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Shopping in Virtual Reality Stores: The Influence of Immersion on System Adoption

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ABSTRACT: Companies have the opportunity to better engage potential customers by presenting products to them in a highly immersive virtual reality (VR) shopping environment. However, a minimal amount is known about why and whether customers will adopt such fully immersive shopping environments. We therefore develop and experimentally validate a theoretical model, which explains how immersion affects adoption. The participants experienced the environment by using a head-mounted display (high immersion) or by viewing product models in 3D on a desktop (low immersion). We find that immersion does not affect the users' intention to reuse the shopping environment, because two paths cancel each other out: Highly immersive shopping environments positively influence a hedonic path through telepresence, but surprisingly, they negatively influence a utilitarian path through product diagnosticity. We can explain this effect via low readability of product information in the VR environment and expect VR's full potential to develop when the technology is further advanced. Our study contributes to literature on immersive systems and IS adoption research by introducing a research model for the adoption of VR shopping environments. A key practical implication of our study is that system designers need to pay special attention to the current state of technology when designing VR applications.

KEY WORDS AND PHRASES: virtual reality, laboratory experiments, immersive retail, IS adoption, hedonic and utilitarian information systems, consumer engagement.

Introduction

Virtual Reality (VR) is a major trend during the last few years and is considered to influence the manner in which companies approach their customers [7, 35, 100]. Although VR's first steps can be dated back to the 1960s [83], the wider consumer population's awareness level has only recently risen to today's high level as a consequence of falling prices and the advancement of VR system quality.

Despite the stated importance, a minimal amount is known about users' adoption behavior regarding VR applications, potentially because many VR applications are still in their nascent stage of development. One such example of a VR application is VR shopping environments. In these environments, customers who own head-mounted displays (HMDs) – such as HTC Vive or Oculus Rift – can dive into a complete, fully immersive 3D environment, move around naturally (i.e., by moving their bodies) in the stores and use navigation devices to interact with products by grabbing them and viewing them from different angles. The customers can (potentially) even communicate with sales persons or friends who appear as avatars. The VR environment can generate a variety of potential advantages, particularly for the retail business. Similar to e-commerce websites, VR stores are not constrained by opening hours and are therefore accessible 24/7 from any place with Internet access. Beyond this, VR applications incorporate multiple sensorial channels [7] that may offer a more interesting consumer experience through imagination and contribute to enhancing consumers' abilities to evaluate products [20]. In fact, Grewal et al. [35] recently emphasized that VR is going to substantially change consumers' shopping expectations.

The retail industry appears to see significant potential in VR. Regardless of whether it is China's e-commerce giant Alibaba (Buy+), the U.S. department store Macy's (Macy's VR), the Swedish furniture manufacturer IKEA (IKEA VR), or Europe's largest retailer for consumer electronics (Virtual SATURN), they all have – as a minimum – launched prototypes for virtual shopping environments, thereby testing opportunities of generating additional value for customers in VR. Nevertheless, as with any novel technology, like e-commerce 15 years ago (e.g., [29, 31]), the main question is whether the customers will accept the technology and eventually use it on a regular basis. Literature that can serve as a starting point for answering this question investigated how virtual product experience influences perceived product diagnosticity or purchase intention [45, 99], it assessed whether VR enhances consumer learning about products [82], and it examined shopping behavior within 3D virtual worlds, which were applied as shopping environments [48, 49]. Although the studies address aspects, which are also relevant for current and future VR shopping environments, the current technology is capable of delivering far more than what was recently understood as VR.

The main characteristic of VR technology is the degree of immersion, which such a system can potentially deliver [82]. Immersion describes to what extent technological features of the VR environment "are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" [79, p. 604]. With the recent advance in consumer VR technology, the immersive experience is considerably more pronounced, because it can create real-world experiences [9]. The degree of immersion of current technologies, such as HMDs, does indeed go far beyond the above mentioned studies, which used ordinary desktop PCs to display products in virtual worlds, such as Second Life, or employed virtual tours, or videos of products. Given that the VR technology has rapidly evolved, past studies give us almost no information about how higher degrees of immersion affect the acceptance of virtual shopping environments. To the best of our knowledge, research has so far not investigated and tried to explain the adoption of highly immersive shopping environments.

Following research in the field of e-commerce [17, 56], we consider a *utilitarian* and a *hedonic* path to explain how immersion influences adoption. The e-commerce literature has identified the ability to view products from various angles and distances, and the possibility to see a simulation of the products' functionality by clicking on images and videos, as factors that positively influence the perceived ability to judge a product (*perceived diagnosticity*) [45]. Based on these findings, we argue that immersion will positively influence perceived diagnosticity and, in turn, the user's acceptance of VR shopping environments through a utilitarian path. Furthermore, building on other research [74, 79], we argue that immersion should positively influence *perceived telepresence*, which is defined as the perception of being present in an unreal environment and, in turn, acceptance through a hedonic path [56, 64, 85].

In order to test our research model, we conduct an experiment in which participants are randomly assigned to either shop in a highly immersive VR shopping environment by using a HMD, or to shop in a low immersive environment by using a desktop computer. Both shopping environments show the exact same supermarket shelf created with (almost) the same software to control for factors other than immersion.

We find that the utilitarian and hedonic path work in opposite directions and, in sum, cancel each other out. In contrast to our hypothesis, we find a negative effect of immersion along the utilitarian path. We are able to explain this result by taking the participant's reported readability of the product information into account. Although we used the best equipment available when we conducted the study, readability was relatively low in the VR shopping environment, due to technical reasons. In fact, when we control for readability, we find that immersion has a positive effect on the consumer's intention to adopt the shopping environment.

Several theoretical and practical contributions result from our paper: First, we specify the term immersion, separate it from telepresence, and discuss how immersion can be experimentally manipulated. Second, we propose and validate a research model for the context of immersive VR shopping environments, which combines and extends existing findings from e-commerce literature with the concept of immersion. In contrast to previous research findings [17, 42, 46, 56], the utilitarian and hedonic paths cancel each other out when testing the framework in an immersive VR context. Third, the empirical results show that the negative utilitarian path in the model can be explained with a current technological restriction, which is the low readability of detailed information on product packages. Fourth, from a practitioner's perspective, we identify key design factors that increase the user's adoption of VR environments. We particularly find that designers need to pay special attention to the current state of the technology. In our context, we find that the readability of content in VR can substantially affect the outcome and usability of VR environments. Other characteristics of VR technology, such as the different possibilities to interact with the environment, restrictions with regard to real-time simulations of items' characteristics, or possible user sickness, can also be factors that need to be taken into account, not only for studying the effects of VR on user behavior and adoption, but also for designing the systems accordingly.

Theoretical Background

Virtual Reality, Immersion, and Telepresence

In contrast to the prior understanding of the term VR in some articles within the IS field (e.g., 3D product presentations or environments shown on a desktop screen [57, 82]), current VR is mostly associated with a simulated environment, which a user experiences by using a HMD or a Cave Automatic Environment (CAVE). Berg and Vance [7, p. 2] state that virtual reality is an immersive computing technology, which incorporates a "set of technologies that enable people to immersively experience a world beyond reality." Although this corresponds with the initial definitions of VR mainly focusing on the applied hardware (for an overview, see [80]), it also draws attention to the resulting subjective impression that VR is "a real or simulated environment in which a perceiver experiences telepresence" [80, pp. 76-77]. Telepresence is defined as "a sense of presence in a mediated environment" [55, p. 42]. Besides the word *telepresence* [64, 82], others describe this phenomenon as *presence* [94], *spatial presence* [73] or *VR presence* [85]. It is a common argument that immersion (technological) is an essential precondition for experiencing telepresence (perception) [21, 73-75], thereby pointing out that telepresence "is a human response to immersion" [74, p. 813]. In our understanding – which is grounded in the definition of immersion by Slater and Wilbur [79] but also follows many other researchers [21, 74, 75, 77] – immersion is not a subjective feeling, but an objective measure throughout. Therefore, the term *immersion* should not be used synonymously to *presence*.

