Video Game User Experience: To VR, or Not to VR?

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***Abstract*—Virtual reality (VR) has become an alternative medium for entertainment purposes, ranging from watching a movie to playing video games. Given the increasing use of VR for video gaming, the current study investigated whether VR gaming might affect the video gaming user experience (UX). We compared three different gaming platforms, namely desktop computer, Oculus Rift, and HTC Vive, in terms of gaming UX satisfaction. A total of 48 participants were randomly assigned to one of the three gaming platforms. Participants played a first-person shooter video game for ten minutes and provided game UX satisfaction ratings. Results revealed no statistically significant differences across the three platforms in video game UX satisfaction levels. Participants, however, rated desktop gaming as significantly more usable, when compared to the two VR conditions. In addition, sense of presence was a strong predictor of game UX satisfaction. Taken together, these results indicate that VR gaming may not always be a better alternative to traditional desktop gaming in terms of video game UX satisfaction, while at the same time providing further support for the putative role sense of presence plays in game satisfaction.**

Keywords—VR gaming; virtual reality; video games; gaming experience.

I. Introduction

The advancements in technology throughout the last decade have made the application of virtual reality (VR) a norm. Testing out the latest VR headsets, such as the Oculus Rift or the HTC Vive, can be a fascinating experience. Many consumers of VR technology are primarily interested in the gaming experience. Reports have noted that 30.4 billion dollars had been spent in the video game industry during 2016 [1]. Considering how expensive a VR headset is, a great amount of those billions of dollars could have been spent on VR technology for various platforms, such as desktop computers or Sony PlayStation.

VR is a three-dimensional, computer-generated environment, enriched primarily with graphics, audio, and haptic feedback, which can be explored and interacted with by users. One of the distinguishing features of VR is that users could experience a world that would be deemed completely fictional. These virtual worlds are often referred to as immersive virtual environments (VE), which provide simulated worlds that can engage users in context-relevant behaviors and that can produce a variety of user experiences (UX) depending on the environment they choose [2]. One of the easiest and most accessible ways to experience VR is for the user to wear a head mounted display (HMD), such as the Oculus Rift or HTC Vive.

Along with the Oculus Rift and HTC Vive, a couple other HMDs are available to consumers, including the Samsung Galaxy Gear VR, Google Daydream, and Sony PlayStation VR. Each headset has their perks and gadgets that go along with their purchase. Galaxy Gear VR is most commonly used with smartphones, as it is smaller and more portable. Oculus Rift and HTC Vive are more commonly used with a desktop computer, and Sony PlayStation VR is used with the PlayStation 4 gaming console. The widespread use and adoption of VR technology facilitates the design and development of new video games in novel ways.

A. Factors Affecting Video Game UX

Video game developers are constantly trying to produce video games that are better than the competition. However, what makes a video game "good" or "better" has been a debatable topic, which is also reflected in video game research. Previous studies have investigated various factors affecting video game quality and video game user experience (UX) satisfaction (or enjoyment) [3]. Of these factors, three major constructs shown to directly influence game UX satisfaction are involvement/engagement, immersion, and presence.

1) Involvement

A deep level of involvement/engagement (referred to as involvement hereinafter) is considered to be an indicator of a good game [4]. Witmer and Signer define involvement as a mental state in which attentional resources are allocated to the processing of perceptual stimuli rendered in the VE [5]. An individual's situational interest in a VE determines the extent to which an individual is involved in the environment. Involvement in a game, thus, requires focusing attention on the game environment, and the more the game is perceived to be relatable by the players, the more involved they will be in the game.

2) Immersion and Presence

Immersion has been a rather elusive construct to clearly define [6, 7]. According to Witmer and Signer [5], immersion is a psychological construct concerned with the extent to which individuals feel encapsulated by the VE and perceive themselves as an integrated component of the environment. In this conceptualization, there appears to be a focus on sensory replacement/overriding so that sensory input from the physical environment receives less cognitive processing capacity in the form of attentional allocation than does perceptual stimuli coming from the VE. Thus, immersion is characterized by an attenuation of physical sensory input (coming from the physical environment in which the user is located) and an amplification of virtual sensory input (coming from the VE with which the user is interacting).

Different from Witmer and Signer's [5] subjective approach, Slater et al. take a more objective, technology-centric approach to defining immersion [8]. In Slater et al.'s definition, immersion refers to the objective sensory fidelity of the virtual world provided by a VR system, including how extensive, surrounding, inclusive, vivid and matching the virtual world is. Extensiveness refers to the number of sensory systems (e.g., visual, auditory, haptic, etc.) to which the VE caters. The quality of being surrounding refers to the degree to which sensory cues are presented panoramically, as opposed to using a narrow field of view. Inclusiveness refers to the extent to which users are isolated from their physical reality by overriding perceptual input from the external environment. Vividness refers to the qualitative aspects of the virtual environment, including richness and quality of content presented to the users, resolution, frame rate, etc. Lastly, immersion necessitates a match between proprioceptive feedback, evoked in the physical environment, and the stream of sensory data, produced in the virtual environment.

