, 2019) and to digitally duplicate or substitute the "real reality" (Dincelli and Yayla, 2022; Xi and Hamari, 2021; Xi *et al.*, 2023; Yim *et al.*, 2017). VR creates a highly "realistic" digital world for users and a sensation of "being there" (Kipper, 2013; Hardiess *et al.*, 2015). Research and discussions in the field have traditionally focused on HMD-based virtual reality, which provides a higher level of immersive experience (Dincelli and Yayla, 2022).

For a long time, AR has been misleadingly considered as a specific subform of VR (Wedel *et al.*, 2020) and limitedly anchored to the use of computer-generated images superimposed on a view of a "real-world" physical environment (Javornik, 2016b; Olsson *et al.*, 2013; Pantano *et al.*, 2017; Voogt and Fisser, 2015). However, AR provides access to additional "augmenting" information (Pantano and Servidio, 2012; Rese *et al.*, 2014) that can take a variety of forms and provide sensory stimulation using graphics, text, video, sound or other virtual elements (Van Krevelen and Poelman, 2010) such as scent (Lu and Smith, 2007) and tactile stimulation (Azuma, 1997). AR is also agnostic as to the "reality" it is augmenting (Rovaglio *et al.*, 2012). Virtual reality can also be augmented by superimposing other content onto it. This has separately been referred to as augmented virtuality (AV) (Albert *et al.*, 2014; Riar *et al.*, 2023) and in the present study corresponds to one of the treatments of the 2×2 experiment (where AR elements are superimposed onto the view of virtual reality in Group 4). In retail, with the help of recognition and tracking techniques (e.g. location-based and image-based AR), relevantly digitalized content can be triggered and displayed on screens in different forms according to specific elements (e.g. images, objects, barcodes, QR codes and location) in the immediate surroundings (Aggarwal and Singhal, 2019).

2.1.2 Acceptance of metaverse shopping. The Technology Acceptance Model (TAM) (Davis, 1989; Van der Heijden, 2004) has been the workhorse theory used to guide research models of the past 30 years that investigate why people adopt and continue using different technologies, ranging from the machines of yesteryear (e.g. mainframes: Panko, 1988) to contemporary technologies such as gamification (Hamari and Koivisto, 2015), VR (Disztinger *et al.*, 2017) and robotics (Conti *et al.*, 2015). According to the seminal vision of TAM, the attitude and behavioral intention of using a specific technology are determined by two factors: *perceived usefulness* and *perceived ease of use* (Davis *et al.*, 1989). However, when IS were more pervasively adopted into leisure use and consequently became a source of intrinsic need satisfaction (Davis *et al.*, 1992; Deci and Ryan, 2000), TAM was expanded to incorporate the hedonic factor of enjoyment (Van der Heijden, 2004). Later iterations conceptualizing the



Source(s): Author's own creation/work

Figure 1.
Metaverse

nature of IS in relation to hedonic and instrumental aspects have developed the realization that most systems serve a so-called dual purpose (Wu and Lu, 2013), where the enjoyment of the system can further lead to utility, due to the higher motivational benefits involved (see, e.g. Koivisto and Hamari, 2019; Köse *et al.*, 2019). Thus, to better understand the intrinsic motivation of technology usage, *perceived enjoyment* (the extent to which the activity of using the technology is perceived to be enjoyable in its own right: Davis *et al.*, 1992) was extended into the TAM model, which aims at providing self-fulfillment to the technology users (Van der Heijden, 2004). More recently, TAM has been the predominant theory used to examine the acceptance and continued use of innovative technology (Wu *et al.*, 2011; Ayeh *et al.*, 2013; Bailey *et al.*, 2017). This theory has been applied and empirically supported in retailing to predict the adoption of various technologies such as self-service retail technology (Kaushik and Rahman, 2015), online shopping (Wei *et al.*, 2018), mobile shopping (Fuentes and Svingstedt, 2017) and quick response (QR) codes (Kim and Woo, 2016).

Metaverse has been believed to blur the boundary between the physical and virtual worlds (Soliman *et al.*, 2017; Suh and Prophet, 2018) as well as the boundary between utility and hedonism, thus making metaverse technologies akin to dual-purposed ISs (Hamari and Koivisto, 2015; Lee and Kim, 2022; Köse *et al.*, 2019; Koivisto and Hamari, 2019; Kool and Agrawal, 2016; Wu and Lu, 2013). Since user acceptance is an important facet of a successfully implemented new technology (Davis, 1993; Dillon and Morris, 1996), a considerable amount of research has focused on the acceptance of the metaverse, and the TAM model is the most commonly used theoretical framework (see, e.g. Aburbeian *et al.*, 2022; Almarzouqi *et al.*, 2022; Akour *et al.*, 2022). Ahead of research covering various fields such as healthcare (Almarzouqi *et al.*, 2022), sports and recreation (Akour *et al.*, 2022; Huang *et al.*, 2023) and education (Papakostas *et al.*, 2023), prior literature has also empirically investigated the acceptance of metaverse (especially VR and AR) in different shopping contexts based on the TAM model (see Table 1) [1]. In terms of research theme and methodology, most studies have examined the acceptance-related aspects of a single AR or VR shopping application based on a user evaluation-based questionnaire (see, e.g. Altarteer and Charissis, 2019; Pantano and Servidio, 2012; Pantano *et al.*, 2017), and the effects of VR and AR on shopping experiences have rarely been investigated and compared together. As for the technologies that have featured in prior studies, most AR retail-related studies have adopted an existing AR application such as the IKEA furniture app (Javornik, 2016a; Rese *et al.*, 2014, 2017) and virtual try-on technology (e.g. sunglasses: see Pantano *et al.*, 2017; clothing: see Huang and Liao, 2015). Accordingly, the selection of AR devices has also been limited to handheld devices (e.g. tablets: Spreer and Kallweit, 2014; mobile phones: Rese *et al.*, 2014; PC with a web camera: Pantano *et al.*, 2017). Due to the limitations of AR devices and programs, the results and conclusions of existing AR studies are basically only applicable to online shopping based on computer or mobile screens and are hence hard to disseminate to a wider range of products. Furthermore, there is also insufficient research on the application of AR (especially wearable AR technology) in other shopping settings such as B-a-M stores.

In contrast, most VR-related studies have been conducted based on self-developed programs for the corresponding devices, such as a HMD (e.g. Peukert *et al.*, 2019) and projector (e.g. Altarteer and Charissis, 2019). However, for the experiment environment used in studies, most VR programs or prototypes have simply created places for shopping activities to take place (e.g. VR shelf: see Sikström *et al.*, 2016; product display: see Altarteer and Charissis, 2019). These experiment settings have limitations for constructing a realistic store that supports the consumer's shopping journey from product search to purchase decision-making. Thus, it is also hard to generalize the empirical results of studies regarding the adoption and acceptance of VR retail. More importantly, in either VR or AR retail studies, XR technologies have mostly been investigated as the context of the research rather than as part of the research model in the form of variables (see, e.g. Rese *et al.*, 2017; Huang and Liao, 2015). Thus, while these studies relate to XR technology, the research models employed do not allow conclusions to be drawn about how XR has affected the shopping experience (e.g. compared with a real-world scenario). In addition, it should also be noted that most VR-related studies have not systematically discussed the acceptance of VR in shopping (concentrating mainly on individual variables), nor have they been based on relevant theory (e.g. Ohta *et al.*, 2015) or had a clear research framework (e.g. Verhulst *et al.*, 2016). Therefore, the empirical evidence lacks knowledge on the acceptance of retail AR and VR technologies in a realistic setting, built on a suitable theoretical basis.