The most prominent feature that objectively describes VR systems, is thus their degree of immersion [82], which covers the degree of isolation from reality (inclusive), the number and particularly the magnitude of different sensory channels that are stimulated (extensive), the presentation format in terms of the field-of-view delivered by the medium (surrounding), as well as the extent to which a system is capable of creating naturalistic environments from a representational point of view (vividness) [79]. In addition to these concepts, Steuer [80] outlines the concept of interactivity as predetermined by the system's features (immersion) and he defines it as the degree "to which users of a medium can influence the form or content of the mediated environment" (p. 80) that can, for example, again be subdivided into factors, which describe the possible interaction space (range) or whether a system naturalistically responds to input signals (mapping). Such technical, recently emerged features that belong to immersion are high-quality graphic cards, which allow the creation of realistic visual stimuli at ultra-low latencies, and advanced human-computer interaction methods, which allow gestural input and room-scale full-body interaction.

Within their study, Suh and Lee [82] use the degree of immersion to classify systems in "non-immersive" and "immersive" VR. According to their classification, VR systems, which use HMDs, are considered as immersive VR, and systems, which use desktop screens, are considered to be non-immersive. Since we argue that even computer screens can deliver a sense of telepresence [54, 55, 80], we classify desktop applications as low immersive rather than non-immersive, thereby suggesting a distinction between high and low immersive VR. Generally, the vision of high immersive VR can be achieved with a HMD. High immersive VR delivers a 360° field of view, which exactly reconstructs real-life viewing habits. The vision's distinct media richness increases the environment's vividness, compared to an ordinary display on a desktop screen (low immersion). In high immersive VR, particularly the perceived size of objects is similar to reality. Furthermore, in high immersive VR, the interactivity with the environment is controlled through manual actions – with or without the help of controllers. Head and hand positions are tracked in real time, whereby the body position is replicated on a one-to-one basis and manual actions, such as grasping, are directly interpreted. In contrast to a low immersion setting, in which all interactions are operated via the computer mouse or keyboard.

Shopping in Virtual Reality Environments

Generally, information systems are often divided into utilitarian and hedonic systems [42]. Van der Heijden [42] describes that the objective of a utilitarian system is "to increase user's task performance while encouraging efficiency," whereas the objectives of hedonic systems are to "provide self-fulfilling rather than instrumental value to the user, are strongly connected to home and leisure activities, focus on the fun-aspect of using information systems, and encourage prolonged rather than productive use" (pp. 695-696). Online retail shopping goals can similarly be understood as being hedonic and utilitarian at the same time [17, 19]. Following the idea of Childers et al. [17] and the empirical results presented by Koufaris [56], we argue that VR applied in a shopping context can be also viewed from a utilitarian and a hedonic perspective.

Utilitarian Perspective of VR Shopping

Perceived product diagnosticity, which is very important for the utilitarian perspective, describes "the extent to which a consumer believes the shopping experience is helpful to evaluate a product" [45, p. 111]. Indeed, e-commerce has oftentimes been criticized for the less pronounced possibilities to evaluate products, for example, feeling, touching, and trying out products, compared to conventional in-store shopping [45, 67, 81]. Prior studies about e-commerce have therefore tried to address this issue by improving the product representation format to directly affect the perceived product diagnosticity [45-47]. The product representation format was manipulated by allowing a simulation of certain product functions by clicking on virtual product buttons (interactivity) or showing videos of products (vividness). In addition, the concept of perceived product diagnosticity has proven to be an important determinant of consumer behavior in further contexts, such as the evaluation of recommendation agents [97] or processing of software product trials [52]. Originally, the concept perceived diagnosticity is grounded in the accessibility-diagnosticity model [27]. In short, the model describes that information is only used as basis for an evaluation of a product, for example, if the information is accessible and perceived as a better source for evaluating the product than all other alternative inputs [27].

Product diagnosticity is important for the utilitarian perspective, because the evaluation of the product is one of the main tasks, which users want to perform effectively and efficiently when they go shopping [2, 14]. These performance aspects translate directly to the construct of *perceived usefulness*, which is undisputedly the best-known construct concerning the evaluation of an IT system's utilitarian characteristic [96]. *Perceived usefulness* was initially defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" [22, p. 320]. When focusing on VR, the construct covers the perceived usefulness of the entire shopping environment, including aspects such as whether the environment increases the productivity or effectiveness of shopping.

In sum, recent literature in the field of e-commerce focused on product diagnosticity as an important factor of information systems, which influences the utilitarian perspective. Prior research was restricted to manipulating single dimensions of immersion, which were implemented on an ordinary desktop PC. It therefore remains an open question whether similar effects can be found in a high immersive VR shopping environment.

Hedonic Perspective of VR Shopping

The counterpart to what is perceived usefulness in the utilitarian perspective, is the affective construct of *perceived enjoyment* in the hedonic perspective [96]. Perceived enjoyment is widely applied for explaining the affective response to system use and is defined as "the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use" [88, p. 351].

Enjoyment is one of the major goals that high immersive systems try to induce for example in fields like gaming; yet, empirically, evidence is still conflictive [11, 44]. When it comes to the field of shopping and retail, we found several studies that found a positive effect induced by perceived enjoyment. Lee and Chung [57], for instance, compare 2 types of desktop-based online shopping experiences: one with a product presentation, which is characterized by images and text, and another one, which is characterized by illustrating a virtual shopping mall on the desktop that enables the user to explore 3D product presentations by moving through the mall. The authors find that shopping in the desktop VR shopping mall leads to a significant improvement regarding the perceived enjoyment and perceived quality assurance, which, as a consequence, increase customer satisfaction. Interestingly, the perceived convenience is not significantly improved. Similarly, the study by Jin [49] empirically validates the shopping experience in a retail store inside the 3D virtual world of Second Life. The author investigates the effect of modality richness on the attitude toward the product, purchase intention, and enjoyment. She finds that an audio modality, compared to a text modality, leads to higher ratings on all three investigated constructs for respondents who had low product involvement, but not for respondents who had high product involvement. Jiang and Benbasat [45, 46] studied flow, which also incorporates cognitive enjoyment as a dimension, and found a positive effect for vividness [45], as well as vividness and interaction [46]. All four studies conducted their experiments in shopping environments shown on a desktop and, thus, had low immersion. The applied experimental setup can also be a reason why the main characteristic of VR – the ability to induce a feeling of telepresence – has not been considered as an important mediator.

Other studies outside the shopping context found a significant relationship between telepresence and enjoyment, for example, in the context of museums [85] and the brand equity of a hospital [64]. In the context of purchasing virtual goods in Second Life, Animesh et al. [4] found – in a survey – that telepresence has an effect on flow, which – as previously indicated– partially overlaps with enjoyment. As a result, we identified perceived telepresence and perceived enjoyment as relevant dimensions for characterizing the hedonic perspective of shopping in a VR environment.

Research Model and Hypotheses Development

Figure 1. illustrates our research model, which we describe in detail in the following paragraphs. The research model divides into 2 distinct paths, representing the utilitarian and hedonic dimension of shopping behavior [17]. We particularly presume that a higher degree of immersion positively influences both paths and that the utilitarian path and hedonic path, in turn, positively impact on the intention to reuse a shopping environment.

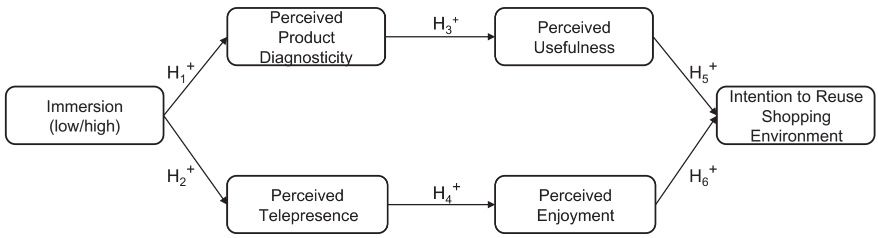

Figure 1. Research model virtual reality (VR) shopping environment.

