Presenting Your Products in Virtual Reality: Do not Underestimate Cybersickness

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Abstract. For e-commerce retailers it is crucial to present their products both informatively and attractively. Virtual reality (VR) systems represent a new marketing tool that supports customers in their decision-making process and offers an extraordinary product experience. Despite these advantages, the use of this technology for e-commerce retailers is also associated with risks, namely cybersickness. The aim of the study is to investigate the occurrence of cybersickness in the context of the customer's *perceived enjoyment* and the *perceived challenge* of a VR product presentation. Based on a conceptual research framework, a laboratory study with 533 participants was conducted to determine the influence of these factors on the occurrence of cybersickness. The results demonstrate that the *perceived challenge* has a substantially stronger impact on the occurrence of *cybersickness*, which can only be partially reduced by *perceived enjoyment*. When realizing VR applications in general and VR product presentations in particular, e-commerce retailers should therefore first minimize possible challenges instead of focusing primarily on entertainment aspects of such applications.

Keywords: Cybersickness · Virtual reality · Product presentation · User experience

1 Introduction

In the last few years, virtual reality (VR) has become a very important instrument for companies to present their products in e-commerce. VR provides unique visualization possibilities and gives users the feeling of being in a different place. Especially in industries where products are difficult to evaluate by consumers prior to purchase, VR can support consumers during their decision-making process [1]. For example, large hotel chains such as Marriot and Hilton are already presenting hotels with VR. As with games, product presentations in VR provide an enjoyable user experience that awakens curiosity and challenges the potential guest [2]. Current study results show that modern VR applications for product presentation are suitable for both apparel retailing [3] and the tourism industry [4], and that they support customers in product assessment. Furthermore, it has been shown that consumers would purchase a virtual reality system if

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more useful applications were available on the market [5]. Despite the great advantages of this new technology, cybersickness is a serious problem for e-commerce retailers. The contribution of this paper is threefold: based on a literature review, we will develop a conceptual research framework that describes the relationships between the identified factors influencing cybersickness (1). A large-scale empirical laboratory study with 533 participants was conducted to determine the effects on cybersickness (2). Furthermore, we will provide practical recommendations for e-commerce retailers to avoid cybersickness in VR product presentations (3).

2 Related Work

Immersive VR technology is continuously improving and spreading. Large application areas include the game industry ("The Lost Future: VR Shooter", [6]), education ("Chemistry VR Cardboard", [7]), medicine ("Stanford Health Anatomy Tours", [8]), as well as business [9] and tourism applications ("VR Cities", [10]). However, a shared negative side effect is common in most usage types: cybersickness. This denotes a form of motion sickness suffered frequently by users exposed to virtual environments. Compared to normal motion sickness, cybersickness arises when a subject feels motion, due to changing visual stimuli, while actually staying stationary [11].

Cybersickness manifests in various forms, such as headaches, blurred vision, salivation, eye strain, dizziness or even vomiting [12]. However, symptoms and their level of severity differ considerably between individuals.

2.1 Cybersickness Causes

In literature [13, 14], three main theories on the cause of cybersickness can be found: (1) the theory of sensory conflict, (2) the theory of postural instability and (3) the poison theory.

The sensory conflict theory states that motion sickness results from discrepancies in the information provided by different sensory modalities. Each time we move, the brain computes the difference of the outgoing motor signals and the incoming sensory input. If the signals do not match, a "sensory conflict" occurs [15]. For instance, if a person sits on a chair while wearing a head-mounted display using smartphone based virtual reality (SBVR) and moves around in the hotel resort, the eye signals that the person is moving, whereas the motor-sensory information of the body is stating 'no movement'. Hence, the motor-signal of the body (rest) is different from the sensory input of the eye (movement). According to the sensory conflict theory, these discrepancies in information cause cybersickness.

The theory of postural instability was developed by Riccio and Stoffregen [16]. They assumed a fundamental link between perception and action. Since postural control is essential to every kind of behavior, motion sickness is conceived as a result of prolonged postural instability. Depending on the ability to control one's own body and on the passive stability of the body in the absence of restraints, postural instability occurs. This means that if users are not familiar with moving in virtual environments, they may feel unable to maintain postural control. This lack of control causes temporal postural instability and therefore, cybersickness until the user has adapted.