2.2 Hypothesis development

2.2.1 Acceptance of AR retail. According to the extant literature related to AR, vividness, novelty and interactivity have been considered as the three main attributes of AR (Azuma, 1997; McLean and Wilson, 2019). The vividness of AR is seen as the ability to produce a sensory-rich mediated environment (Steuer, 1992) and is usually related to the aesthetic aspects and display quality of information (Flavián *et al.*, 2019; McLean and Wilson, 2019). The novelty of AR refers to the unique and personalized content experienced through the AR display (McLean and Wilson, 2019). The interactivity of AR technology can allow sensory information to be digitally overlaid in either the physical or virtual environment according to user preference (Rovaglio *et al.*, 2012). Overall, it can be seen that the digitized display of information in more vivid, novel and interactive ways can lead to high perceived enjoyment. Thus, we propose the following hypothesis:

H1(a). AR has a significant positive effect on perceived enjoyment.

However, the interactivity of AR usually requires mental and physical user effort (Heeter, 1989; Nam, 2015) and therefore has the potential to reduce the perceived ease of use. Compared with non-AR mediated shopping (e.g. traditional physical shopping), consumers need to make more physical and mental effort when using devices, operating AR systems and processing information from multiple channels. For example, there are limitations in information processing for current AR technology in terms of response time speed and physical resource consumption. More importantly, using AR in shopping activities requires consumers to mentally process and integrate various forms of information from multiple channels simultaneously (split-attention effect, see, e.g. Sweller, 2005), which might lead to high cognitive load and mental effort. As these aspects can potentially decrease the subjective evaluation of the perceived ease of use of AR for shopping, we propose the following hypothesis:

H1(b). AR has a significant negative effect on perceived ease of use.

It should be noted that in the shopping process, the main role of AR is to digitally display controllable information in the environment (McLean and Wilson, 2019; Yim *et al.*, 2017). Thus, AR alone may not influence shopping performance and efficiency in terms of, e.g. information-seeking and decision-making. In other words, the use of AR may not influence consumers' evaluation of how useful the information is. The argument offered in most previous studies that AR can increase shopping value is mainly due to the "additional" content/information provided rather than AR technology as a human-computer interface itself (see, e.g. Rese *et al.*, 2017; Huang and Liu, 2014; Yim *et al.*, 2017). Accordingly, there should be an assumption that no differences in the shopping experience in terms of perceived usefulness would be seen between AR and non-AR environments when the total amount and content of information are controlled to be the same and when the AR technology itself does not significantly hamper the experience. In this study, we propose the following null hypothesis and its corresponding alternative hypothesis:

H1(c)₀. AR has no significant effect on perceived usefulness.

H1(c)ₐ. AR has a significant effect on perceived usefulness.

A null hypothesis is often used in scientific research to test whether there is a significant relationship between two or more variables and is acceptable in the IS field (see, e.g. Johnston *et al.*, 2015; Dong and Wu, 2015; Jiang and Benbasat, 2007). Here, the null hypothesis is put forward to examine whether there is no effect of AR on perceived usefulness. In this study, we do not debate null hypothesis significance testing (NHST) within the hypothetico-deductive tradition (see Mertens and Recker, 2020), but we believe that research contributions should not only depend on significant results. Thus, even a supported null hypothesis can still bring meaningful insights, especially to such a new and promising research area.

2.2.2 Acceptance of VR retail. The core feature of VR is to situate the user in an immersive computer-mediated environment, i.e. by creating the environment in a three-dimensional model and allowing the user to experience it through display technology that appears to insert the user into that environment (Siegrist *et al.*, 2019). With the aid of interactive modalities (Schnack *et al.*, 2019), VR can create similar perceptions and experiences in the virtual world as in the "real" world and thus achieve the goal of diminishing the relevance of the difference between the real and the virtual (Lee *et al.*, 2013). However, in some studies, VR might have the characteristics of the so-called "magic circle" of the game world (Castronova, 2008; also see "non-consequentiality": Xi and Hamari, 2021), which has provided opportunities for a variety of activities that are typically either not done well or safely in real life without concerns for the consequences involved (Schultheis and Rizzo, 2001; Reid, 2004). From this point, VR may give rise to curiosity and playfulness in the user, as the actions they undertake within VR may not have similar consequences to their real-life equivalents. For example, in a real shopping context, the consumer must be careful not to damage goods on display, whereas, in VR, consumers can be allowed to freely use and interact with virtual products, even in an extreme, playful and risky way (Xi and Hamari, 2021). Thus, we propose the following hypothesis:

H2(a). VR has a significant positive effect on perceived enjoyment.

However, as representative wearable technology, VR usually requires a higher amount of physical resources, which leads to high demand for comfort, wearability and functionality. Many critics of HMD systems have reported restricted movement, motion sickness, limited field of view and discomfort (McComas *et al.*, 1998; Reid, 2004), together with complex manipulations and difficulty using controllers, all of which indicate that VR requires a high degree of effort and has a high potential to lead to a low ease of use perception toward shopping. We have to admit that such limitations might be overcome with the development of VR technology, but this is still hard to achieve. Therefore, our assumption of perceived ease of use in the current study is based on the potential of using existing consumer-grade VR devices for providing shopping experiences and can be put forward in the following hypothesis:

H2(b). VR has a significant negative effect on perceived ease of use.

Similar to AR, we can reasonably assume that there should be no distinct difference in perceived usefulness between VR and non-VR shopping environments when the VR content is purposefully replicated to correspond with current reality. As technology for substituting reality (Xi and Hamari, 2021), VR would not change or affect a shopping decision-making process that involves duplicated information and the environment. Accordingly, there should be an assumption that no differences in the shopping experience in terms of perceived usefulness would be seen between the VR and non-VR environments. Therefore, we propose the following null hypothesis and a corresponding alternative hypothesis:

H2(c)₀. VR has no significant effect on perceived usefulness.

H2(c)ₐ. VR has a significant effect on perceived usefulness.

2.2.3 TAM in XR retail. TAM proposes that perceived usefulness and perceived ease of use determine a person's attitude toward using a technology, which in turn determines their intention to use it (Ha and Stoel, 2009). In the study of Van der Heijden (2004), perceived enjoyment was added to the extended TAM model as the additional motivational determinant of acceptance. This has been empirically examined in a number of technology-related studies in business and retail sciences (Ha and Stoel, 2009; Van der Heijden and Verhagen, 2004; Lee *et al.*, 2006; Lee and Chang, 2011). Thus, we hypothesize that in XR shopping, the relationships between different constructs, such as perceived usefulness, perceived ease of use, perceived enjoyment, attitude and intent to use, would be consistent with the theoretical foundation of TAM (Ajzen and Fishbein, 1975; Davis *et al.*, 1989, 1992; Van der Heijden, 2004)—see H3 to H6. Figure 2 further depicts the research model and the hypotheses featured in this study.

H3. Perceived ease of use has a significant positive effect on ***(a)*** perceived enjoyment, ***(b)*** perceived usefulness and ***(c)*** attitude.

H4. Perceived enjoyment has a significant positive effect on attitude.