Effect of Immersion on Perceived Product Diagnosticity and Perceived Telepresence (H1 and H2)

When shopping online, customers must primarily draw on the information provided by the respective shops, because the fact of the matter is that they are not able to touch and feel the products, which can lead to a more difficult assessment of product quality compared to in-store shopping [81], or even feelings of uncertainty [68]. According to Pavlou et al. [68], the perceived product diagnosticity can be created through signals. One such signal is the product's representation format, which can significantly influence a consumer's perception of a displayed product, and simultaneously also the perceived product diagnosticity, because it helps consumers to understand the product features and, thus, to better judge product information and make decisions. For example, in an e-commerce setting, Jiang and Benbasat [45] investigate effects of *visual* (varying viewing perspectives) and *functional* (experiencing product features) *control*, which cover aspects related to the vividness and interactivity dimensions of immersion. They show that, compared to a pallid product presentation, which uses pictures, functional control has a positive influence on perceived diagnosticity [45]. They also found that functional control had a stronger influence than visual control, possibly because the high visual control group did not change the representation format considerably: the product could be considered via QuickTime from all sides, compared to the display of a pallid picture. In another set of studies, they also include video product presentation formats in the comparison and again show that video presentations significantly increase the perceived diagnosticity, compared to a pallid picture presentation [46, 47]. We expect that the difference between viewing products from various angles and distances in low and high immersive environments will be much more pronounced than the difference between pallid pictures and QuickTime illustrations or videos in the way that Jiang and Benbasat [45-47] implemented them in a desktop scenario. High immersive environments enable high-quality 360° views and it is also possible to turn the products naturally with hand movements, which enables the users to position the product very flexibly in front of their eyes. Moreover, the true-to-scale product representation facilitates a product evaluation, which is very close to the habits in reality. At the same time, the experience still differs from physical reality, because the user will not get haptic input – that is, she cannot feel the surface, texture, or weight of the individual product. However, future research can use specific hardware installations to give haptic or olfactory input and generate an even more immersive experience [62]. In sum: High immersion VR shopping environments are very similar to a physical store regarding the visual input and the interaction possibilities. Building on the similarity regarding the visual input and interaction possibilities, we therefore hypothesize:

Hypothesis 1: The higher the degree of immersion of the shopping environment, the higher the perceived product diagnosticity.

In addition to the effects on perceived product diagnosticity, the degree of immersion can influence a customer's affective response to a shopping environment. According to Sylaiou et al. [85] "the goal of an immersive simulation is the ability to mislead one's senses reinforcing illusion of being somewhere other than one's physical location" (p. 246), thereby emphasizing the causal relationship between immersion and the induced perception of telepresence. The dimensionality of the shown information (2D vs. 3D) is shown to influence the perceived *telepresence* [64]. In a similar way, Klein [55] confirms that media richness, as well as user control, can induce a sense of telepresence. Increasing the immersion of a system according to the dimensions of [79, 80], should boost the media richness, as well as the interactivity of the system, and therefore we expect an impact on the perceived telepresence. As previously stated, participants can interact with the high immersive shopping environment in several ways and, for example, Animesh et al. [4] show that interactivity has an influence on telepresence. We therefore hypothesize as follows:

Hypothesis 2: The higher the degree of immersion of the shopping environment, the higher the perceived telepresence.

Effect of Perceived Product Diagnosticity on Perceived Usefulness (H3)

A system is perceived as useful when it helps to fulfill a requested task. Within a shopping context, this requested task can be to understand product characteristics in order to support decision making. For instance, Kempf and Smith [52] measured the *perceived diagnosticity of trial*, which was defined as "the degree to which the consumer believes the trial is useful in evaluating the brand's attributes" (p. 328), thereby showing the close connection between diagnosticity and usefulness. We particularly argue that one of the consumers' main goals is to achieve a high product understanding, due to the increased ability of thoroughly evaluating a product [14, 47]. Therefore, shopping environments, which increase this product understanding, should also increase the perceived usefulness [47]. In a study comparing different product presentation formats, Jiang and Benbasat [47] showed that higher perceived website diagnosticity leads to a higher perceived usefulness of the website. Based on this, we state the following:

Hypothesis 3: Perceived product diagnosticity has a positive influence on the perceived usefulness of the shopping environment.

Effect of Perceived Telepresence on Perceived Enjoyment (H4)

An increase in media richness – for example 2D vs. 3D virtual worlds [64], or static pictures vs. videos [46], or question-based vs. attribute-based product customization [51] – leads to an emotional experience, which is characterized by perceived *enjoyment*. Within their study, Nah et al. [64] particularly show that a higher sense of telepresence leads to higher perceived enjoyment. They also outline the importance of considering telepresence as a predecessor of the hedonic construct of enjoyment. These findings are in line with a statement by Lombard and Ditton [58] that presence (i.e., telepresence) is a significant influencing factor of enjoyment. In addition, the correlation between telepresence and enjoyment was shown by Sylaiou et al. [85] in the context of interacting with a virtual museum. We therefore state as follows:

Hypothesis 4: Perceived telepresence has a positive influence on perceived enjoyment.

Effect of Perceived Usefulness and Perceived Enjoyment on Intention to Reuse the Shopping Environment (H5 and H6)

Since the highly immersive VR technology, which is applied in the context of shopping, is new, the users' intention to reuse a VR shopping environment is of enormous interest. We expect that the utilitarian, as well as the hedonic, path will significantly influence the intention to reuse the VR shopping environment. In the context of online consumer behavior, the complementary influence of both perspectives (hedonic and utilitarian) – similarly operationalized by perceived usefulness and enjoyment – on the intention to reuse, has been shown by Koufaris [56] before.

Following the technology acceptance model [22] and the empirical results presented by Jiang and Benbasat [46] and Koufaris [56], perceived usefulness will, in turn, increase the intention to reuse the shopping environment. In online shopping contexts, a number of studies have shown the interplay of those beliefs on behavioral intention [29, 47, 67]. We therefore propose:

Hypothesis 5: Perceived usefulness of the shopping environment has a positive influence on the intention to reuse the shopping environment.

It is a common argument that something, which is perceived as enjoyable, is a good candidate to be reused in the future. In fact, Koufaris [56] – while investigating online consumer behavior – found this interplay between enjoyment and the intention of returning to a web-store. Similarly, in the context of applications to customize products in online-shops, Kamis et al. [51] found that shopping enjoyment has a significant effect on the intention to revisit an online-shop in future. Furthermore, effects of perceived enjoyment on the intention to return to or reuse a website, are found over the attitude toward shopping on a website [46] or the perceived decision quality [97]. Moreover, Nah et al. [64] found that enjoyment affects the intention to visit a virtually seen hospital in reality. For the purpose of determining the intention to reuse a VR shopping environment, we therefore hypothesize:

Hypothesis 6: Perceived enjoyment has a positive influence on the intention to reuse the shopping environment.

Method

Manipulation of Immersion

In order to test the research model, we conducted a laboratory experiment, which manipulated the degree of immersion of the shopping environment between subjects. The participants had to make several purchase decisions either in a highly immersive VR shopping environment whilst wearing a HMD (HTC Vive, 2017 edition), or in a low immersive shopping environment displayed on a full HD 24" desktop computer screen. Thus, in the high immersion group, the participants had a panoramic field of view, which was made possible through the HMD (surrounding), and complete visual isolation from physical reality (inclusive). In terms of the immersion-dimension *extensive*, both groups were similar mainly accompanying the visual sense. Nevertheless, we argue that the magnitude with which the visual sense is accommodated is different between the groups, with the HMD addressing it more strongly. With respect to *vividness*: Although the HTC Vive reportedly has a combined resolution of 2160 x 1200 pixels,[1] it is technically questionable to simply add up the resolution of both eyes. Due to the large field of view (100° horizontally), the HTC Vive achieves approximately 11 pixels per degree visual angle.[2] Whereas the human fovea can presumably work with 60 pixels per degree and beyond [26]. The 24" full HD computer screen (1920 x 1080 pixels), which was used for the study, presents approximately 40 pixels per degree at the typical distance of about 60 cm. Yet, the field of view of the HMD is much larger and thus a larger area of the visual field is stimulated by the scenario. It is hence difficult to objectively compare it to the low immersion environment. In both setups we maintained the highest possible framerate, which is 90 Hz for the HMD and 60 Hz for the desktop. The computer systems driving the two setups were designed to match these requirements.[3] Nevertheless, taking other factors that influence vividness into account, for example the high immersion environment supporting stereoscopic vision, simulated physics when handling the products, or dynamically changing shadows compared to the static shadows in the low immersion environment, we can conclude that the vividness is more pronounced in the high immersion environment.

