Reducing Cybersickness: The Role of Wearing Comfort and Ease of Use

Kai Israel [a], Christopher Zerres [a], Dieter K. Tscheulin [b]
[a] *University of Applied Sciences Offenburg, Department of Media and Information, Badstraße 24, 77652 Offenburg, Germany, kai.israel@hs-offenburg.de*
[b] *University of Freiburg, Department of Business Administration, Platz der Alten Synagoge, 79085 Freiburg, Germany*

Abstract: The paper focuses on how wearing comfort and ease of use of smartphone-based head-mounted displays can minimize the occurrence of cybersickness.
OCIS codes: (000.2700) General Science; (330.1400) Vision - binocular and stereopsis; (330.4150) Motion detection

1. Introduction

The unique visualization possibilities of virtual reality technologies are used more and more frequently for direct customer communication. Due to the increasing distribution of suitable end devices in the consumer field, a large number of different systems are available that enable the user to access virtual reality. Smartphone-based virtual reality systems are among the most common solutions currently available on the market [1].

An important factor that affects the user experience of technologies is their perceived ease of use. Ergonomic aspects are of crucial importance for smartphone-based head-mounted displays (SBHMDs) [2, 3]. Another special feature of virtual environments is cybersickness, which can occur during the use of virtual reality applications [3]. The aim of the present study is to investigate the effect on cybersickness of the perceived ease of use and the perceived wearing comfort of SBHMDs.

2. Conceptual Framework

The construct of perceived ease of use represents “the degree to which a person believes that using a particular system would be free of effort” [4]. The perceived comfort describes the feeling of how comfortable the individual feels when wearing the SBHMD. The term ‘cybersickness’ encompasses symptoms of dizziness, nausea and general discomfort which are caused by the use of SBHMDs.

In general, portable wearables should be comfortable to wear. For SBHMDs, the perceived wearing comfort is a particularly important factor because the user wears such a device directly on his head. From an ergonomic perspective, SBHMDs must be optimally adapted to the user [3]. In this context, we assume that the perceived wearing comfort improves the natural interaction with SBHMDs, which positively affects the perceived ease of use.

H1: A positive perceived wearing comfort of an SBHMD has a positive effect on the perceived ease of use

Another relationship which we assume is between the perceived wearing comfort and the occurrence of cybersickness. If the user perceives the wearing of an SBHMD as disruptive, this negative feeling may provoke the occurrence of cybersickness. In particular, the weight or head strap of the device could affect the user during use [5]. On the other hand, an ergonomically designed SBHMD can also help reduce cybersickness. Potential interference (e. g. pressure on the nose) can be eliminated if the SBHMD corresponds to the individual ergonomic requirements of the user. This leads to a reduction of cybersickness.

H2: Greater perceived wearing comfort of an SBHMD leads to less cybersickness

Direct interaction with the virtual reality application is another way to avoid the occurrence of cybersickness. The replication of familiar motion sequences is of particular importance for good usability [3,6]. Any user interaction should result in a predictable response from the application [7]. The easier the application can be used, the less likely it is that signs of cybersickness will occur.

H3: Greater perceived ease of use of an SBHMD leads to less cybersickness

3. Method and Results

For the study, a self-developed virtual reality application for the Samsung Gear VR was used. In this virtual reality application, the participants were asked to explore a hotel (Figure 1). After the participants had gained an impression of the hotel, a questionnaire was distributed to them. The questionnaire contained questions on the perceived ease of use (3 items), the perceived wearing comfort (5 items) and cybersickness (4 items) measured with a 7-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (7). In sum, a total of 561 valid questionnaires were collected. Based on this data, a structural equation model was developed using the PLS-SEM method. For the evaluation of the measurement model, the internal consistency reliability, convergent validity and discriminant validity were used. All values were above the required minimum values of the respective criteria.

Figure 1: Example picture of the virtual reality application

In the next step, the path coefficients of the structural model were calculated by the PLS algorithm. The significance of the hypothetical relations was assessed by the bootstrapping method (5,000 sub-samples). Based on the results of these calculations we were able to verify all three hypotheses (Table 1).

Table 1: Results of hypothesis testing

Hypothesis	Relationships	Path coefficient	Confidence Interval (Bias Corrected)	t-Value	p-Value	Supported
H1	Wearing Comfort → Ease of use	0.284	[0.199, 0.367]	6.595	0.000	Yes
H2	Wearing Comfort → Cybersickness	-0.251	[-0.333, -0.160]	5.635	0.000	Yes
H3	Ease of use → Cybersickness	-0.204	[-0.293, -0.109]	4.341	0.000	Yes

4. Conclusion

Our study shows that the perceived ease of use and the perceived wearing comfort reduce cybersickness. In particular, the perceived wearing comfort ($\beta = -0.251$) minimizes the probability that signs of cybersickness will occur during the use of SBHMDs. Accordingly, ergonomic aspects should always be taken into account in the product design of SBHMDs. In addition, our results show that the perceived wearing comfort simplifies the usability ($\beta = 0.284$) of SBHMDs. Good usability of an SBHMD has a direct influence on the occurrence of cybersickness ($\beta = -0.204$). For developers of virtual reality applications, this means that the control of a virtual reality application should be adapted primarily to the natural movements of the user. The user must therefore be immediately able to learn intuitively how to control the application. The avoidance of unexpected system reactions leads to an increase in the perceived ease of use, which can reduce the occurrence of cybersickness.

5. References

[1] H-s. Choi, and S-h. Kim, "A content service deployment plan for metaverse museum exhibitions - Centering on the combination of beacons and HMDs," International Journal of Information Management **37**, 1519–1527 (2017).

[2] K. Bodine, and F. Gemperle, "Effects of Functionality on Perceived Comfort of Wearables," in Seventh IEEE International Symposium on Wearable Computers, 2003. Proceedings (IEEE, 2003), pp. 57–60.

[3] K. M. Stanney, M. Mollaghasemi, L. Reeves, R. Breaux, and D. A. Graeber, "Usability engineering of virtual environments (VEs): Identifying multiple criteria that drive effective VE system design," International Journal of Human-Computer Studies **58**, 447–481 (2003).

[4] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," MIS Quarterly **13**, 319 (1989).

[5] M. Pölönen, "Subjective experiences of watching stereoscopic Avatar and U2 3D in a cinema," Journal of Electronic Imaging **21**, 011006-1-011006-8 (2012).

[6] J. R. Wilson, "Virtual environments applications and applied ergonomics," Applied Ergonomics **30**, 3–9 (1999).

[7] S. Aromaa, and K. Vaananen, "Suitability of virtual prototypes to support human factors/ergonomics evaluation during the design," Applied Ergonomics **56**, 11–18 (2016).