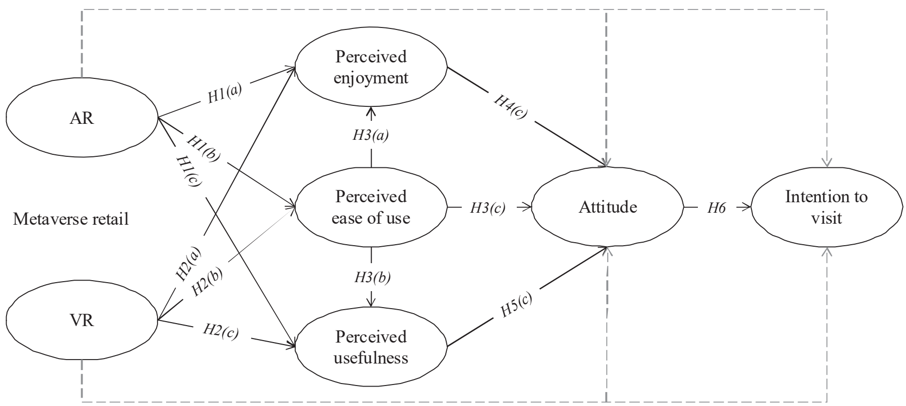
H5. Perceived usefulness has a significant positive effect on attitude.

H6. Attitude has a significant positive effect on the intention to visit.

3. Research method

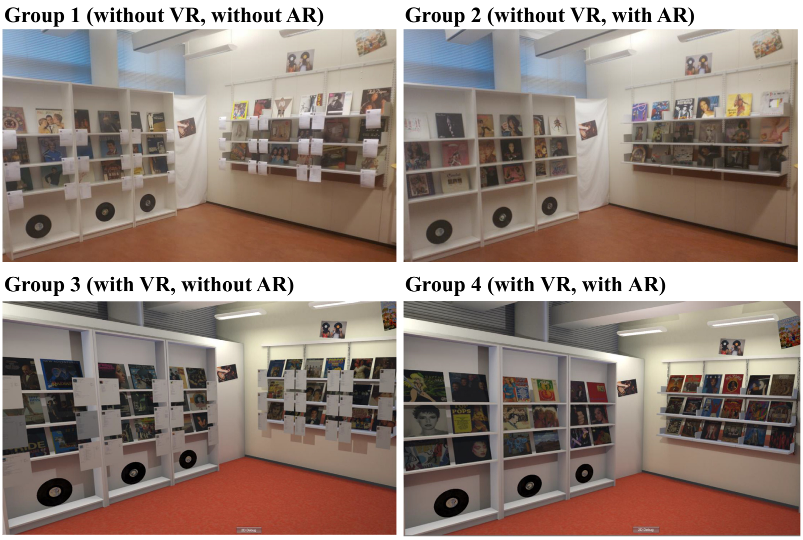
3.1 Design

This study adopted a 2 (VR: with vs. without) × 2 (AR: with vs. without) between-subjects experiment design (see Plate 1). The independent variables were therefore composed of the dummy-coded variables of AR (with = 1, without = 0) and VR (with = 1, without = 0). For the measurement of perceived ease of use, we employed the NASA Task Load Index (NASA-TLX)



Note(s): The dotted lines between variables indicate the potential path relationships. Since there might be some unexpected and effects between AR / VR, attitude and intention to visit, we also tested the direct effects of AR/VR on attitude and intention to visit in this study
Source(s): Author's own creation/work

Figure 2.
Research framework in this study



Note(s): The horizontal axis represents AR technology, value ranges from 0 (without) to 1 (with); the vertical axis represents VR technology, value ranges from 0 (without) to 1 (with)

Source(s): Author's own creation/work

Plate 1.
2 (VR: with vs. without) × 2 (AR: with vs. without) between-subjects experiment design

(Tang *et al.*, 2003). The remaining variables were composed of the psychometric constructs dictated by the technology acceptance model, including perceived usefulness, perceived enjoyment, attitude and behavioral intention (Davis, 1989; Van der Heijden, 2004; Vijayasarathy, 2004).

3.2 Participants

The data for this study was collected from September to November 2019. A total of 165 participants with diverse nationalities were recruited from students at a Finnish university to participate in a shopping-related experiment on the university premises (see *Section 3.5*). Three disqualified participants were identified, and five outliers were omitted during the data-cleaning stage, leaving a sample of 157 for analysis. Among the 157 participants, 54.1% identified as male, and the ages of 122 participants ranged from 20 to 29 years old. Eighty-nine (56.7%) participants were undergraduate students, and 89 (56.7%) had a monthly income of less than €499. The recruited participants came from different countries, including Finland (33.1%), Germany (8.3%), Vietnam (8.3%), China (7.6%), Spain (5.7%), Russia (4.5%), India (3.2%), France (3.2%), Italy (2.5%) and elsewhere. The *F*-test results in Appendix 1 indicate that there was no significant difference between samples across the four groups (all *p*-values >0.05).

We considered the following ways to minimize non-response bias during data collection. First, we offered incentives to motivate participants. Second, we ensured the respondents' anonymity. Third, we sent reminders and assisted with rescheduling. Finally, we encouraged and ensured that all participants completed all tasks in the experiment study. In addition, the results of *T*-tests for comparisons between 50 early respondents and 50 late respondents showed that there were no significant differences in demographic and technology use characteristics, which suggests that there was no non-response bias.

As part of the experimental procedure, each participant was given a gift card (virtual value €10) to buy products in the second-hand record shop during the experiment. The participants were not otherwise compensated; however, each participant got to keep the records they selected in the shop [2]. The purpose of this type of compensation scheme was to garner *realistic* decisions that are made in the shop environment, as the compensation depends upon the rational choices made by the participant. Upon arrival at the laboratory, each participant was randomly assigned to one of four groups (Group 1, n = 40; Group 2, n = 41; Group 3, n = 40; Group 4, n = 36). The study design and procedure adhered to the ethical guidelines set by the Finnish National Board on Research Integrity TENK guidelines (2019).

3.3 Materials

3.3.1 Shops. A physical LP record shop (4.24 meters × 5.09 meters = 21.58 square meters) was built on the university campus. The shop functioned as the experimental setup for each condition. In the control group (shop using neither AR nor VR), the shop functioned as a common B-a-M shop. In Group 2 (shop using only AR), the shop functioned similarly, but with the exception of product information being displayed through an AR headset display (Microsoft HoloLens: see *Section 3.3.4*) rather than through printed product information. In Group 3 (shop using only VR), the same room was used. However, the "control" condition was fully replicated in virtual reality (e.g. textures, lighting conditions and geometry) by using laser scanning and Unity 3D for modeling (LiDAR [3] technology (direct time-of-flight) provided by FARO (brand name) Laser Scanner Focus 3D: see *Section 3.3.4*). The shop in Group 4, utilizing both VR and AR, combined the conditions from Group 3 with the superimposed product information as employed in the conditions of Group 2. In Group 4, the head position of the participant was tracked to predict which record the participant was looking at (similar to the shop used for Group 2), but without using image recognition. The shop floor plan, size, decoration and layout were identical in each condition (see Plate 1). Each wall was equipped with three layers of three-row shelves to achieve a uniform distribution of the products across the room (in total 27 shelves and two products were displayed on each shelf). The video source for each shopping condition is provided as an open-access supplementary file at https://cutt.ly/XR-shopping.

3.3.2 Products. In order to improve the internal and external validity of the research, product-related factors were considered such as providing the same interactivity in all conditions and facilitating information searching and processing for the shopping experience was easy to be modeled in the computer-based environment for VR-mediated conditions. No gender or cultural bias was present in the products, and a large number of real products (approximately 600) were used to simulate a realistic shopping process. Eventually, second-hand English LP Records [4] (31.4 cm × 31.4 cm) were selected as the experiment materials for this study since participant familiarity with the specific artists/bands on display among the records in the shop could be well controlled. As with the general shopping process in daily life, participants searched for and processed relatively simple product information, interacted with products, made a purchase decision with the given €10 gift card and took their chosen products back home.