In order to increase the control over factors other than the intended manipulation of immersion, we use (almost) the same program code for displaying both shopping environments (implemented by using Unity 5.5.3f1). The participant therefore saw the exact same product information and product models in both environments, which are shown in Figure 2.[4]

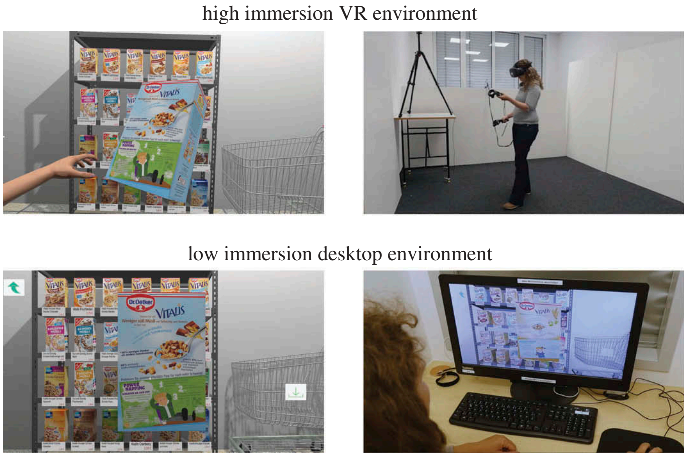

Figure 2. Virtual reality (VR) shopping environment and desktop shopping environment (top: high immersion VR; bottom: low immersion desktop environment; left: first-person perspective; right: third-person perspective).

Next, we describe how the dimension *interactivity* [80] was operationalized. In both environments, the participants can take products from the shelf. In the highly immersive environment, the participants can move freely within the environment (by natural walking) and they can also interact with the environment by using the two associated HTC controllers (one for each hand). By clicking and holding the controller's trigger, the participants can grab products and then move and turn their hands just as in a natural environment (the products "stick" to the controller and turn according to the participants' hand movements). The participant can also pass products from the one hand to the other hand, or even drop, pick up, or throw products (physics simulation). We also inserted a 3D model of a shopping cart in the VR environment in which participants had to put the chosen products. By designing the high immersive VR shopping environment, we followed the hardware and software guidelines of Slater and Usoh [78]. For instance, the factor formulated as "The self-representation of the participant, that is the participant's "virtual body," should be similar in appearance to the participant's own body, respond correctly, and be seen to correlate with the movements of the participant" [78, p. 222], was achieved by tracking the motion of the hands, as well as the head position, which was supported by the HTC Vive equipment. Through this, it was also possible to map the viewpoint exactly according to the real-world eye level (proprioceptive mapping). In the low immersive desktop environment, the participants interacted with the environment by using a mouse as input device. The participants could take a product from the shelf by clicking on it. The respective products popped up and could be rotated 360° by either clicking on it or moving the mouse, thereby enabling the participants to inspect the package from each side (including top and bottom).

After having described the operationalization of all five dimensions individually, Table 1 demonstrates how the two environments differ along the dimensions of immersion presented by Slater and Wilbur [79] as well as Steuer [80].

Table 1. Manipulation Categorized According to the Concepts of Immersion.

Technological concepts [79,80]	High immersion group	Low immersion group
Inclusive	physical reality visually shut out	physical reality visually exists apart of the screen
Extensive	visual (higher magnitude)	visual
Surrounding	panoramic field of view (110° diagonally)	limited to external 24” screen (47.76° diagonally)
Vivid	1080 x 1200 pixels (per eye) stereopsis, dynamic shadows, simulated physics	1920 x 1080 pixels no stereopsis, static shadows, no simulated physics
Interactive	proprioceptive mapping, controller used as input device; head and controller tracking	static environment, mouse used as input device

As the table illustrates, we linked all the facets of the two environments to the associated dimension of immersion [79, 80] and, therefore, to the underlying theoretical construct *immersion*. If we now compare the two environments along all dimensions in a similar fashion as proposed by Slater [77] (e.g., “Given two systems, if one has a larger field of view than the other, then the first is (in my definition) more immersive than the second” [77, p. 560]), we can conclude that we have successfully instantiated the underlying theoretical construct immersion (high/low) through our two environments with which we can confirm instantiation validity [59].

Task and Procedure

Overall, the experimental procedure was the same for all participants. After arriving at the laboratory, they filled out a consent form, answered a short pre-questionnaire concerning their product involvement, and received instructions about the procedure, payment, and task. Afterwards, they participated in a training task to familiarize themselves with the task and especially with the shopping environment. The training task (same task as in the experiment, but with a different product category) ended when the participants felt confident about interacting in the respective environment. Then the actual experiment started. After completion of the experiment, the participants filled out a questionnaire.

We selected muesli as product category, because it is a low involvement and habitually bought product for which consumers' relatively simple decision-making processes can be realistically tested in an experiment. Moreover, it allows for a conservative test of the effects, since we expect the effect of immersion on the utilitarian and hedonic path to be more pronounced (positive) for high involvement products. Furthermore, the product packages were easy to model in 3D (a very similar package size for most types of muesli; simple and planar surfaces). For a detailed discussion of why we have chosen muesli as product category, we refer the reader to the section "Limitations, Contributions, and Future Research."

Each participant answered ten consecutive choice tasks. We decided for repetitive choices in the same product category because of two reasons. First, we wanted to make participants familiar with the shopping process as fast as possible. Second, we wanted to be able to measure the participants' preferences. Thus, the choice tasks are generated by using a choice-based conjoint (CBC) design [71]. The CBC design enables measuring the utility value of each product and the price sensitivity of respondents. This analysis is interesting from a marketing perspective, but goes beyond the scope of this paper. We will nevertheless report some of the results in the Discussion section. Furthermore, the CBC-based optimal design of the choice tasks ensures similarity to decisions, which consumers face in the marketplace, and involves trade-offs between product and price. Each choice task consists of 24 products, which are drawn from a total set of 40 products, and the prices vary for the same product across different choice tasks. Thus, each choice task gives the respondent reasons to think about the question which of the mueslis fits the personal preferences best and the varying prices motivate them to make each decision anew. For the last 2 of the 10 choice tasks, the sample was randomly divided into 2 parts: Approximately half of the participants answered the last 2 choice tasks in the same environment (VR or desktop environment) and the other half made their choice in front of real shelves in the laboratory. We will show later that this division does not affect our results. We did that, because we measured the participants' eye movements in the high immersion group in order to be able to compare user behavior in VR with user behavior in reality. Eye movements in VR can be measured unobtrusively, because our SMI eye tracker is integrated in the HMD and therefore it should not have an impact on the participants' answers to our dependent variables.

All the participants' choices were incentive-aligned to motivate our respondents to disclose their true preferences (in line with Ding et al. [24]). Each participant received an initial endowment of €14. It was explained to respondents that we would randomly realize one of their choices at the end of the experiment and would discount the price of the selected product from the initial endowment. In return, they would receive the chosen product.

We also controlled for bottom-up effects of visual attention that could potentially influence the probability of looking for and choosing products off the shelf. For example, studies by Atalay et al. [5] showed that products, which are in horizontally central positions on the shelf, receive more visual attention, and, consequently, are chosen more often. Chandon et al. [16] found that increasing the number and position of shelf facings increased the attention to product packages and the probability of buying the respective products. We therefore randomly filled the 4 central positions on the shelf with 4 of the products in each of the conjoint design's 168 shelf configurations. Afterward, the products that were not assigned to one of the central positions were placed on the shelf such that the products belonging to the same brand were located next to each other. By arranging the products in this way, we tried to ensure that the shelves looked realistic, because products of the same brand will also be placed next to each other in a real store.