The poison theory looks at cybersickness from an evolutionary point of view. As early as 1977, Treisman [17] claimed motion sickness to be a result of difficulties in programming eye or head movements. These difficulties arise when consistent and unpredictable disturbances between the spatial frameworks of vestibular, visual or proprioceptive inputs occur. The brain's automated reply when encountering such "hallucinated" disturbances is acting against poison ingestion. In this view, cybersickness is based on a maladaptive process, which originally helped the body to get rid of toxic substances.

Besides the three main theories on the causes of cybersickness, there are other factors discussed in the literature. Not surprisingly, technological issues can favor cybersickness, such as flicker, time lag or positions outside the design of eye point. Additionally, not every VR device and virtual environment holds the same risk of triggering cybersickness [18].

Considering the perception of the virtual environment itself, susceptibility to cybersickness may also vary if the position of the user in the imagery is not at the design eyepoint. Every virtual scene has a viewing region in which the user perceives the imagery best. The optimal viewing position is called the "design eyepoint". As the user moves away from this center, the perception of imagery becomes more and more distorted until the imagery is totally imperceptible. Perceiving those distorted visual keys may induce symptoms of cybersickness [19].

Military research suggests that watching other people interacting with the virtual environment is more likely to trigger cybersickness than controlling the input by oneself [19]. Probably, movements and interaction results can be more easily anticipated when interacting directly with a virtual environment [19, 20]. This is even more relevant when interactions might be unexpected, e.g. in flight simulators with advisors and trainee pilots [19].

In order to reduce as much as possible the risk of cybersickness due to such technical factors, the application used in the study locates the user right in the design of the eye point. Since only one user interacts with the application, unanticipated interactions are eliminated.

3 Research Framework and Hypotheses Development

VR is receiving increasing attention and thus more effort is being put into the development of new gadgets and applications [21–24]. The main aim of these is to offer new and more realistic experiences and interactions in a virtual world. To become a successful and widely used technology (like for example smartphones), the acceptance of users is essential. Not only for VR, but for any other kind of information technology (IT) several criteria need to be satisfied to gain user acceptance. The "Technology Acceptance Model" (TAM) combines these factors and predicts the individual adoption and usage of ITs [25]. This study examines the effects of SBVRs on the user's well-being and its research hypotheses are derived from the criteria for user acceptance of TAM 3 [26]. In TAM 3 several additional determinants were developed, which refer to perceptions based on the general beliefs of an individual regarding computers and their usage [27]. The relevant factors of the TAM 3 examined in this study are described in the following sections.

3.1 Perceived Challenge

The construct of *perceived challenge* is based on a combination of various different factors, all posing possible risks to maintaining an enjoyable virtual product experience for a user. For instance, a feeling of anxiety or a lack of confidence in one's own capabilities of using VR systems can prevent a user from having a pleasant virtual product experience [28].

Other reasons for not having an enjoyable virtual product experience may be excessive effort to clearly perceive the VR imagery due to visual limitations, or high cognitive effort to understand a task in general. Additionally, unfamiliarity with the functionalities of VR technology is another common reason, as well as task-specific factors such as time constraints or bad visibility conditions. As the theory of postural instability states, if users are not familiar with moving in virtual environments, they may feel unable to maintain postural control, which triggers *cybersickness*. Therefore, the research hypothesis to be verified is as follows:

H_1: The challenge perceived by the user while using a VR product presentation has a positive influence on the occurrence of cybersickness

In addition, we suggest that the *perceived challenge* influences not only the occurrence of *cybersickness*, but also the *perceived enjoyment* of a VR product presentation. If the *perceived challenge* is caused by physical factors, such as blurred imagery due to visual limitations, unintuitive control or complex functionalities, this is an unpleasant experience for the user. We therefore assume that tasks giving users the feeling of being overstrained will have a negative impact on their *perceived enjoyment*. In view of this, the hypothesis to be examined is as follows:

H_2: The challenge perceived by the user while using a VR product presentation has a negative influence on the perceived enjoyment of such an application

3.2 VR Anxiety

VR anxiety describes the apprehension or even a sort of fear which arises when facing the possibility of using a VR System. As previous research has shown, this apprehension regarding computer systems may arise from unknown developments and their underlying processes, or a lack of detailed introduction to a new technology or bad early experiences with it [26]. Since SBVRs is a very new marketing tool for virtual product presentation, most customers know little about the development and underlying processes of this new technology. Rather, an SBVR looks very futuristic for the customer in comparison to traditional digital devices (e.g. laptop, desktop, tablet) and is thus reminiscent of science fiction. Therefore, we assume that if a general apprehension in using such futuristic systems exists, these feelings are also transferred to technologies using virtual environments. Accordingly, we assume in this study that if users are afraid of using a SBVR, they could perceive the actual use of a SBVR as demanding. Consequently, the research hypothesis to be verified is as follows:

H_3: The users VR anxiety about using a VR product presentation has a positive influence on the challenge perceived by the user while using such an application

3.3 VR Self-efficacy

VR self-efficacy refers to the control belief of an individual during the usage of a VR system [27]. The belief that one does or does not have control over a system depends on personal judgment of one's own capabilities in interacting with it. Users who are not confident about successfully performing a given task using VR technologies perceive the task as very challenging or complex. If users believe they are able to perform a specific task using a specific computer system, their self-efficacy is strong, and they will not have the feeling of being confronted with a challenging problem. Therefore, the research hypothesis to be verified is as follows:

H_4: The users VR self-efficacy regarding using a VR product presentation has a negative influence on the challenge perceived by the user while using such an application

3.4 Perceived Enjoyment

The construct of *perceived enjoyment* describes the intrinsic motivation of an individual to use a system independent of any performance benefits, just because the use of the system generates enjoyment [29]. Within the scope of this study, the construct of *perceived enjoyment* quantifies whether and to what extent the VR product presentation provides the user with enjoyment or pleasure. It thus reflects the hedonistic perspective of the system experience [30].

The unique visualization options in SBVRs open up a completely new form of product presentation (e.g., hotels, automobiles). Due to the immersive experience, users feel that they actually are in another world. In this artificially created world, users can independently explore the virtual environment in a natural way, to get an impression of the offered product. For instance, the detailed and realistic presentation of a travel accommodation creates a unique, immersive and interactive product experience, whereby the feelings of fun and pleasure for the customer may be stimulated. As previous research shows, vivid three-dimensional product presentations and the possibility of direct interactions with the product are important factors that increase the *perceived enjoyment* of the potential customer [31–33].

In addition, several studies have revealed that *perceived enjoyment* has a negative effect on the occurrence of simulator sickness [34, 35]. As the researchers argue, users suppress symptoms of simulator sickness when they enjoy the virtual environment.

Consequently, users are more willing to experience a degree of these negative symptoms if the virtual experience is related to pleasure, enjoyment and fun. The users' perception is thus outweighed by the feeling of enjoyment, which reduces the occurrence of *cybersickness*. In view of this, the hypothesis to be examined is as follows:

H_5: *The perceived enjoyment by the user while using a VR product presentation has a negative influence on the occurrence of cybersickness*

3.5 Curiosity

Curiosity is defined as *"a desire to know, to see, or to experience that motivates exploratory behavior directed towards the acquisition of new information"* [36, p. 793]. *Curiosity* thus represents the intrinsic expectation of the user that the acquisition of additional information is a joy [36]. Furthermore, *curiosity* is one of the central factor, which is frequently used in behavioral research to explain the intrinsically motivated usage of technology [37, 38].

As previous research shows [36, 39–41], the intrinsically motivated *curiosity* is responsible for the development of *perceived enjoyment*. Rouibah argues in his study on the use of instant messaging services, that the *perceived enjoyment* of direct online-based communication is not the result of the conversation itself, but rather the intrinsic motivation of learning something new about the communication partner [39].

This intrinsic desire to discover, to see or to experience something new could be stimulated by the immersive experience of an SBVR. With the innovative visualization and interaction possibilities of this technology, the virtual world becomes an impressive interactive experience, which continuously stimulates the user′s *curiosity*. In the current study, *curiosity* is created by both well prepared contents and technology that triggers the 'wow' effect. The panoramic images of the hotel resort show the most beautiful views of the complex and convey a relaxing, quiet, clean and modern atmosphere. On the technological side, curiosity is created by offering several locations in the hotel complex that can be visited by the user. These movement possibilities make the users curious to explore the available locations in the hotel further. Thus, the acquisition of new knowledge becomes an entertaining experience for the users. Accordingly, the hypothesis to be verified is as follows:

H_6: *The curiosity aroused in the user through a VR product presentation has a positive influence on the user's perceived enjoyment of such an application*

3.6 Telepresence

Telepresence describes the subjective perception of users as to what extent the physical reality is wholly or partly substituted by the VR [42–44]. Thus, the *telepresence* reflects the perceived feeling of users of being more in the VR than in the physical reality [44, 45]. The more immersive the design of a VR product presentation, the more users feel isolated from the physical world [46]. By this decoupling the immersion of users is further strengthened, until they feel they totally belong to the virtual world. As previous research has revealed, this immersive feeling of being there could enhance *perceived enjoyment*. In the context of virtual changing rooms the findings indicate that while using a virtual changing room, users escape into a fictional world, which gives them pleasure and thus increases the *perceived enjoyment* [47].