3.3.3 Extra product information. In regular shopping, consumers usually seek extra information to make purchase decisions. In this study, AR was operationalized as the way of information presentation (the information page was either attached to the shelf or displayed as being superimposed on the environment). The extra product information was gathered from the Discogs website [5], including general product information (e.g. label, format, country, release year, genre and style), track list, social statistics, companies and credit information (see Plate 2).

3.3.4 Apparatus. Microsoft HoloLens. Microsoft HoloLens version 1 AR glasses were used in the shopping condition with only AR (Group 2) in order to superimpose a computer-generated image with the LP record information on the user's view of the real world. The Microsoft HoloLens is equipped with a 1,280 × 720 display resolution (per eye), producing a total of 2.3 million light points and weighs 579 grams.

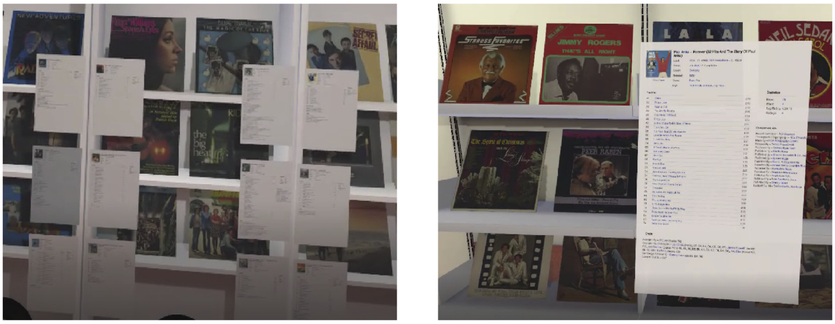
FARO Laser Scanner Focus 3D. The Faro laser scanner focus 3D is a precise and powerful high-speed 3D scanner for various applications. It has a scanning rate of one million points per second and a scanning range of up to 130 meters, a resolution of up to 70 megapixels (color), with a field-of-view coverage of 360°(horizontal) by 300°(vertical).

Valve Index. In shopping conditions with VR technology (Group 3 and 4), the participants used the Valve Index headset (tethered with a free-movement enabling 3.5 meters cable and scanned by two base stations) and its controllers. The Valve Index headset is a fully-immersive headset weighing 809 grams and is equipped with dual 1,440 × 1,600 RGB LCDs, runs at 120 Hz and covers about a 130-degree field-of-view. It is equipped with two controllers (one for each hand) that enable a haptic interface for grabbing records naturally via 87 sensors to track hand and finger positions.

Plate 3 presents the main devices used for constructing and simulating the different shopping environments.

3.4 Measurements

In this study, the main constructs included perceived ease of use, perceived usefulness, perceived enjoyment, attitude and intention to visit and were adapted from existing literature. In terms of perceived usefulness, three items, including efficient, useful and productive, were developed in this study, referring to previous literature (Davis, 1989; San Martín and Herrero, 2012). In addition, perceived enjoyment was measured with four items taken from Van der Heijden (2004); attitude was measured with two items; and intention to visit was measured with three items adapted from



Source(s): Author's own creation/work

Plate 2.
Non-augmented (in Groups 1 and 3) (left) vs. augmented (in Groups 2 and 4) (right): from the participant's view

Note(s): All devices used in this study are available in the market
Source(s): All the used pictures were found from the internet.
1. https://variety.com/wp-content/uploads/2016/02/screenshot-2016-02-29-at-9-41-48-am.png?w=1000&h=563&crop=1&resize=1000%2C563
2. https://geo-matching.com/media/Enk07Ep5.jpg?w=640&s=08d26ec70e98c4387870507f35a8057b
3. https://m.media-amazon.com/images/I/61rt14PIodL.jpg

Plate 3.
Microsoft HoloLens AR glasses (left), the FARO Laser Scanner Focus 3D (middle) and the Valve Index VR headset and controllers (right)

Vijayasarathy (2004). A seven-point Likert scale was used to measure perceived usefulness, perceived enjoyment, attitude and intention to visit, ranging from 1 (representing strongly disagree/improbably) to 7 (strongly agree/very probably). From a technology perspective, perceived ease of use can be seen as the extent to which individuals view the use of technology as being effortless, resulting in enhanced productivity, performance, efficiency and control (Davis, 1989; McLean and Wilson, 2019). To measure perceived ease of use, we employed the NASA-TLX (Tang *et al.*, 2003; Hart and Staveland, 1988), where scoring is achieved by rating 6 items of workload from 0 to 100 in increments of 5, including mental demand, physical demand, effort, frustration, performance and temporal demand. The items of the NASA-TLX were reversed and further converted into a seven-point Likert scale. See Table 2 for all measures. The loadings of EUS 2 and EUS 4 were lower than 0.6 (Wong, 2013); therefore, they were omitted.

Constructs		Loadings
Perceived usefulness (Source: Davis, 1989; San Martín and Herrero, 2012)		
Overall, I found my shopping experience ______		
USF 1	efficient	0.755
USF 2	productive	0.863
USF 3	useful	0.786
Perceived enjoyment (Source: Van der Heijden, 2004)		
Overall, I found my shopping experience______		
ENJ 1	enjoyable	0.849
ENJ 2	exciting	0.832
ENJ 3	pleasant	0.694
ENJ 4	interesting	0.853
Perceived ease of use (Adapted from NASA Task Load Index; Source: Tang *et al.*, 2003; Hart and Staveland, 1988)		
EUS 1	How mentally demanding was the shopping task, e.g. thinking, deciding, calculating, remembering, looking, searching (reversed)	0.842
EUS 2	How physically demanding was the shopping task, e.g. walking, picking, turning, controlling (reversed)	omitted
EUS 3	How hurried or rushed was the pace of the shopping task (reversed)	0.629
EUS 4	How successful were you in accomplishing what you were asked to do in the shopping task (reversed)	omitted
EUS 5	How hard did you have to work mentally and physically to accomplish your level of performance in the shopping task (reversed)	0.793
EUS 6	How insecure, discouraged, irritated, stressed and annoyed were you in the shopping task (reversed)	0.677
Attitude (Source: Vijayasarathy, 2004)		
ATT 1	Visiting a shop which can provide a similar shopping experience would be a good idea	0.927
ATT 2	I would like to visit a shop that can provide me with a similar shopping experience	0.903
Intention to visit (Source: Vijayasarathy, 2004)		
INT 1	I intend to visit a shop which can give me a similar shopping experience frequently	0.877
INT 2	I intend to visit a shop which can give me a similar shopping experience whenever appropriate	0.903
INT 3	Please indicate the probability that you will visit a shop which can give you a similar shopping experience in the near future	0.898

Note(s): The loadings of items EUS 2 and EUS 4 were lower than 0.6; therefore, they were omitted in the analysis
Source(s): Author's own creation/work

Table 2.
Measurement scales

Following Podsakoff *et al.* (2003), potential common method bias in the current study was controlled through the design of the study's procedures and statistical controls. Regarding procedural remedies, the measures of investigated variables were collected from different sources to eliminate the effects of, e.g. consistency motifs, social desirability tendencies and any tendencies on the part of the rater to acquiesce or respond in a lenient manner. Existing scales of previous studies were used to reduce measurement errors, and the order of all measurements was randomized via the advanced features of the SurveyGizmo survey platform (now Alchemer). In addition, the scale items were tested and improved through a pilot test with 20 participants before conducting the formal experiment. In this study, we did not collect any identifiable information and anonymized all of the participants' answers. Regarding statistical controls, Harman's one-factor test was used to determine the presence of common method variance bias among the self-report variables. Only 33.67% of the variance in the variables could be explained by one factor. Thus, no general factor was apparent.