Operationalization of Dependent Variables

We operationalized all dependent variables in the research model in a questionnaire by using common scales from literature.[5] For an overview of the applied items, we refer to Table B1 in Appendix B. In addition, we measured certain scales, which were used in related literature. In particular, these were ease of use [22], the flow dimensions of *time distortion* and *concentration* [56, 65], customer satisfaction [86], as well as compatibility, interactivity, and vividness [46]. We also controlled for product involvement (FCBI Scale [70, 87]), innovativeness [1], mental and physical effort [38], simulator sickness [53], prior experience with VR technology, and demographics such as age and gender. Since pretests showed that small text printed on the product packages were difficult to read in VR, we controlled for readability with a single-item construct, which asked the participants to rate the readability on a 7-point Likert scale from "very bad" to "very good," with the following wording: "Could you read all information which you wanted to consider for the evaluation of the muesli properly during the experiment?"

Results

Due to the confirmatory research objective of our study and an adequate sample size, covariance-based structural equation modeling (CB SEM) was used for the analysis of the main model [30, 32].[6] Following other work [47, 97], we test the effects of the treatment manipulation on the two dependent variables perceived product diagnosticity and telepresence separately by conducting a MANOVA.

Throughout the analysis, we followed a two-stage approach first confirming the reliability of the measurement model and thereafter analyzing the structural model including testing the hypotheses. Before we report these results, we summarize important descriptives concerning the sample and the dependent variables.

Descriptive Results

The participants were recruited from a large German university using the organizing and recruiting software *hroot* [8] and, when invited, were not informed about the fact that it would be a VR study. Yet, they were informed that we were looking for participants who generally eat muesli. On average, the pure experimental time, i.e., from starting the first questionnaire until finishing the second questionnaire, was 27.62 (SD = 7.69) minutes for the low immersion group and 38.42 (SD = 7.76) minutes for the high immersion group. The data was gathered in a period of about 6 weeks. Please note that because of the effort of recording the high immersion group – where we could only have one participant at a point of time – it took us alone 5 weeks for collecting the data for this group. Initially, 296 participants took part. Due to technical issues during the experiment – problems with the software, but mostly because of technical problems with the eye-tracker – the number of participants in the VR group declined to 132 and in the desktop group to 128. Three participants from the desktop group had to be excluded; two had abnormally short response times in the second questionnaire (participant's response time < mean(response time) - 2*SD(response time)) and one failed to answer a control question. After data cleansing, the sample size was 257 in total.

As mentioned in the methodology section, the two main groups were again divided into subgroups, one of which executed the last 2 choice tasks in front of a real shopping shelf. We tested each construct for differences in the answering behavior between these different subgroups and found no significant differences (see Table C1 in Appendix C) when comparing them with statistical tests (Mann-Whitney U or Welch's two-sample t-test, respectively). Based on this, we decided to merge the 2 groups for further analysis.

The average age within the sample was 22.63 (SD = 2.60) and among the participants were 34 percent women, which correspondents to the percentage of female students at the inviting university. An analysis of the VR group participants' prior experience with VR shows, that for more than half of the participants (68) our experiment was their first experience with VR (53 participants stated it was their second or third time, whereas 11 stated that they have experienced it more often). Table 2 summarizes the mean values and standard deviations for the dependent variables and indicates whether these differed significantly between the two groups.

Table 2. Summary of Variables

	VR (N = 132)			Desktop (N = 125)				ALL (N = 257)	
Construct	M	SD	normtest.p	M	SD	normtest.p	p	M	SD
Diagnosticity	4.08	1.31	.125	4.69	1.51	.001	.001	4.38	1.44
Telepresence	5.11	1.34	.000	3.51	1.47	.029	.000	4.33	1.61
Enjoyment	5.06	1.34	.000	4.44	1.29	.145	.000	4.76	1.35
Usefulness	4.27	1.23	.036	4.28	1.59	.007	.655	4.28	4.28
Intention	4.05	1.66	.002	3.91	1.72	.001	.495	3.98	3.98
Readability	3.95	1.56	.000	5.69	1.33	.000	.000	4.79	1.70

Note: M, mean; SD, standard deviation. normtest.p based on Shapiro-Wilk test.

The results for the NASA TLX [38] and the simulator sickness questionnaire [53] were mixed.[7] We find that the *cognitive* and *physical load* were perceived as significantly higher in the high immersion condition in comparison to the low immersion condition ($p < .05$ and $p < .001$), whereas the perceived required *effort* (considering both aspects, i.e., mental and physical work) to accomplish the desired level of performance did not differ significantly between the conditions ($p = .05$). These results are somewhat inconclusive. With respect to the simulator sickness questionnaire, we found significant differences for the dimension *dizziness* between the conditions ($p < .05$): 1.5 percent of the participants within the high immersion group reported moderate and 9.8 percent mild symptoms, whereas in the low immersion group 3.2 percent claimed to have experienced mild symptoms. Similarly, for the dimension *general discomfort* the reported values were significantly different ($p < .001$), whereby values that differed from "no symptoms" were assigned only for the VR environment (11.4 percent stated mild and 3.2 percent moderate symptoms). It thus seems that these 2 dimensions are generally more of a concern for the VR condition. For the dimension *fatigue*, significantly less symptoms were reported for the high immersion condition than for the low immersion condition ($p < .01$), thereby indicating a more positive assessment for the high immersion condition with respect to this dimension.

Immersion did not significantly influence the perceived ease of use of the shopping environment (Mann-Whitney U test: $W = 8735$, $p = .390$, $r = -.05$). In addition, the values of ease of use are rated quite high (a combined average score of 6.51 for both groups on a 7-point Likert Scale), indicating that the usage of both environments was clear, understandable, and easy to learn.

Measurement Model

To analyze the quality of the SEM-measurement model, we performed a confirmatory factor analysis (CFA) using LISREL 9.30. First, we assessed the assumption of multivariate normality checking each indicators skewness and kurtosis (univariate normality) as well as Mardia's normalized estimate of multivariate kurtosis [60]. For the measures of univariate normality, the values do not indicate a departure from normality according to the thresholds given by West et al. [93], however, the index of multivariate kurtosis (51.202) and its critical ratio (15.295, i.e., Mardia's square) are indicative of multivariate nonnormality [15]. Therefore, as a precaution, we used robust maximum likelihood (RML)[8] as estimation method, since this method adjusts for non-normality in the data [50]. We assessed the model using five fit indices (recommended cutoff values in parentheses): comparative fit index (CFI $\geq$ .95), Tucker-Lewis Index (TLI $\geq$ .95), root mean square error of approximation (RMSEA $\leq$ .06), standardized root mean square residual (SRMR $\leq$ .08), and adjusted goodness of fit index (AGFI $\geq$ .90) [30, 32, 43]. The initial model showed acceptable fit for three indices[9]: Satorra-Bentler $\chi 2_{(125)} = 245.72$, $p < .001$, CFI = .95, RMSEA = .061, SRMR = .069, while two did not exceed the recommended threshold value: TLI = .93, and AGFI = .85. However, these values were satisfactorily improved in the process of measurement model specification as described in the following paragraphs.

Next, we assessed the psychometric properties of the measurement scales. Composite reliability (CR) was well above the threshold value of .70 [36] for all constructs, thereby indicating internal consistency reliability. Only the CR value of perceived telepresence (.692) failed to exceed the threshold value. After removing the item TEL.4., the CR value for the construct rose above the threshold (.727). We then assessed the convergent validity of the measurement model. All measurement items loaded significantly on the respective latent variable ($p < .001$) and the standardized loadings were all above the cutoff value of .60 [6, 18] except for ENJ.2. (.462; $p < .001$) and TEL.3. (.584; $p < .001$). We therefore examined the effect of removing these items on CR and average variance extracted (AVE), as Hair et al. [36] suggest to only remove items from a scale if item deletion leads to an increase in AVE or CR above the required cutoff value. Item deletion of both indicators, indeed, led to an increase of the AVE of telepresence (.477) and enjoyment (.488) above the suggested cutoff value of .50 [6]. We thus excluded ENJ.2. and TEL.4. from further analysis. Table 3 summarizes the results for the assessment of internal consistency reliability and convergent validity.