Such fictional worlds can be created with SBVR. By using 360-degree panoramic images, an extraordinary user experience is created in which users immerse themselves in an unknown world. In addition, the natural interaction with the virtual world increases the degree of immersion. This gives users the intense feeling of being there. Wherever users turn their heads, they can see another aspect of the virtual product, which provides a strong feeling of immersion and can increase the *perceived enjoyment* of the virtual product presentation. The research hypothesis to be verified is as follows (Fig. 1):

H_7: The feeling of telepresence provided to the user by a VR product presentation has a positive influence on the user's perceived enjoyment of such an application

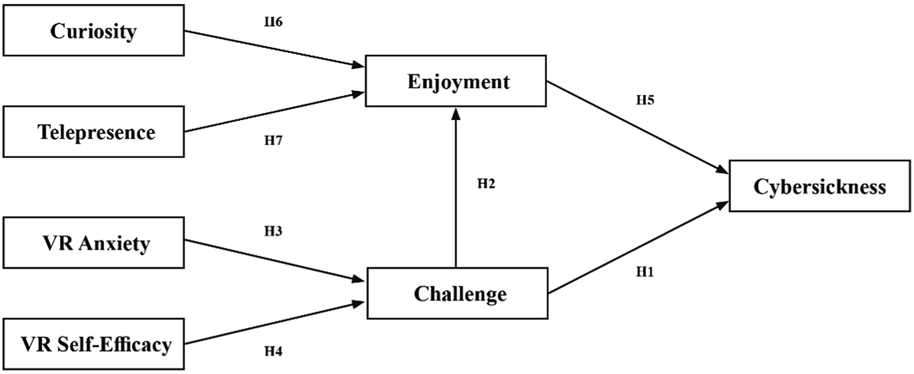

Fig. 1. Conceptual research framework.

4 Study

4.1 Study Participants

In total, 569 questionnaires were collected. After the elimination of 36 questionnaires, which were incomplete, a total of 533 questionnaires were used for the analysis. Table 1 indicates that of the 533 participants 44.8% were female. Over 94% of the respondents were familiar with the term 'virtual reality' and around 50% of them already used VR. A large group of our study participants, almost 60%, were students between 20 and 29 years old. About 25% of the participants were between 30 and 49 years old and working as employees (33.2%).

Table 1. Characteristics of respondents (n = 533).

Characteristics		Frequency	Percentage (%)
Gender	Female	239	44.8
	Male	294	55.2
Age	Under 20	21	3.9
	20–29	321	60.2
	30–39	89	16.7
	40–49	41	7.7
	50–59	33	6.2
	60+	28	5.3
Profession	Student	324	60.8
	Employee	177	33.2
	Pensioner	17	3.2
	Others	15	2.8
Smartphone owner	Yes	525	98.5
	No	8	1.5
Familiar with term “virtual reality”	Yes	503	94.4
	No	30	5.6
Virtual reality used	Yes	273	51.2
	No	260	48.8

For the analysis of the proposed model, we used structural equation modeling. Especially in the context of new technologies like VR and for modeling latent variables the Partial Least Squares (PLS) approach is well suited [48]. In addition, PLS has proven to be suitable for modeling structural equations, exploring the structure of existing theories, and identifying the dominant constructs of a model. [49]. Therefore, the model estimation was performed with SmartPLS 3.2.6 [50].

4.2 Task: VR Product Presentation

Since SBVRs are a new technology we could not assume that all the study participants were familiar with the technology and thus able to evaluate it. Therefore, it was necessary to provide a VR product presentation to familiarize them with the technology. The self-developed application contains 43 professional 360-degree panorama photographs of a hotel in Greece. It allows users to virtually explore the hotel by navigating via hotspots to certain points of interest such as the wellness area, the beach and the lobby. In addition, an extra menu was implemented that could be displayed if the user looks downwards, for a certain amount of time. From a technical point of view, the application consists of the above described photographs which were exported using the 3D visualization software Unity and the Oculus Rift Application Programming Interface for the Samsung Galaxy S7 (Fig. 2).

Fig. 2. Screenshot from VR product presentation.