We conducted a confirmatory factor analysis to test the reliability, convergent validity and discriminant validity of the measurement model by using SmartPLS 3.0 software. Specifically, we used out-loadings of the items, internal consistency reliability (Cronbach's α), composite reliability of the latent variable (CR) and average variance extracted (AVE) to reflect the scale's reliability (see Table 2 and Table 3). The values of Cronbach's α and CR for all variables exceeded 0.7 (Hair *et al.*, 2006), which indicated that the level of reliability of the scales is satisfied. In addition, all of the value loadings in this study exceeded 0.6 (Chin *et al.*, 1997; Hair *et al.*, 2006) and ranged from 0.629 to 0.927 at a significance level of 0.05 or less. The average variance extracted (AVE) for all constructs was higher than 0.5 (Bagozzi and Yi, 1988). Therefore, the measurement instrument used in this study had a satisfactory convergent validity.

Discriminant validity was assessed using two approaches. First, discriminant validity was assessed using the method proposed by Fornell and Larcker (1981) by comparing the square root of each AVE with the correlation coefficients for each construct. According to Table 3, the square roots of the AVEs are larger than those of the inter-construct correlation coefficients. Overall, the discriminant validity for this measurement model can be accepted, and supports the distinctions found between constructs. Second, the heterotrait-monotrait (HTMT) ratio of correlation was employed and the results indicated no discriminant validity problems, given that all HTMT values were significantly less than 1 (Henseler *et al.*, 2016).

	AR	VR	Perceived ease of use	Perceived enjoyment	Perceived usefulness	Attitude	Intention to visit
AR	*1*						
VR	−0.032	*1*					
Perceived ease of use	−0.228	−0.003	*0.740*				
Perceived enjoyment	0.090	0.169	0.025	*0.809*			
Perceived usefulness	0.083	−0.067	0.093	0.512	*0.803*		
Attitude	0.126	0.068	−0.226	0.470	0.372	*0.915*	
Intention to visit	0.116	−0.035	−0.138	0.406	0.408	0.809	*0.893*
Cronbach's α	1	1	0.723	0.827	0.726	0.807	0.873
CR	1	1	0.827	0.883	0.844	0.912	0.922
AVE	1	1	0.548	0.655	0.645	0.838	0.797

Note(s): The diagonal (italic values) means the square root of AVE
Source(s): Author's own creation/work

Table 3.
Composite reliability (CR), the square root of the average variance extracted (AVE) and correlations between constructs

3.5 Procedure

3.5.1 Recruitment. To keep participant reactions as realistic as possible, we did not disclose the key research questions in the recruitment advertisements, but participants were informed of the entire research purpose after each experiment had been concluded. We described the research purpose as “a study of shopping experience” without disclosing any of the experiment details. We used the same content in both online (using the intranet system used by the university community) and offline advertisements (tri-fold flyers) for recruiting university student volunteers. A total of 265 students entered our recruitment system, and a final total of 165 students finally participated in the experiment [6].

3.5.2 Pre-survey. When the participant arrived at the lab during a designated time slot, the researchers introduced the entire experiment process. They instructed participants to read the consent form of the study and to fill out the pre-survey.

3.5.3 Tutorial. Once the pre-survey was completed, researchers guided the participant to the shop room and introduced the experiment procedure step by step, according to the instruction page (see Appendix 2). All participants were randomized to join one of the four groups. For the three XR-mediated shopping conditions, the researchers introduced the devices and guided participants on how to wear and use the headset and controllers. For both Groups 3 and 4, two tutorial shopping programs were developed without revealing any details of the shops.

3.5.4 Experiment. Participants were asked to spend 10 min in the shop and make their purchase decisions independently and in accordance with their own preferences. When the shopping time ended, researchers asked participants to pay with the gift card they had received. Each participant was told that if he/she needed any help or felt uncomfortable during shopping, a short break during the experiment could be offered, and they would be welcome to request additional breaks. When the shopping was completed, participants were asked to fill out a post-survey.

3.5.5 Pilot study. Before the actual experiment, a pilot study ($N = 20$) was conducted for all conditions to test the measurement items contained in the pre-survey and post-survey, the experimental procedure, instructions, apparatus and methods. Especially in the shopping conditions with VR, instructions for the use and guidance of the HMD headsets and corresponding programs were key aspects of the pilot studies.

4. Results

The analysis of structural equation modeling was conducted using Smart-PLS 3.0 software, with parameters set as follows: bootstrapping (2000 iterations), a two-tailed test and a significance level of 0.05. With regard to the hypotheses related to the effect of AR technology: AR led to poorer usability (perceived ease of use) but did not have an effect on perceived usefulness or perceived enjoyment (see Table 4 for the full results). The results show that AR had a significant negative association with perceived ease of use ($\beta = -0.229$, $p = 0.004$). Thus, H1(b) was supported. In addition, there was no significant relationship between AR and either perceived enjoyment ($\beta = 0.107$, $p = 0.165$) or perceived usefulness ($\beta = 0.108$, $p = 0.208$), confirming our hypothesis that AR itself would not lead to better or inferior perceived usefulness and rejecting our expectation that AR would lead to higher perceived enjoyment. Thus, H1(a) was rejected; the null hypothesis $H1(c)_0$ was supported; and the alternative hypothesis $H1(c)_a$ was rejected. Accordingly, when compared with non-AR shopping, AR technology offers neither inferior nor better hedonic value in terms of enjoyable and pleasant experiences incurred during shopping, nor does it change the utilitarian value of information in items of perceived usefulness. The results also empirically confirm the proposed hypothesis that AR technology decreases the perceived ease of shopping. However, this reduction did not lead to a reduction in perceived enjoyment or perceived usefulness.

Table 4.
Full results of path coefficients (bootstrapping, sample = 2000)

Hypotheses	Results	Paths	β	*T*	*P*	95% CI	
H1(a)	Rejected	AR → Perceived enjoyment	0.107	1.391	0.165	−0.047	0.257
H1(b)	Supported	AR → Perceived ease of use	−0.229	2.893	0.004	−0.386	−0.066
H1(c)$_0$	Supported	AR → Perceived usefulness	0.108	1.259	0.208	−0.059	0.272
H1(c)$_a$	Rejected						
–		AR → Attitude	0.020	0.285	0.776	−0.111	0.160
–		AR → Intention to visit	0.011	0.234	0.815	−0.081	0.104
H2(a)	Supported	VR → Perceived enjoyment	0.173	2.005	0.045	−0.006	0.337
H2(b)	Rejected	VR → Perceived ease of use	−0.011	0.133	0.894	−0.173	0.153
H2(c)$_0$	Supported	VR → Perceived usefulness	−0.062	0.730	0.465	−0.215	0.114
H2(c)a	Rejected						
–		VR → Attitude	0.020	0.271	0.786	−0.130	0.162
–		VR → Intention to visit	−0.090	1.839	0.066	−0.187	0.002
H3(a)	Rejected	Perceived ease of use → Perceived enjoyment	0.051	0.382	0.702	−0.203	0.296
H3(b)	Rejected	Perceived ease of use → Perceived usefulness	0.117	0.982	0.326	−0.135	0.321
H3(c)	Rejected	Perceived ease of use → Attitude	−0.250	3.280	0.001	−0.380	−0.078
H4	Supported	Perceived enjoyment → Attitude	0.364	4.852	0.000	0.221	0.514
H5	Supported	Perceived usefulness → Attitude	0.207	2.863	0.004	0.063	0.345
H6	Supported	Attitude → Intention to visit	0.814	23.62	0.000	0.745	0.877

Note(s): *β* = Standard Regression Coefficient, *CI* = Confidence Interval; the significance level was set at 0.05
Source(s): Author's own creation/work

VR had no significant association with the two constructs of technology acceptance: perceived ease of use ($\beta = -0.011$, $p = 0.894$) and perceived usefulness ($\beta = -0.062$, $p = 0.465$) toward shopping, while it had a positive relationship with perceived enjoyment ($\beta = 0.173$, $p = 0.045$). Accordingly, H2(a) and the null hypothesis H2(c)$_0$ were both supported, while H2(b) and the alternative hypothesis H2(c)$_a$ were rejected. Therefore, contrary to our hypothesis and previous studies (regarding, e.g. discomfort: Martínez-Navarro *et al.*, 2019; cybersickness: Liu and Uang, 2011), the VR implementation did not negatively affect the ease of the shopping task.

