How Perceived Real-World Danger Affects Virtual Reality Experiences

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Abstract. Since current VR system blocks user's view (vision) of the real world as well as all the wires and physical objects around him/her, major VR manufactures such as HTC suggest securing a large space before experiencing the immersive virtual environment. There are possibilities that these "potential danger" elements could induce a negative effect on their virtual reality experiences. Exploring a relationship between user's percieved danger of the real world and immersion in the virtual reality is the main topic of this paper. In particular, we wanted to see the level of perceived danger when a user in the immersive virtual environment encountered a dangerous situation from the objects in the "real world".

Keywords: Virtual reality · Risk perception · Presence · Risk management

1 Introduction

On December 21st, 2017, a 22-year-old man was reported dead while wearing a virtual reality headset. He fell onto a glass table and passed away because of blood loss [1]. This incident was the first one in which a person died in relation to VR headsets. Human injuries were commonly reported while playing virtual reality games such as selfie tennis [2] alone side with damage to controllers or even to players' bodies in VR playing experiences. It is very likely that the users step onto the wires without noticing their existence and hurt themselves.

The idea of "being there" is one initial concept of a virtual reality system [3] but Current virtual reality systems are not capable of delivering a fully immersive experience. With a real-life potential risk being considered, how people's VR experience is affected by this perceived real-world risk is the main focus of this paper.

2 Virtual Reality Systems

With the market for virtual reality growing as much as $33.9 billion in the next several years [4], various high-fidelity immersive virtual reality platforms are available to consumers, such as Oculus Rift and HTC VIVE. An increasing number of people are using virtual reality headsets to teach, learn and have fun. Virtual reality system creates

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a virtual environment where people can play games, simulate working environments or explore where people might not be able to reach.

One primary goal of virtual reality systems is to increase realism. Virtual reality generates a virtual environment which generates the idea of "being there" [3]. The sense of being elsewhere can generate a higher level of immersion which contributes to the simulation process of virtual reality [5]. Virtual reality systems create a higher level of immersion by using higher refresh rate displays (matching human eye) or better tracking devices (to simulate your body movement within the virtual world) [6].

Current virtual reality systems often involve three sensations: visual (Head Mounted Display), auditory (headphones), and tactile (controllers) [7]. These systems aim to enhance the experience of these three sensations and "fooling" people to think that they are elsewhere. With current technology restrictions, it is impossible to provide real-world experiences completely. Therefore, content providers (individuals or organizations) tend to use more engaging content to minimize technology shortcomings.

2.1 Possible Danger Regarding VR HMD Display Systems

"While wearing the VR headset you are blind to the world around you," according to HTC information safety information [9]. Virtual reality headsets block people's view of the outside world to increase realism. Manufacturers use different approaches. One standard solution is to clear a large field. Oculus rift recommends clearing out a play environment and map it within the system. Advanced solutions such as HTC VIVE include front-facing cameras to help identify the objects in real life and generate obstacle signs within the system.

These systems are not without their flaws. The tracking of Oculus Rift is not adapting to real-time changes such as an immediate interrupt by another person or something accidentally enter the playing area. HTC VIVE has only front-facing cameras, and they are not turned on by default which can increase the safety risk during a virtual reality experience.

While the concern of virtual reality generating physical damage to human beings is not being discussed directly, a trend in research of bridging the physical-digital gap between virtual environments and the real world showed the awareness of this topic. Researchers focused on redesigning VR environments to suit the physical world such as redirected walking [10]. Other solutions like pairing real-world objects with virtual counterparts [11] or generating a "Reality skin" [12]. These solutions showed the awareness of potential danger using virtual reality systems. These solutions are excellent for reutilizing objects, but significant brands and companies have not yet adopted them. The danger of physical damage is still present when using virtual reality systems.

3 Literature Review

The idea of virtual reality has been around for 40 years. With the development of computer technology, current immersive virtual reality differs from what a traditional virtual reality or virtual environment. In this chapter, a definition of immersive virtual reality is formed based on previous researches and critical concepts of immersion and presence is explained.

3.1 Definition of Immersive Virtual Reality

Modern virtual reality is mostly treated as a collection of hardware, including computers, head-mounted displays, headphones, and motion-sensing trackers. Steuer [13] argued that this hardware-oriented definition did not provide a conceptual unit of analysis. Based on a hardware collection approach, the virtual reality systems in this paper refer to systems with a high-quality wide field-of-view stereo head-mounted display as well as six degrees of freedom head tracking.

As Steuer [13] described in his article, virtual reality as a concept is referred to every single project of virtual reality experience. Therefore, a virtual reality system should also include content as well. By combining content and hardware, researchers can form a solid definition of virtual reality.

A recent definition of virtual reality came from Pan and Hamilton [14] which is as simple as a "computer-generated world." It covers a critical aspect of this concept which is a computer program that simulates a world that can be presented to people. However, according to this definition, a desktop viewed VR would also be VR [15].

Also, a VR is different in definition to an immersive VR. Immersive virtual reality would be closer to the definition of an immersive virtual environment with a current virtual reality hardware system. An immersive virtual environment is a computer-generated environment which surrounds the user and increase of being within it or sense of presence in particular [16].

A working definition of immersive virtual reality for this paper will be defined as follows:

"An experience generated by computers to surround users and increase their sense of being in the virtual environment using a collection of virtual reality system hardware including a high-quality wide field-of-view stereo head-mounted display and six degrees of freedom head tracking".