Table 3. Properties of Measurement Scales

					Correlations				
	M	SD	CR	AVE	DIAG	TEL	USE	ENJ	INT
Diagnosticity	4.38	1.44	.873	.631	**0.79**				
Telepresence	4.33	1.61	.708	.556	–0.12	**0.75**			
Usefulness	4.28	1.41	.900	.694	0.37**	0.10	**0.83**		
Enjoyment	4.76	1.35	.806	.581	0.10	0.51**	0.22**	**0.76**	
Intention to reuse	3.98	1.69	.952	.869	0.22**	0.16*	0.46**	0.28**	**0.93**

Note: *$p < .05$. **$p < .01$ (two-tailed test). CR, composite reliability; AVE, average variance extracted. Diagonal values are square root of AVE.

For assessing the discriminant validity, we conducted for each pair of constructs a scaled difference chi-square test [12, 13] comparing obtained values from a constrained CFA model in which the correlation between a pair of constructs were set to unity (fixed) to a CFA model without constraints in terms of correlation (free) [3, 6]. All test results revealed a significantly lower chi-square value for the unconstrained (free) model indicating that the pairs of constructs are not perfectly correlated which confirms discriminant validity [3, 6]. Finally, the measurement model which meets the required internal consistency reliability, convergent validity and discriminant validity showed excellent model fit (Satorra-Bentler $\chi2_{(80)} = 109.76$, $p = .015$, CFI = .99, TLI = .98, RMSEA = .038, SRMR = .044, AGFI = .91).

Hypotheses Testing: Effect of Immersion on Perceived Product Diagnosticity and Perceived Enjoyment

We conducted a multivariate analysis of variance (MANOVA) to test the effect of our experimentally manipulated variable, immersion (high/low), on perceived product diagnosticity and perceived telepresence. All MANOVA test statistics (Pillai's trace, Wilks' lambda, Hotelling's trace, Roy's largest root) revealed that the treatments differ significantly with respect to the two dependent variables ($p < .001$) (see Table C4 in Appendix C). We therefore conducted two linear regressions separately on each dependent variable [28].

We surprisingly find a negative effect along the utilitarian path (Table 4). Therefore, H1 is not supported. We find that the higher the immersion, the lower is the perceived product diagnosticity.

Table 4. Linear Regression Model for Perceived Product Diagnosticity

Model	Unstd. Coeff. B	Std. Coeff. Beta	Bias [a]	Std. Error [a]	Sign. (2-tailed) [a]	95 percent CI for B [a,b] Lower Bound	Upper Bound
Constant	4.693		–.001	.138	.000	4.427	4.951
High (vs. low) immersion	–.618	–.214	–.001	.177	.000	–.980	–.262

Note: [a]due to non-normally distributed errors, results are based on 5000 bootstrap samples; [b]Bias Corrected and accelerated (BCa) bootstrapping Confidence Intervals (CI). R^2=.046; adj. R^2=.042. Re-estimating the model without applying bootstrap procedure reveals similar results.

As hypothesized, a higher degree of immersion has a positive effect on perceived telepresence (H2), thereby revealing that the higher immersion group leads to higher perceived telepresence than the low immersion group (see Table 5).

Table 5. Linear Regression Model for Perceived Telepresence

Model	Unstd. Coeff. B	Std. Coeff. Beta	Bias [a]	Std. Error [a]	Sign. (2-tailed) [a]	95 percent CI for B [a,b] Lower Bound	Upper Bound
Constant	3.508		–.002	.134	.000	3.250	3.765
High (vs. low) immersion	1.602	.497	–.003	.180	.000	1.240	1.962

Note: [a]due to non-normally distributed errors, results are based on 5000 bootstrap samples; [b]Bias Corrected and accelerated (BCa) bootstrapping Confidence Intervals (CI) R^2 = .247; adj. R^2 = .244. Re-estimating the model without applying bootstrap procedure reveals similar results.

Hypotheses Testing: Effect of the Utilitarian and Hedonic Path on the Intention to Reuse the Shopping Environment

We then proceeded with assessing the SEM-structural model. We again used LISREL 9.30 to test the proposed model and applied RML as estimation method. First, we checked the overall fit of the model and found the proposed model to meet all required fit indices (Satorra-Bentler $\chi2(85) = 123.10$, $p = .004$, CFI = .98, TLI = .98, RMSEA = .042, SRMR = .079, AGFI = .90) indicating that the model fits the data well. Second, we continued to test the remaining hypotheses. Figure 3 shows the results for the structural model.

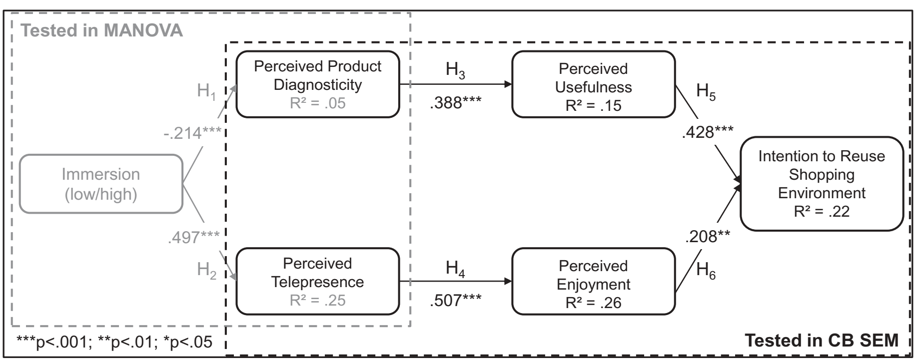

Figure 3. Results for the structural model.
Note: R^2 values for perceived product diagnosticity and perceived telepresence and the standardized path coefficients from immersion on the latter two (all printed in grey) come from the multivariate analysis of variance (MANOVA) and the regression models. CB SEM, covariance-based structural equation modeling.

All relationships in the structural model are significant. In line with H4, higher perceived telepresence positively influences the perceived enjoyment, suggesting that a higher degree of telepresence induces a higher level of enjoyment. Ultimately, H6 is supported, signaling that higher enjoyment positively influences the intention to reuse the shopping environment.

In contrast to the induced positive effect of immersion along the hedonic path, we surprisingly found that the higher the immersion, the lower is the perceived product diagnosticity. However, the remaining hypotheses (H3 and H5) of the utilitarian path can be confirmed, thereby suggesting that a higher degree of perceived product diagnosticity leads to a higher level of perceived usefulness, which, in turn, impacts finally, significantly, and positively the behavioral intention.

To summarize, the two main paths (hedonic and utilitarian) point in opposite directions. Whereas the hedonic path is positive, the utilitarian path is negative, due to the significant negative relationship between immersion and perceived product diagnosticity.

Further Analysis of the Utilitarian Path

In order to account for the unexpected negative effect of high immersion on perceived product diagnosticity, we conducted further analyses. In search of potential explanations for this phenomenon, we tested the influence of the technological constraint *readability*. Given the technical details about the visual fields of the HMD and the desktop screen used in our study, we expected the low immersive environment to have higher readability than the high immersive environment. This was confirmed with a Mann-Whitney U test ($W = 13119$, $p < .001$, $r = -.52$; mean(low immersion) = 5.69, SD(low immersion) = 1.33; mean(high immersion) = 3.95, SD(high immersion) = 1.56). This might explain the negative effect of immersion on product diagnosticity. Indeed, the inclusion of readability as mediator between immersion and perceived product diagnosticity leads to an indirect only (full) mediation [101]. Following the approach by Hayes [40], we applied bootstrapping (bias-corrected (BC) [41]) for testing the mediation model. The direct effect of immersion on perceived product diagnosticity is not significant (CI [−.747, .018]) when we insert readability in the model as mediator, whereas the indirect effect is significant (CI [−.492, −.051]; see Table C5 in Appendix C for further results). Thus, the low readability in the high immersion group explains the negative effect of high immersion on perceived product diagnosticity. Please note that the direct effect of immersion on perceived product diagnosticity has a negative coefficient, which contradicts our H1 (see Table C5 in Appendix C). Since this effect is not significant, we do not want to over-interpret this result. Yet, a possible reason might be that the users in our low immersion group experienced rather high product diagnosticity compared to what they are accustomed to at e-commerce stores. In fact, they were able to see the product in a 360° field of view by moving the computer mouse. This feature is not yet implemented in all e-commerce stores and thus might have positively influenced the users' product diagnosticity judgments in the low immersion condition.