Unlike what is commonly found in technology acceptance research, there was no significant effect between ease of shopping and perceived enjoyment and/or perceived usefulness. Perceived ease of use was not significantly associated with either perceived usefulness ($\beta = 0.117$, $p = 0.326$) or perceived enjoyment ($\beta = 0.051$, $p = 0.702$), which deviates from the bulk of technology acceptance literature (discussed later in the manuscript). Thus, H3(a) and H3(b) were rejected. Since perceived ease of use was negatively related to attitude ($\beta = -0.250$, $p = 0.001$), hypothesis H3(c) was rejected. This interesting observation may be a proxy indication that difficulty of use may co-occur with, for example, curiosity, interest to try again and/or general novelty that could be a powerful predictor of a (re)visit intention. However, this was unaccounted for by the TAM model (i.e. in the construct of perceived enjoyment). Consistent with a long vein of TAM research, perceived enjoyment and perceived usefulness were positively associated with attitude ($\beta = 0.364$, $p < 0.001$ and $\beta = 0.207$, $p = 0.004$, respectively), and attitude was further positively associated with intention to visit ($\beta = 0.814$, $p < 0.001$), so hypotheses H4, H5 and H6 were all supported. The direct effects between AR/VR and attitude and between AR/VR and intention to visit were all insignificant (all p-values >0.05), indicating that overall, AR and VR did not directly decrease (or increase) the attitude and future (re)visit likelihood of customers.

5. Discussion

5.1 Main findings

In this study, we conducted a 2 (VR: with vs. without) × 2 (AR: with vs. without) between-subjects experiment on the effects of VR and AR on the technology acceptance of XR (shopping) and its effect on customers' attitude and visit intention. In summary, we found that AR had a significant negative effect on perceived ease of use, with no significant effects on either perceived enjoyment or perceived usefulness (*Finding 1*). Meanwhile, VR had a significant positive effect on perceived enjoyment, with no significant effects on either perceived ease of use or perceived usefulness (*Finding 2*). We also found that in the metaverse shopping context, perceived enjoyment and perceived usefulness significantly and positively influenced consumers' attitude and consequently, their intention to (re)visit metaverse shops (*Finding 3*). However, previous findings regarding the positive effects of perceived ease of use on perceived enjoyment, perceived usefulness and attitude were not confirmed in this study. Surprisingly, worse perceived ease of use led to a positive attitude toward shopping in the metaverse (*Finding 4*). Those results altogether indicate that although AR would have a significant negative effect on perceived ease of use, such an effect may not negatively influence consumers' adoption of AR shopping. Below, we present a comprehensive discussion of the main findings combined with our research contributions regarding empirical, theoretical and methodological aspects, along with practical implications for retailers and designers of metaverse shopping.

5.2 Research contributions

This study enriches the metaverse and retail literature by providing important and valuable evidence based on rigorous experiment design on consumers' acceptance and adoption of metaverse shopping. As presented in Table 1, investigations on the acceptance of metaverse in previous literature have mainly been based on the evaluation of specific AR or VR applications (e.g. Javornik, 2016a; McLean and Wilson, 2019; Oyman *et al.*, 2022), and there are concerns about the robustness of findings in the extant literature and their generalizability. More importantly, due to an inconsistent understanding of metaverse-related concepts, AR and VR have not been discussed and are rarely compared in one study. To the best of our knowledge, this study is the first to conceptually discuss and empirically examine different virtual technologies, including AR and VR, which significantly extend the current literature. At the outset of this study, we assumed that wearing HMD and using ways of interacting outside the real world would introduce limitations to the ease of the studied task (shopping). The results indicate that while AR did have a significantly negative effect on ease of shopping, a lower level of ease of shopping was also positively associated with attitude. Such results indicate that the overall shopping experience might not suffer tremendously beyond the issues caused by usability, as long as the XR implementation is suitable and of high quality—i.e. comparable to the physical experience. These research results provide empirical evidence and inspiration for researchers involved in the interdisciplinary study of IS, human-computer interaction and marketing science to explore the role and value of XR technology in retail management.

Furthermore, this study makes a considerable theoretical contribution to technology acceptance by examining the TAM framework in the metaverse context. Compared with previous yet segmented discussions on the advantages and drawbacks of XR shopping which influence its adoption (Hawkins, 2022; Kliestik *et al.*, 2022), this study has extended the TAM framework (see, e.g. Aburbeian *et al.*, 2022; Almarzouqi *et al.*, 2022; Akour *et al.*, 2022) to explore the utilitarian and hedonic value of XR shopping systems. Considering the technology acceptance of XR adds possible interesting findings to the theory of technology adoption as a whole and challenges the established understanding that IS are regarded as more attractive when they are easier to use. On the one hand, the level of perceived ease of use regarding XR technology would not seem to significantly influence the sense of enjoyment and usefulness. Such results differ from the findings of previous literature that perceived ease of use has a positive association with perceived enjoyment (e.g. Kim and Forsythe, 2008; Pantano and Servidio, 2012; Rese *et al*., 2017) and perceived usefulness (Huang and Liao, 2015; Kim and Forsythe, 2008) and indicates the optimistic aspect of XR that a difficulty in using technology may not always be detrimental. On the other hand, a low level of usability (i.e. low perceived ease of use) leads to a positive attitude toward using XR. This interesting observation may be examined in future studies by exploring the psychological mechanisms of unique and positive features of the systems involved. The difficulty of use may co-occur with issues such as coolness (Kim *et al*., 2015), newness and awkwardness (Bunz *et al*., 2021), challenge (Altarteer *et al*., 2013) and consumer curiosity toward XR technology (Manis and Choi, 2019). Therefore, an interest to try again and/or the perception of general novelty could be a powerful predictor of attitude and behavioral intention. However, the TAM model was unable to account for this.

In terms of methodological contribution, this study provides an important reference point for future studies on undertaking a randomized controlled study on the effects of technology on adoption. While this study tested the difference of experience stemming from VR or AR technologies applied to a shopping context, the design can be replicated in other contexts where the goal is to isolate the effect of the core essence of the technology. As mentioned earlier, the majority of previous studies have failed to isolate and compare the effects of AR and VR. Due to a lack of a conceptually accurate understanding of AR and VR, it could have been challenging for previous studies to carry out comparative research in identical settings. Moreover, particularly in the design of experiments, researchers have often overlooked confounding factors (such as adding information for consumers or attempting to make the scenario completely different from the B-a-M). This gap in the extant literature has made it close to impossible to realistically infer just what the technology itself implies to considerations of XR acceptance and adoption. An important aspect to recall about the present study is that it attempted to create XR-mediated shopping experiences as close as possible to the original B-a-M scenario, with other external factors (e.g. interactive features, amounts of information, prior product knowledge, visual perceptions and body movement range) being strictly controlled. Hands-free wearable AR glasses were used rather than handheld devices such as a tablet or mobile phone, together with a high-resolution VR HMD with controllers that enabled natural interactions rather than a trigger, joystick, or mouse and keyboard. These features facilitated free body movement rather than sitting in front of a computer (e.g. Martínez-Navarro *et al*., 2019) or moving in a limited space created by a big projector (e.g. Verhulst *et al*., 2016) or a CAVE [7] system (e.g. Bigné *et al*., 2016). AR or VR technology did not provide any extra information, features or other aids for the shopping task beyond the core features of VR and AR headsets that would not have been present in the B-a-M scenario. This study maximized the attributes and nature of XR technology to reduce the limitations caused by technological immaturity, as well as to control almost all of the possible factors that might affect the results of the study. Therefore, one of the main contributions of the present study is that it is able to show that XR technologies are able to replicate the B-a-M experience without a clear negative impact on consumer/user experience, which has been seen as a major hindrance to XR adoption by both companies and consumers.