3.2 Immersion and Presence

Studies have argued that immersion is a multifaceted concept involving media (medium), users and contexts [17–19]. Early studies treat immersion as a "quantifiable description of a technology" which includes "the extent to which the computer displays are extensive, surrounding, inclusive, vivid and matching" [17]. User "matching" or context relativeness is also important to determine the level of immersion. As "quality of experience" [20], users feel immersed within the VR content based on themselves and social contexts. Based on the definition of an immersive virtual reality experience, feeling immersed is not contributed only by the hardware of the virtual reality, but also the content of this virtual reality. An immersive experience can be judged by its level of immersion as an ongoing procedure [20].

Presence and immersion are strictly mentioned in these studies. Presence is commonly defined as a sense of being in the virtual environment instead of where the people's real body exists [21]. Some scholars treat presence and immersion as a synonymous concept [22] which indicates that adding presence to the concept of immersion is only confusion. Immersion can also be treated as synchronicity of media, user, and contexts where presence is only a human consciousness of being there. Based

on Slater and Wilbur's study [17], presence is a function of user psychology of recognizing being inside a virtual setting while immersion is the quality of this experience.

3.3 Attention

Attention is one of the key concepts in communication theories. As suggested in the LC4MP model [23], people have a limited capacity for information processing. That is to say: Even though people can process several tasks simultaneously, they can only process a certain amount of information at the same time.

The engagement level of the activity also affects this allocation of attention. A higher level of engagement leads to higher level of attentional demand of the task. With high engagement required in VR-based activities, an individual needs more attention allocated in one activity than regular flat screen-based activities [24]. As people pay more attention to the VR-based activities, virtual reality systems have long been used for pain relief in the medical field as a distraction.

Previous studies found that VR is a more useful tool in relieving burn pain, wound care and chronic pain [25–28]. The patients feel less pain during a medical treatment as more of their attention were drawn by the virtual reality experience. Explained by the "gate theory" in the medical field, VR reduces the perceptions of the pain and diverts patients' attention away from the pain by providing visual and audio cues which lower patients' actual feeling of the real world [29]. These studies all treat VR as a distraction source to the real-life experiences. Individuals pay attention to the virtual reality story so that they feel less of the real world.

3.4 Risk Perception

People's judgment about the likelihood of negative things such as injury or illness is called risk perception. This judgment will determine people's actual activity towards that risk or hazards. There are two main dimensions: how much people know about the risk and how they feel about them [30]. In the virtual reality experience, people are not capable of knowing the ongoing risk that is happening in the real world. Therefore, they might rely on their memory of what they have already observed before putting up VR headset. From a psychological point of view, people rely on heuristic cues to assess risk level [31]. Lacking sufficient "data" may lower people's risk perception of the situation [32]. That is to say, if people are not able to obtain such heuristic cue, their risk perception could be affected. However, the people have already formed a risk perception before putting up VR headset. Therefore, how pre-formed risk perception will affect virtual reality experience when people are not able to obtain heuristic cue remain to be studied.

4 Method

This study investigated how being aware of the potential danger in the real-world would affect virtual reality experiences. Thus, this study adopted a between-subject design with two conditions (no real-world objects/with real-world objects) to see whether higher level of perceived danger of falling will affect VR experiences.

The study used a VR HMD along with two level of perceived danger of falling (no danger situation vs. danger situation) in the experiment area. The perceived danger of falling in this study were objects (e.g., paper boxes) lying in the VR setting environment.

Before they put up VR HMD, the subjects were shown the experimental field and they were asked to finish a questionnaire asking their perceived danger of falling. The subjects will then be randomly assigned to two conditions and asked to experience the "room escape" game. While they were playing the content in VR, their behaviors were observed by the researcher especially on interactions with real-world objects such as paper boxes or wires.

After the virtual reality experience, the subjects will be asked to finish a questionnaire measuring a level of presence, attention, and enjoyment while playing the game.

4.1 Measurements

Perceived risk was measured using a seven-point Likert scale developed for this study. Items were used to measure the subject's perceived risk of falling using a VR headset (e.g., How safe do you think of using VR headset in the current environment?).

Presence was measured using a fifteen-item seven-point-Likert scale modified from a presence questionnaire [33]. Items were divided into measuring immersion to the virtual world (e.g., How much were you able to control events in the VR headset?), awareness of the virtual world (e.g., How aware were you of events occurring in the virtual world around you?) and involvement of the virtual world (e.g., How involved were you in the virtual environment experience?).

Attention was measured using five items on a seven-point-Likert scale self-reported attention questionnaire revised from the Situational Self-Awareness Scale [34]. Items were adopted from the original surrounding items and revised to measure virtual environment attention (e.g., "I am keenly aware of everything in the virtual environment," "I am conscious of what was going on in the virtual world").

Enjoyment was measured using the Physical Activity Enjoyment Scale (PACES), adopted from Kendzierski and De Carlo's study [35] with a total item of seventeen.

Subject behavior was observed by the researcher. The amount of times when subjects were concerned about getting trapped by the objects in the real-world was coded. Follow-up questions were asked by the researcher such as "Were you aware of the real-world objects when you do ….".

5 Discussion

The results showed that the subjects in the experimental group reported a higher level of perceived level of danger than the control group. We also see tendencies of subjects reporting a lower level of enjoyment, presence, and attention when their perceived level of danger is high. Based on the strong theory backup, though not sufficient subjects were tested at the current stage of this study, we highly expect a stronger correlation will be found when more subjects were tested. Also, we observed subjects feel less hesitant in the virtual reality environment. Therefore, the memory of the environment could also play a role in this relationship between perceived danger and virtual reality experiences. Further studies will be done to measure the subject's memory of the environment as well as using new biological measurements to test attention to the virtual reality experience.

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