4.3 Operationalization

The constructs of the research model were operationalized on the basis of established items that were adapted to our study design. While standards such as age, gender, travel habits and prior experience with VR are incorporated, we also examine the effects of VR exposure on users. The questionnaire consists of 28 statements, covering the following factors: *perceived challenge*, *curiosity*, *perceived enjoyment*, *cybersickness*, *telepresence*, *VR anxiety* and *VR self-efficacy*.

The participants rate each statement on a Likert-scale, where seven signals ‘I strongly agree’ and one means ‘I strongly disagree’. The construct *perceived challenge* (four items) is based on the scale of Novak et al. [51]. Three items from Agarwal and Karahanna were adapted to measure *curiosity* [37]. The construct of *perceived enjoyment* comprises six items, derived from Childers et al. [52]. Four items from the scale of Kennedy et al. were used for the operationalization of the *cybersickness* construct [53]. The construct of *telepresence* was operationalized using three items from Klein [42]. Four items from Venkatesh and Bala were adapted for the measurement of the construct *VR anxiety* [26]. Also, the construct *VR self-efficacy* based on the scale of Venkatesh was queried by four items [27].

4.4 Data Collection and Design of the Study

In preparation for the recruitment of the study participants, we developed a website containing important information on the study. This also helped us to coordinate the appointments. The recruitment was carried out in two steps. Firstly, a personalized invitation was sent by e-mail to all students to draw attention to the study. In total, about 4,000 students were approached. In addition, we personally contacted companies and organizations by telephone. In consequence, 235 employees agreed to participate in the research. The study was conducted from November 2016 to February 2017 in a laboratory where all subjects could move freely. During the study, 569 users participated: 334 students and 235 non-students.

Fig. 3. Design of the study.

The study was conducted in four major steps (Fig. 3): we started the research by showing the participants a self-produced introductory video that explained the aim of the study. In a second step an initial short questionnaire was handed to the participants asking for their travel habits and some sociodemographic information such as gender, age and occupation. It was also important in this step to ask them about their experience with VR before they actually used the VR device. At the beginning of the third phase, the subjects were given the VR glasses to watch a demonstration video. After the demonstration, an audio playback started, in which the scenario was described: the participants had to imagine that they were planning a two-week all-inclusive trip and they had the chance to get an impression of a hotel by using a VR product presentation. To make sure that the participants actively used the application we gave them a small task. The task was to find out what color the chairs at the beach were. The participants had 10 min to explore the VR product presentation. Finally, a second questionnaire was given to the participants that aimed to assess the VR product presentation of the hotel. To ensure anonymity, both questionnaires were put into a sealed envelope on completion.

5 Results

5.1 Assessment of the Measurement Model

The assessment of the measurement model included the evaluation of the internal consistency reliability, convergence validity, and discriminant validity [49]. For internal consistency, typically the Cronbach's alpha coefficient (α) is calculated. Following Nunnally´s recommendation of a minimum value of 0.7 all factors fulfilled this requirement [54]. In addition, an assessment of the composite reliability (ρc) and the Dijkstra-Henseler's coefficient (ρA) was performed [55]. Again, all values were above the required minimum values for the respective criteria. Therefore, the internal consistency was given.

Table 2. Validity and reliability of the constructs.

Construct and items	Loading	α	ρA	ρc	AVE
Criteria	> 0.7	> 0.7	> 0.7	> 0.7	> 0.5
Challenge (CHAL)		0.736	0.781	0.826	0.544
Using the virtual reality application …					
was a challenge for me	0.702				
was exhausting for me	0.771				
was demanding for me	0.814				
challenges me to perform the best of my ability	0.653				
Curiosity (CURI)		0.858	0.871	0.914	0.780
The virtual tour …					
excites my curiosity	0.914				
arouses my imagination	0.801				
makes me curious	0.930				
Enjoyment (ENJ)		0.908	0.921	0.929	0.688
Using the virtual reality application …					
is fun	0.867				
is enjoyable	0.899				
is pleasant	0.905				
is entertaining	0.771				
is boring[a]	0.738				
is exciting	0.780				
Cybersickness (CSICK)		0.852	0.880	0.899	0.691
While I was using the virtual reality application,…					
I had a queasy feeling in my stomach	0.784				
I got nauseous	0.820				
I got vertigo	0.828				
I had an uncomfortable feeling	0.890				

(*continued*)

Table 2. (*continued*)