5.3 Practical implications

The findings from this study serve to strengthen the confidence of retailers in adopting metaverse-oriented retail and business strategies. For a long time, retailers have been applying digital retail technology to supplement B-a-M shops in order to improve accessibility and convenience (Childers *et al.*, 2001). While the Internet revolutionized how we acquire information and make decisions (such as in the context of shopping), it greatly reduced the experientiality and multisensory nature of cognitive and emotional processes. Now, with the advent of XR, it is believed that this experientiality of decision-making might be coming back across domains. However, warranted concerns over the usability and naturalness of XR technologies have loomed over their adoption by firms and their customers. Overall, this study has been able to alleviate the negative expectations toward the use of XR in different domains, particularly in the context of retailing, which was the focus of our study. In this study, we showed that a well-implemented replication of physical activities through VR and AR technologies was overall on par with the physical counterpart when it comes to adoption and acceptance. In particular, VR even led to a higher level of perceived enjoyment and even though the workload appeared to be higher when using AR, it did not prove to be bothersome with respect to perceived usefulness, perceived enjoyment, attitude and willingness to use it in the future.

Retailers are encouraged to make use of the different advantages of VR and AR to provide a virtual shopping experience. In our study, the three digital realities (VR, AR and AV) were compared with B-a-M shopping (between-subjects study design) and for experimental purposes, all participants were required to participate in the experiments in the same physical space. This comparison might not be completely fair for XR as a lot of the value of XR rests in the same aspects as can be seen in the value of the Internet and in particular, it can be used from home. In this study, B-a-M and XR showed the same levels of value, which is a hugely positive result as it shows that shopping from home through XR technology may offer an equal experience, saving valuable time and money for the customer while reducing the costs of maintaining B-a-M premises. Retailers should also notice the potential of combining VR and AR together in the retail environment (similar to the AV shopping conditions featured in Group 4). Based on the results of this study, the additional AR technology did not decrease the perceived ease of use toward shopping in the virtual reality environment. This indicates that AR can provide more value when used in virtual reality. Other interactive technologies such as recommendation systems (Ahn *et al.*, 2015; Guo and Elgendi, 2013), robotics and artificial intelligence (Cruz *et al.*, 2019; Tao and Zhang, 2017) can also be integrated into virtual reality using interactive AR modalities.

When creating an XR-mediated shopping environment, the product type should be taken into consideration by both retailers and designers. In this study, it seems that the virtual visual experience brought by 3D programming technologies and HMD devices can create the same or even a better shopping experience (e.g. enjoyment) as in physical reality. However, it is undeniable that products that rely heavily on other dimensions of experientiality, such as food (taste), perfume (smell), clothing (touch and trial experience) and speaker (audio), require sensory modalities such as auditory, olfactory, artificial flavor and haptic feedback to be included in virtual reality. That said, this study at least provides empirical evidence for shopping experiences that mainly involve visual information such as product appearance and packaging.

Moreover, it can be seen that XR plays an important role in influencing shopping intention, even with a relatively low ease of use. Mobile-based XR technologies such as mobile AR applications and VR cardboard offering a 360-degree view are favored by most retailers, and these devices have relatively high economic value and low development costs. However, they do not offer many advantages in creating high-experientiality shopping due to the limitations of hand, head and body movement, interaction function and a continued need to be hand-held. In this study, consumers had a high acceptance of using the wearable HMD device for shopping. Thus, retailers could consider applying these research results obtained in the laboratory setting to the practical retail environment, by choosing suitable wearable XR devices and developing corresponding interactive programs for providing optimal shopping experiences.

6. Conclusions

While the adoption and hype around XR technologies have been volatile and oscillating, the current consensus has been somewhat set on the pessimistic view that XR technologies would not be able to provide an experience that would be on par with the real experience (Yung and Khoo-Lattimore, 2019). Therefore, while there have been a lot of warranted and unwarranted expectations to transform many tasks of the real world into fully digitalized ones, these fears have hindered the adoption of XR. In this study, we set out to build a realistic and high-quality implementation that transformed a complicated task of shopping in real life into a digitalized experience through VR and AR technologies. We constructed a physical B-a-M shop and stocked it with approximately 600 products with accompanying product information and pricing. We then created three XR-mediated shopping experiences employing accurate laser scanning to model the shop in a 1-on-1 scale as a 3D environment: an AR shop (where the product information was superimposed onto reality), a VR shop (where the experience took place completely in VR) and an AV shop (where the experience completely took place in VR and the product information was superimposed onto reality). Based on the results from 157 participants, this study indicates that AR and VR can indeed offer an experience that is on par with and even better than the normal B-a-M experience. In support of this, the findings show that AR and VR did not significantly and negatively influence users' perceived usefulness and that VR significantly increases perceived enjoyment, while AR had a significantly negative effect on perceived ease of shopping. Interestingly, we found that poorer perceived ease of shopping was significantly and positively associated with attitude while having no significant effect on perceived enjoyment and perceived usefulness.

7. Limitations and future directions

This study has some limitations that should be discussed. While not a limitation *per se*, it is worth repeating for future comparison and reproducibility of the results that the perceived ease of use was measured through the NASA-TLX instrument of workload, as it is better suited for measuring the overall ease of a task or an activity (or the lack thereof). Therefore, our measure was not only limited to the perceived ease of use of the technology but reached onto the entire task performed by using the technology. We recommend that future studies on technology acceptance employ more comprehensive measures of the workload involved in order to further increase the granularity of what kinds of dimensions of perceived ease of use/workload (e.g. rating and weight) may be differentially affected by XR and how they further affect other psychological and behavioral outcomes.

Regarding the employed metaverse technologies featured in this study, one of the limitations is that the investigated user experience was mainly based on HMD-based visual experience. The adoption and acceptance of other sensory modalities for haptic, olfactory and auditory experience and full-body movement can be researched in future studies. Additionally, this study measured user experience through the participants' subjective self-reports, which might possibly be biased or inaccurate and can only reflect their past or delayed experiences rather than their immediate or real-time experiences. To mitigate these limitations, future researchers might use a combination of research methods, such as observational studies, in-depth interviews and objective performance metrics (see, e.g. neural recordings: Saffari *et al.*, 2023; gaze analysis: Chen *et al.*, 2023; immersive netnography: Kozinets, 2022), in order to gain a more comprehensive understanding of consumer experiences.

Even though a possible limitation of this study lies in TAM's simplicity, TAM is still a very useful tool through which to gauge the acceptability of new technologies and is applicable as a theoretical foundation for investigating the acceptance of metaverse shopping. However, it is acknowledged that TAM has a limitation in regard to its comprehensive coverage of factors leading to the adoption and acceptance of IS and IT. Therefore, to enrich and develop the extant technology acceptance theories, future studies can examine different models and theories of individual acceptance, such as the Motivational Model, the Theory of Planned Behavior, the Model of PC Utilization and the Innovation Diffusion Theory in different metaverse contexts.