As an additional analysis, we were interested whether immersion has a direct effect on our main dependent variable, namely the intention to reuse the shopping environment. We therefore computed an ordinary least square linear regression model with and without readability as control variable (bootstrapped with 5000 samples). It reveals that, when controlling for readability, high (vs. low) immersion has a positive influence on the intention to reuse the shopping environment ($p < .05$), whereas there is no effect if we do not control for readability ($p = .523$). Concerning the VR environment, the estimated coefficient for the intention to reuse the shopping environment is 0.50 higher on the 7-point Likert scale compared to the desktop environment with low immersion when we control for readability ($p < .01$ for readability). Please refer to Table C6 in Appendix C for details of the analysis. In sum, this analysis shows that as soon as readability problems are solved in the VR environment, immersion is supposed to positively affect the intention to reuse the shopping environment.

Discussion

We conducted an experiment to analyze how the immersion of an IT artifact – a shopping environment – affects the users' intention to reuse it in the future. Our results show that immersion influences the user's intention along two paths, which ultimately cancel each other out. The degree of immersion increases users' enjoyment, because they perceive higher telepresence. Thus, they have more fun while shopping in this environment, because they escape reality and feel as if they are actually present in the shopping environment. Immersion therefore has a positive impact on user experience [39]. From the literature, we know that experience has a positive influence on other important factors, such as repatronage intentions [37], loyalty [25], or the time spent in a store, and the intention to buy more and other items [84]. In sum, immersion can therefore not only positively influence the user's intention to reuse the IT artifact, but most probably it can also make other important benefits available to the IT system provider. Although an analysis of these other benefits is beyond the scope of this work, we can at least provide certain insights about the participants' preferences, which we were able to measure, due to the conjoint-analytic design of our choice task experiment. We tested how immersion affects *price sensitivity*, thereby describing the extent to which the customer focuses on the price when making the purchase decision, instead of attaching importance to other product characteristics. Participants in the high immersion group (mean = .3162, SD = .0922) were significantly less price-sensitive than participants in the low immersion group (mean=.3899, SD = .1017; $W = 11737$, $p < .001$, $r = -.37$). Since our experiment was fully incentivized in the sense that the participants had to actually buy one of the chosen products, this result most probably has high external validity. It has major implications for retailers: Consumers might actually spend more money in a highly immersive shopping environment, because they are less price-sensitive.

To our surprise, we found that immersion has a negative effect on the users' perceived product diagnosticity and, thus, along the utilitarian path. We were able to explain this result with reference to a technical limitation of the current VR technology: Not all the participants could properly read the detailed product information, which was printed on the packaging. This technical limitation was unavoidable, because the HMD (HTC Vive), which we used in our study, had the highest resolution that was available for consumer devices when we conducted the study. At the time, we were aware that the current state of technology could potentially limit the generalizability to future IT artifacts, due to the results' dependence on the current technology. We therefore decided to conduct the experiment with a few precautionary measures: In order to address the problem as best as possible, we included a visual test in the experiment's preparation phase during which the participants had to read a short text aloud. Then, they were asked to report how good the readability was. If necessary, the settings were checked and adjusted again. When, within the experiment, a package was taken off the shelf, it was invisibly rescaled to a factor of 1.5 in order to increase the readability of information written in small letters. Still, these measures apparently did not entirely resolve the technical issues. In future research, however, the problem might vanish, since technology companies are already working at a fast pace on high-resolution HMDs that have resolutions of 4K or more.

Given that our experiment was the first VR experience for the majority of the participants, we found a relatively small percentage of participants who report negative experiences, such as dizziness or general discomfort. According to the participants, the high immersive environment creates less fatigue than the low immersive environment. In addition, the high ratings for ease of use also underline the quality of our application and the easiness to learn interacting with it, although it was for most of the participants their first time experiencing a VR application. Moreover, we also measured frustration, as well as perceived enjoyment, and the empirical results suggest that our participants had a good VR experience. In sum: While the utility of the VR environment has partially been diminished by technological restrictions, a multitude of other factors indicate a good usage experience.

Limitations, Contributions, and Future Research

We identified that the lower readability in the high immersion VR environment explained the negative influence of immersion on the utilitarian path. The importance of this technical limitation in our research model is interesting and directly transferable to all other packages on which consumers like to read detailed product information (e.g., frozen pizza, food processors or furniture [size, material, etc.]). At the same time, future research is required, because similar issues for other products and settings are likely. An example of insufficiently advanced algorithms that lead to limitations of the current technology would be cloth simulation, which is presently excellent for non-real time computer generated graphics (movies), but not yet ready for real-time interactive virtual reality multi-layer cloth simulations. Therefore, virtual tryouts of clothing that use a personalized avatar are still bound to technical limitations and the usefulness of high immersive environments might be affected by this technical constraint. Personalized clothing combined with virtual tryouts could be one of the most important advantages of mixed reality, since it is large scale, highly competitive, highly individual, and highly risky if the customer is not happy with the product delivered. We, thus, argue that it is important to conduct further empirical studies to test how these new developments of VR technology affect users' adoption behavior and to provide continuous advice to the system designers of VR applications.

We combined the theory about hedonic and utilitarian motives of online shopping [17] with the concept of immersion, which is especially relevant for the new context of VR shopping environments. To do justice to the influence of immersion, the paths were extended to include perceived diagnosticity (utilitarian) and perceived telepresence (hedonic). We also contribute to theory by explaining the negative utilitarian path via a new mediator "readability." Yet, we only found an R^2 value of 0.22 for the intention to reuse the shopping environment. Our study focused on cleanly manipulating immersion and studying its effect with an emphasis on a strong theory-driven simple model. We leave it to future research to identify other factors, such as trust in technology or the user's propensity to be an early adopter that might influence the user's intention to use VR shopping environments.

In future studies, one might further disentangle the single dimensions of immersion and study which of them, or which combinations of them, have the largest effect on utilitarian as well as hedonic variables and, thus, in turn, influence the adoption intention. The meta-analysis of Cummings and Bailenson [21] provides initial insights about the relationship between immersion and telepresence. The authors investigated how different facets of immersion affect spatial presence (i.e., telepresence) and found that when only a single dimension of immersion was manipulated, the strength of the effect on telepresence varied substantially. While manipulations of the field of view (surrounding) or of the stereoscopic vision (vividness) produced medium-sized effects and the tracking level (interactivity) had a large effect, image quality and resolution (also part of vividness) had significantly smaller effects. In line with these previous findings, we speculate that, in our study, telepresence was mainly influenced by differences in the field of view (110° vs. 47,76° diagonally; surrounding) and also by inclusiveness (a dimension not explicitly analyzed by Cummings and Bailenson [21]), because being completely isolated from physical reality compared to experiencing an environment on a quite narrow field of view while seeing an experimental cabin apart from the screen, should strongly help users forget about their immediate physical location. Furthermore, we expect the tracking level (head and controller tracking, as well as proprioceptive mapping vs. none; interactivity) to have a major impact on telepresence, because being able to grab and turn products with a controller while moving in front of a supermarket shelf and, in particular, seeing the environment responding to the movements, should feel much more natural compared to interacting with a mouse and keyboard.

In contrast, the relationship between immersion and product diagnosticity is largely unexplored. The studies that come closest are the ones by Jiang and Benbasat [45-47]. In their empirical studies, the authors show that different product presentation formats that can best be described as vividness and interactivity positively influence product diagnosticity (they mostly compared product presentations in terms of pallid pictures to video presentations). We argue that the differences between the environments in our study are even more pronounced. For our high immersion environment, we believe that the increased interactivity leads to a product evaluation close to the habits in reality (assessing products close to real-scale from different angles and distances). This is reinforced by the dimension of vividness, which specifically represents the naturalness of the environment (e.g., stereopsis, dynamic shadows, simulated physics) or the panoramic field of view (surrounding). All in all, we assume that the similarity to physical reality leads to the perception that one can evaluate the product appropriately. However, within the mediation analysis, we show that the technical constraint readability (i.e., resolution) had a substantial effect on perceived diagnosticity. We, therefore, argue that, unlike for telepresence, in our setting, the resolution and, thus, the quality of stimuli (specific facets of vividness) plays a prominent role that dominates the assessment of diagnosticity. All in all, we speculate that the dimensions of immersion have different effects on diagnosticity, as well as telepresence, and that, depending on the designer's goal, specific technical factors have to be implemented accordingly. More research needs to be conducted in the future to verify these speculations.