Construct and items	Loading	α	ρA	ρc	AVE
Telepresence (TELE)		0.810	0.822	0.888	0.727
While I was using the virtual reality application, I felt as if I were in another world	0.768				
Through the virtual simulation I had the feeling of really experiencing the situation	0.884				
When I navigated through the virtual world, I felt I was in a different place	0.899				
VR anxiety (VRANX)		0.906	0.911	0.934	0.781
If I imagine having to use virtual reality glasses,…					
it scares me	0.876				
it makes me nervous	0.827				
it makes me uncomfortable	0.934				
it makes me uneasy	0.895				
VR self-efficacy (VRSE)		0.864	0.876	0.908	0.711
I would dare to use virtual reality glasses…					
if I had only the manual for reference	0.761				
if I had seen someone else using it before trying it myself	0.892				
if someone showed me how to do it first	0.882				
if I had enough time to become familiar with virtual reality glasses	0.832				

[a] Reverse coded.

In a second step, the convergence validity of the measurement model was examined by the outer factor loadings and the average variance extracted. The outer factor loadings of the assigned indicators should exceed 0.7 [49]. Almost all items fulfilled this requirement, which is visualized in detail in Table 2. Only one item of the construct challenge had a lower outer loading. In this regard, we investigated whether the elimination of this indicator leads to an increase in composite reliability. This was not the case, so the indicator was maintained as it increased internal consistency and contributes to content validity [49]. After the examination of the outer loadings the average variance (AVE) was determined. As shown in Table 3, the minimum requirement of 0.5 was met by all factors [48]. Consequently, convergence validity was confirmed by both outer factor loadings and the average variance.

To assess discriminant validity the Fornell-Larcker criterion was used [56]. According to the Fornell-Larcker criterion the average variance of a construct must be

Table 3. Squared-inter-correlations between constructs (AVE shown in bold on diagonal) and $HTMT_{.85}$ criterion (gray).

	CHAL	CURI	ENJ	CSICK	TELE	VRANX	VRSE
CHAL	**0.544**	0.185	0.265	0.452	0.136	0.410	0.078
CURI	0.030	**0.780**	0.782	0.229	0.570	0.209	0.237
ENJ	0.064	0.484	**0.688**	0.275	0.557	0.295	0.218
CSICK	0.176	0.040	0.066	**0.691**	0.085	0.275	0.036
TELE	0.006	0.225	0.228	0.004	**0.727**	0.111	0.128
VRANX	0.116	0.035	0.077	0.061	0.008	**0.781**	0.141
VRSE	0.004	0.042	0.038	0.000	0.011	0.014	**0.711**

higher than the squared inter-correlations between the constructs. From Table 3 we can observe that the criterion was met by all constructs. We also used the heterotrait-monotrait (HTMT) ratio of correlations to verify discriminant validity. Taking the more conservative value $HTMT_{.85}$ the results in Table 3 show that the discriminant validity of the measurement model was also confirmed by the HTMT method since all results are below the threshold value of 0.85 [57].

5.2 Assessment of the Structural Model

Several measures are suggested to assess the structural model. In a first step we used the coefficient of determination (R^2) [49]. According to Cohen the proportion of the explained variance is considered as small from 0.02, as medium from 0.13, and as large from 0.26 [58]. Figure 4 shows that all endogenous variables had medium and large values. Besides the coefficient of determination, the predictive relevance (Q^2) of the structural model was assessed with the Stone-Geisser test [59, 60]. The Stone-Geisser makes it possible to determine whether the established model is suitable for the reconstruction of empirical data ($Q^2 > 0$) [61]. The Stone-Geisser criterion was met by all endogenous variables (Fig. 4). Finally, the structural model was assessed by using the standardized root mean square residual (SRMR) value. The model fit can be

Table 4. Results of hypothesis testing.

	Relationships	Path coefficient	CI (Bias Corrected)	t-Value	p-Value	Supported
H1	CHAL → CSICK	0.402***	[0.282, 0.471]	7.844	0.000	Yes
H2	CHAL → ENJ	–0.138***	[–0.214, –0.068]	3.695	0.000	Yes
H3	VRANX → CHAL	0.338***	[0.237, 0.442]	6.239	0.000	Yes
H4	VRSE → CHAL	–0.021	[–0.081, 0.120]	0.478	0.633	No
H5	ENJ → CSICK	–0.161***	[–0.270, –0.070]	3.204	0.000	Yes
H6	CURI → ENJ	0.582***	[0.481, 0.669]	12.102	0.000	Yes
H7	TELE → ENJ	0.191***	[0.120, 0.269]	5.075	0.000	Yes

Note: *** $p < 0.001$.

confirmed if values are below 0.08 [48, 49]. For our model the SRMR had a value of 0.06, so the requirements were fulfilled.