Possibly stemming from our substitution of perceived ease of use with workload measured by NASA-TLX, our results indicated that usability was conversely correlated with user attitude. Again, while not necessarily a limitation of the present study, our research points toward a possible limitation in the technology adoption model and its operationalization of measurement. Novel technologies (such as VR and AR) might pose confounding factors for technology adoption that are not only undetectable by mere perceived values, including ease of use, enjoyment and usefulness but may also shift path coefficients between extant variables of the model. In the present study, an unexpected finding where poorer usability predicted positive attitude hints toward a co-occurring hidden variable that correlated with poor ease of use but which is simultaneously able to create a positive experience that is not explained either by enjoyment or usefulness. Similar odd findings regarding perceived ease of use have been detected in existing studies; however, research and in-depth investigation into such concealed phenomena are lacking.

The music product category selected in this study has sufficient product information to facilitate information-seeking and decision-making behaviors during the shopping process and has the technical advantage of being suited for creating 3D virtual objects. On reflection, it seems to have been the best choice for the XR-mediated shopping experiment, especially based on student samples. However, the results of this study might be limited to the media-related consumption context and products such as books, postcards and posters may also meet experiment design requirements, which can be investigated in future studies to examine the robustness of the results yielded in the current study. In addition, for other types of products, such as large-size products (e.g. furniture, houses or cars), clothing, luxury products and entertainment products, consumers are usually eager to get more experiential value and trial possibilities when shopping. To address this, other product types can be investigated in future experimental studies and in order to conduct a more generalizable and international study, large-size international surveys can also be considered to improve the external validity of the research results.

It should also be mentioned that this study only investigated the shopping experiences of single consumers and did not research interactions with others such as other consumers and shopping assistants. Social aspects have been considered as an essential factor in retail research (e.g. in relation to arousing positive emotions: McGrath and Otnes, 1995; technology acceptance and attitude: Hassanein and Head, 2007; buying intention: Chen *et al.*, 2022). In particular, VR has been considered as an "empathy machine" (Bujić *et al.*, 2020), which is intuitively correlated with pro-social behaviors in the shopping context. However, due to the limitations of current XR devices, technologies and experiment design, there is still a research gap in regard to whether and how social factors influence XR shopping experiences. Thus, future XR shopping research can bring social factors into consideration, such as shopping in the presence of others, different types of social interactions and group shopping.

Notes

1. Studies that used multiple screens/monitors were included given that they took the expansion of the FOV (field of view) into consideration, so as to create a more immersive experience based on developing technologies and devices (see Xi and Hamari, 2021).

2. We prepared approximately 600 LP record products in the storehouse; they were categorized into one of the product conditions based on color, brightness, newness and content. The products in each

product condition were evenly and randomly distributed to record pools per treatment group to fill the store shelves. For each participant, 54 products were displayed on three layers of three-row shelves (2 products per shelf) in the shop. After completing the experiment, the participant was given the records he/she had "bought." Any records "bought" by previous participants were restocked with new records in the same price category.

3. LiDAR: Light Detection and Ranging.
4. An LP (derived from "long playing" or "long play") is an analogue sound storage medium—a phonograph record format characterized by a speed of 33 1⁄3 rpm and 12- or 10-inch (30- or 25-cm) diameter.
5. Discogs is a website and crowdsourced database of information about audio recordings, including commercial releases, promotional releases and bootleg or off-label releases (https://www.discogs.com/).
6. As indicated in section 3.2 Participants, three disqualified participants were identified, and five outliers were omitted during the data cleaning stage, leaving a remaining sample of $N = 157$ for analysis.
7. CAVE: Cave Automatic Virtual Environment.

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(The Appendix follows overleaf)

Appendix 1

Measure	Group 1 (n = 40)	Group 2 (n = 41)	Group 3 (n = 40)	Group 4 (n = 36)	F	P
Biological sex					1.396	0.246
Male	67.5%	46.3%	50.0%	52.8%		
Female	32.5%	53.7%	50.0%	47.2%		
Age					1.426	0.237
Less than 19	12.5%	9.8%	15.0%	16.7%		
20–24	47.5%	65.9%	55.0%	55.6%		
25–29	25.0%	17.1%	17.5%	27.8%		
30–34	10.0%	4.9%	10.0%	0.0%		
35–39	2.5%	2.4%	0.0%	0.0%		
40–44	0.0%	0.0%	2.5%	0.0%		
45–49	0.0%	0.0%	0.0%	0.0%		
50–54	0.0%	0.0%	0.0%	0.0%		
55–59	2.5%	0.0%	0.0%	0.0%		
Education					1.388	0.248
Bachelor student	47.5%	61.0%	52.5%	66.7%		
Master student	42.5%	34.1%	40.0%	30.6%		
PhD student	10.0%	4.9%	7.5%	2.8%		
Monthly income (pre-tax)					2.220	0.088
Less than 499 euro	57.5%	56.1%	45.0%	69.4%		
500–999 euro	15.0%	26.8%	25.0%	11.1%		
1,000–1,499 euro	10.0%	7.3%	12.5%	2.8%		
1,500–1999 euro	2.5%	4.9%	2.5%	0.0%		
2000–2,499 euro	10.0%	2.4%	0.0%	2.8%		
2,500–2,999 euro	0.0%	0.0%	5.0%	0.0%		
3,000–3,499 euro	0.0%	0.0%	2.5%	0.0%		
Confidential	5.0%	2.4%	7.5%	13.9%		
Importance of music					0.578	0.631
Extremely unimportant	0.0%	0.0%	0.0%	0.0%		
Unimportant	0.0%	0.0%	0.0%	0.0%		
Slightly unimportant	7.5%	4.9%	2.5%	2.8%		
Neutral	5.0%	7.3%	7.5%	8.3%		
Slightly important	30.0%	12.2%	22.5%	19.4%		
Important	32.5%	46.3%	45.0%	33.3%		
Extremely important	25.0%	29.3%	22.5%	36.1%		

Note(s): The percentage represents the proportion of participants in each category relative to the total number of participants in each group
Source(s): Author's own creation/work

Table A1.
Demographic and other personal information (frequency)

Appendix 2
Experiment instruction

Scenario:

While you are passing by a second-hand LP record shop, you suddenly realize that you have a **10 euro** gift card given by your friend last week. You find out that the expiry date of the gift card is today, which means you have to use it as soon as possible. Thus, you decide to use this gift card to get records for yourself before the shop closes. Remember the shop will close in 10 min.

Gift card: This gift card has a 10 euro value. You can use it to buy any records in the shop. Please try to make the best purchasing decision because you can get the records in the end and get them back home. Remember you cannot get any amount of the gift card and you have to use it completely.

LP record: You can pick up records, turn around and read information. Each record has its own price tag on the back. There are **54 records** in the shop in total. Just remember don't open the cover to avoid scratching the record and each hand can only hold one LP record.

Extra information: We provide extra information for each record which can help you to make a better purchase decision. You can find, e.g. the artist's name, album title, released year, style, track-list, company, credit and social-related information.

Time: You need to spend a **full 10 min** in the shop. The researcher will knock on the door when the timer ends. You are not allowed to use the phone or watch during shopping.

Purchase decision: During the shopping time, you can put the selected records on the cashier table and change your selection at any time. We will only ask you to pay the LP records on the cashier table when the time ends. Thus, make sure the total amount of the selected products does not exceed **10 euro.**

Notice: If you need any help or feel uncomfortable during shopping, you will be offered to take a short break during the experiment and are welcome to request additional breaks.

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