Yet, we decided to test the effect of immersion by simultaneously manipulating several subdimensions of immersion, because, first, we wanted to understand the big picture before focussing on the *small* facets. This is a common approach for a research study that investigates technology, which has not been used in many other studies in this context before, because by making strong manipulations, we can expect a larger effect size. Second, we wanted to test the two environments (i.e., VR and Desktop) the way they are currently offered on the market and primarily used. Thereby, a desktop environment, for instance, is mostly equipped with a full HD screen, as well as a mouse and keyboard as input devices, whereas state-of-the-art VR technology supports stereoscopic vision, room-scale tracking, and proprioceptive mapping. Consequently, by using one of the best VR glasses available on the consumer market, we ensured the currentness and practical relevance of our study.

We chose muesli as a product category, since testing this low involvement product, which is bought habitually, allows for a more conservative test of our model: In line with the behavioral decision-making literature [63, 66], we expect consumers to intensify their search and undertake cognitively demanding search processes for high involvement products, such as tents, clothes, furniture, or cars. For high involvement and non-habitual buying decisions, consumers can potentially benefit from the possibilities to interact with the products in the high immersive environment, because they can evaluate the products from all angles in real scale, look inside the product, or try different functionalities. They could, therefore, better judge various characteristics of the respective products. In addition, we expect that consumers will also enjoy these evaluation possibilities even more in high immersive environments.

Another reason for choosing muesli as a product for our empirical study is that the external validity of the data should be relatively high for muesli. It can be expected that, for high involvement products, consumers would gather information over several weeks, starting with need recognition and continuing with extensive pre-purchase information search activities [34]. The resulting more complex decision-making processes would therefore be less adequate to be realistically studied in our experiment. A laboratory setting may arguably intensify the participants' search compared to when they make decisions in regular supermarkets but, in our experiment, we find that decisions were made much faster as soon as the participants were used to making decisions. Compared to the first task, the respondents needed, on average, only about 61 percent of the time when making decisions in the last of the conjoint tasks. We therefore have at least some evidence that the respondents became accustomed to making decisions and applied decision heuristics (as they do in the marketplace for habitual decisions to save time and effort [95]). Examining such rather short decision processes is, therefore, also very suitable for an experimental study with time-limited sessions. Thus, since the purchasing context is realistic for muesli and no expert knowledge is required to make these typical consumer decisions in our experiment, we have some indication that consumers behaved like they would do in the marketplace. Muesli as a product also has the advantage that all respondents had consumed the product in recent years, had, thus, prior experience with the product, and knew, to some extent, which attributes were relevant for them when making decisions. Furthermore, we were able to fully incentive-align the choices such that the respondents received one of the products they had chosen immediately after the experiment ended. Despite all these arguments for mueslis, the investigation of high involvement products in further empirical studies is a promising and challenging task for future research.

Our study is also limited in that we showed only one shelf to the participants without creating an entire store environment. Still, we decided in favor of the simpler design to more easily control situational factors, such as the width of the aisles or the distances to reach certain products. How immersion affects both paths, is probably more pronounced when users can actually experience an entire VR store, because VR technology can improve self-orientation and, therefore, affects factors, such as *navigation* [90]. We hence concur that expanding our research to an entire VR store, as recently implemented in a study by Schnack et al. [72], would be interesting. Furthermore, the degree of immersion by itself in a complete VR store is probably much higher than in front of a single VR shelf, which can create an even higher variance between the two immersion groups in an experiment and, thus, lead to the model having an even larger explanatory power. Thus, although our results might not be generalizable with respect to these other products and VR environments, we believe that the immersion's positive impact is rather underestimated in our study. This underlines the large potential that we see for the adoption of VR artifacts. In addition, faithful rendering, shading, and lighting are factors that strongly influence the realism and the degree of immersion experienced by the user. We did our best to make our VR environment highly immersive, but acknowledge that there is still room for further improvement, such as using more advanced lighting or shading. Furthermore, researchers can also include other multimodal factors, such as ambient sound and olfactory stimulations, to further increase the degree of immersion.

A further limitation of our experiment is that the consumer VR market is still in its infancy, which also means that most of the participants in our study had no prior VR experience. The novelty of the VR environment could, for example, have had a positive effect on the participants' enjoyment [10]. Furthermore, they had to learn how to interact in VR and this could have been an interesting experience and might have affected the results. However, the above mentioned limitation, namely not showing a complete retail store, could have kept the novelty factor quite low, because the complete potential of VR technology was not implemented. In the same vein, VR offers much more than mirroring reality one-to-one. In our study, the VR shopping environment was meant to replicate reality, because this was experimentally the cleanest way to manipulate immersion (without confounding the shopping environment with new features, which are only possible in VR). In future VR applications, however, users could potentially beam themselves up into space, could go shopping with avatars of their real friends, could be assisted by intelligent and interactive user assistance systems that are highly personalized [61, 69], could add interesting gamification elements, or the retail store itself could automatically adapt to the user's preferences [61]. Moreover, new possibilities of interacting with products in VR and AR settings may increase feelings of product ownership [98] over a product and, thus, potentially be used by marketers in VR shopping contexts. In essence, a replication of reality is not the correct approach to really test the adoption behavior of future VR technology. Our study is therefore limited by the fact that it focuses on a sound manipulation of the concept immersion, but does not test the possible effects of future VR technology. Nonetheless, a comparison of consumer behavior in virtual reality and physical reality in future studies is interesting, since it enables assessing the similarity of behavior in both environments [76].

Conclusion

In this article, we report results from an experiment which succeeds in systematically manipulating immersion, thereby analyzing its effects on the users' adoption. We find that immersion influences the user's intention to reuse the shopping environment along two paths (a hedonic and a utilitarian path), which ultimately cancel each other out. Immersion has a positive effect on the hedonic path, whereas the effect on the utilitarian path is negative. We show that the low resolution of the HMD explains this negative effect. This result provides some evidence for the notion that when even more advanced VR technology is available, immersion will also positively affect the utilitarian path. Although the perceived resolution of VR displays is at present not as good as the perceived resolution of computer screens (in terms of pixels per visual angle), it is immensely important to deal with the technology from an early stage, since it has the potential to dramatically change the interaction with computer systems. This change will not only affect the individual consumer, but also entire industry sectors, which will need to weigh up this technology's potential benefits or threats.

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Notes

1 https://vive.com/us/product/vive-virtual-reality-system/

2 https://roadtovr.com/understanding-pixel-density-retinal-resolution-and-why-its-important-for-vr-and-ar-headsets/

3 Please see Table A1 in Appendix A for the system specifications and applied rendering parameters.

4 In addition, we refer to a video showing both environments as well as to a video comparing the high immersion (VR) shopping environment to the physical reality. Please see https://pub.uni-bielefeld.de/record/2934590

5 Scales used in the research model: Perceived telepresence (TEL) [54, 55, 64], perceived enjoyment (ENJ) [33, 56], perceived product diagnosticity (DIAG) [46], perceived usefulness (USE) [23, 56, 91], intention to reuse shopping environment (INT) [89, 92, 97].

6 Testing the model using Partial Least Squares SEM (PLS SEM) reveals qualitatively similar results.

7 Please note: Within this section, we focus on the most important findings. For the complete results, we refer to Table C2 and C3 in Appendix C. For an overview of the applied items, we refer to Table B2 in Appendix B.

8 Calculating the model with the standard ML estimation, leads to qualitatively similar results.

9 Robust fit indices based on Satorra-Bentler's $\chi 2$.

Supplemental Material

Supplemental material for this article can be accessed on the publisher's website.

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