In order to examine the research hypotheses a analysis of the path coefficients was conducted. However, the significance of the respective paths is verified by using the bootstrapping method (5,000 subgroups). The results showed that six of the seven proposed relationships were highly significant. (Table 4). The factors *curiosity* and *telepresence* both had a positive influence on the *perceived enjoyment* with an SBVR (β = 0.582***; β = 0.191***). *Perceived enjoyment* was on the other hand negatively influenced by the factor *perceived challenge* (β = –0.138***). The results also showed that *perceived enjoyment* significantly reduced *cybersickness* (β = –0.161***), while *perceived challenge*s increased *cybersickness* (β = 0.402***). Additionally, we found a significant effect of *VR anxiety* on the *perceived challenge* associated with using the SBVR (β = 0.338***). Only the proposed relationship between *VR self-efficacy* and *perceived challenge* (β = –0.021) could not be confirmed.

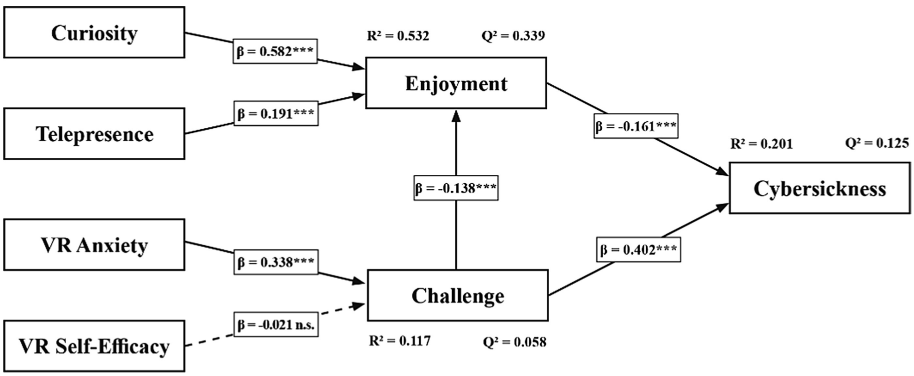

Fig. 4. PLS results of the structural model.

6 Discussion and Recommendations for VR Product Presentations

Cybersickness can be a large obstacle to a successful application of VR product presentations. If users start feeling sick while navigating in a virtual world, their excitement obviously decreases, and it is likely that the customers' satisfaction with an innovative product experience decreases likewise. According to the results of this study, retailers need to design VR product presentations with low user requirements. The main reason for this is that demanding VR product presentations significantly increase the occurrence of *cybersickness* (ß = 0.402***). Furthermore, a high level of *perceived challenge* significantly decreases the *perceived enjoyment* of a virtual world (ß = –0.138***). These two impacts make *perceived challenge* the most important factor that needs to be regulated in order to create a VR product presentation with a low risk of triggering *cybersickness*.

The *perceived challenge* of a VR product presentation describes the level of difficulty when dealing with it. There are several factors that enhance the *perceived challenge*, such as an unintuitive control, complex functionalities, or anxiety. Customers who are not technophiles might have concerns about using new technology: they do not know how the systems work and are reluctant to use them. In particular, for innovative technology, such as VR, a fear of the unknown virtual world quickly arises. This *VR anxiety*, results in a significant increase of the *perceived challenge* of VR product presentations (ß = 0.338***).

On the other hand, the findings suggest that *VR self-efficacy* has no impact on the *perceived challenge*. Apparently, even a poor evaluation of a user's own capabilities does not increase the *perceived challenge* of a VR product presentation. This is an advantage for retailers offering VR product presentations in non-technical areas: even unexperienced customers can enjoy the full benefits of an exciting, interactive product experience.

However, the *perceived challenge* of a VR product presentation does not only increase the occurrence of *cybersickness* – it also affects the *perceived enjoyment* of the application (ß = –0.138***), which itself has the potential to reduce *cybersickness*. A high level of *perceived challenge* obviously decreases the *perceived enjoyment*. The feeling of being challenged too much, or even being overstrained, enhances frustration and clearly reduces fun. If customers get the feeling of not being able to manage the requirements of a VR product presentation, they will stop using it. This impact of *perceived challenge* on *perceived enjoyment* further strengthens the design recommendation for retailers to focus on a low-level challenging virtual product presentation.

Furthermore, increased *perceived enjoyment* reduces the occurrence of *cybersickness* (ß = –0.161***). The more enjoyable a VR product presentation is, the fewer symptoms of cybersickness occur. A reason for this might be that if the interaction with the virtual world is fun, users pay less attention to distracting details. The focus lies on the content, the acquisition of information and the interaction with the environment, which pushes technical inaccuracies into the background. In order to create an exciting "wow" effect for customers, *curiosity* (ß = 0.582***) and *telepresence* (ß = 0.191***) are crucial factors.

A VR product presentation, which creates *curiosity* about the product and makes the consumers feel present in the virtual world, enhances the subjective *perceived enjoyment* most effectively (ß = 0.582***). For some customers, innovative technology itself is the basic motivation to test the application. The crucial aspect for retailers is then to pick up on this curiosity and stimulate it further. The VR product presentation needs to present the product in an interesting way. For example, a virtual customization in real-time (e.g. by changing the color of a product or adding optional functionalities), or the possibility to explore details of the product, might encourage customer *curiosity*. If the intrinsic wish of acquiring as much information about a product as possible (*curiosity*) is successfully created, the customer feels entertained while using the VR product presentation and enjoys the innovative experience.

The *perceived enjoyment* can be enhanced even further if an immersive *(telepresence)* virtual environment is offered (ß = 0.191***). The more immersion users feel in a virtual world, the more fascinated they are and the more enjoyable and interesting the experience becomes. If interactions with the virtual product feel real, customers create positive memories, which typically will support a purchase decision.

7 Conclusion

In the current study, we created a conceptual research framework which describes the relationships between the factors influencing cybersickness. The relationships of the different factors were evaluated in a study with 533 participants. At first, all participants watched a self-produced introductory video that explained the aim of the study. In a second step a short questionnaire was used to collect the participants' travel habits, sociodemographic information and their experience with VR. After completing the first questionnaire the subjects were given 10 min to explore the virtual tour in a hotel resort using 43 professional 360-degree panoramic images. Finally, a second questionnaire assessed the VR product presentation.

As a result, it turned out that six out of the seven relationships in question had significant positive and negative effects on each other. *Perceived challenge* was the most important factor to cope with: a highly challenging application increases *cybersickness* and reduces *perceived enjoyment*. *Perceived challenge* can be enhanced by *VR anxiety* but is not affected by *VR self-efficacy*. *Curiosity* and *telepresence* both support *perceived enjoyment* significantly, which itself significantly reduces the occurrence of *cybersickness*.

We conclude that the findings generally support the positive effect of a virtual product presentation on consumers. This unfamiliar experience poses challenges, which can reduce the fun of using the VR product presentation and increases the occurrence of cybersickness.

Using the results of this study, some basic recommendations for developing a successful VR application can be deduced. VR developers in general and e-commerce retailers in particular should pay special attention to the two influencing factors of *perceived challenge* and *perceived enjoyment*. It is crucial to keep the recommended order of: first reduce *perceived challenge* in the VR application and then enhance *perceived enjoyment*. Since *perceived challenge* has effects on *cybersickness* and *perceived enjoyment*, it is also important to reduce the risk of *cybersickness* as much as possible and then make use of the additional, beneficial impact of *perceived enjoyment*. If these recommendations are taken into account carefully, the VR product presentation for marketing purposes can be beneficial for retailers and consumers alike. Whereas consumers enjoy a new and exciting product experience, retailers earn the benefits of this innovation via positive purchase decisions.

7.1 Limitations and Future Research

In the present study, a conceptual research model was developed in which important factors were identified that both increase and decrease the occurrence of *cybersickness*. Although this study provides important academic and practical insights into the occurrence of *cybersickness*, the findings are subject to several limitations that may be investigated in future research.

While our study had a large sample size, one limitation is that all participants had a similar cultural background. Future research results conducted with participants from other cultures may therefore differ from the results of this study. In particular, cultural differences in technology affinity may have an influence on the occurrence of cybersickness and should therefore be investigated in further studies.

Furthermore, the sample included a large proportion of participants under the age of 30. Through a more homogeneous distribution of the study participants among the different age groups, age-specific differences could be identified in future studies, which would contribute to a more general understanding of the occurrence of cybersickness in VR applications.

Due to the central role of the *perceived challenge* for the occurrence of *cybersickness*, this factor should be further specified in future studies. In this respect, it would be interesting to investigate to what extent technology-related features of SBVRs (e.g. display resolution, usability, wearing comfort) influence the *perceived challenge* for users.

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