According to Witmer and Signer [5], presence is a mental state in which an individual feels like they are in an environment other than the one they are physically occupying. Sense of presence in VE involves the experiential phenomenon of being in the virtual world, while being isolated from the physical world. Witmer and Signer postulate that the extent to which users experience a sense of presence in a VE depends on their involvement and immersion in the environment [5]. Based on Witmer and Signer's conceptualization, sense of presence in games necessitates a focus on users identifying with the game character, putting themselves in the character's place, and vicariously experiencing what the character experiences [5]. Feeling present in a game, thus, involves users mentally transporting into the virtual world and temporarily experiencing the game reality as their own reality.

While Slater et al. [8] differ from Witmer and Signer [5] in the operational definition of immersion, which serves a quality attribute of the virtual environment in relation to its sensory fidelity, they define presence in a similar fashion. Specifically, Slater et al.'s definition also capitalizes on the subjective, psychological nature of presence and retains the proposition that it refers to the experiential sense of being in the virtual environment. Considering both schools of thought, Witmer and Signer's [5] definition of immersion seems to blur the distinction between immersion and presence, as both seem to be concerned with the subjective psychological experience of being part of the virtual environment. This can be reconciled by adopting Slater et al.'s [8] definition of immersion in relation to the sensory fidelity of a VE and preserving both school of thoughts' views on presence as a subjective psychological experience in which users no longer perceive their interaction with the VE as a mediated experience and instead the virtual world becomes a reality for them. The current study adopts the synthesis of these two definitions. Regardless of which definition is used for immersion, immersion is thought to directly influence presence, with more immersive environments evoking a greater sense of presence.

It follows from the foregoing discussion that the immersive nature of VR environments, enriched with high-fidelity three-dimensional graphics and increased interactivity, provides a greater level of sensory engagement to users during the gameplay, increasing involvement with the game. As proposed by Witmer and Signer [5], this results in a greater level of immersion in the game environment, increasing users' identification with the virtual character and the virtual world. Increased involvement and increased immersion are the reason why VR environments are expected to enable users to experience increased presence [5, 8-10], which in turn paves the path for a more enjoyable video game UX [6, 11-13].

3) Displays

Another aspect that can affect the gaming experience is the type of display that is used during the gameplay. Differences in displays could play a role in users' enjoyment of video games. From the traditional gaming experience of a desktop computer to the newer HMD VR systems, gaming satisfaction or enjoyment has been a crucial factor. The idea of technology allowing users to feel more immersed and present in their experience could potentially lead to a greater user satisfaction [14]. VR affords users the unique opportunity to actually become the characters in the game, and thus allowing gamers the chance to become fully immersed in the environment.

While VR does have some drawbacks, such as the effect of cybersickness – feelings of motion sickness while interacting with a VE [14, 15] –, it does allow users to feel fully in control of the environment. Since VR offers the unique opportunity to directly interact with one's environment, it is important to understand the difference between a traditional desktop display and HMD (used for VR). A desktop display is the traditional way in which users usually experience videos games, and it is generally a two-dimensional computer screen placed in front of the user [15]. This flat display is the more traditional way to play video games, as the user is able to sit down at their desk and to start playing their preferred games. Since these screens are only two-dimensional, the display cannot be controlled with the user's head motions, as can be done with an HMD. By using both a keyboard and mouse, gamers can navigate within the game environment and interact with their surroundings.

Since HMDs became commercially available, their popularity has increased. HMDs are unique in that users are able to wear their display, which enables them to be more mobile with their display when compared to a desktop display. HMDs also offer the ability to portray different images to each eye, allowing the user to perceive the world in three dimensions and experience a sense of depth within the virtual world (i.e., stereoscopic view) [15]. Additionally, HMDs afford the opportunity to track the user's head position and movement [15]. This tracking ability allows the user to control the perspective of the game by simply moving their head. Taken together, these features offer gamers a more immersive experience, and therefore, could be a contributing factor in the rise of VR gaming to its stardom in the video game industry.

B. VR and Video Game UX

The explosion of VR in gaming brings to light the question of how VR might affect the gaming UX satisfaction. Since VR is more accessible to consumers and a larger portion of games now offer VR support, it is prudent to understand how this technology affects the gaming experience. Does a user enjoy their gaming experience more when using a VR system, compared to a traditional desktop platform? Shelstad et al. tackled this question by comparing game UX satisfaction between desktop and VR gaming [3]. Using a within-subjects design, Shelstad et al. had the same group of participants play a strategy game on both a desktop and VR (Oculus Rift) gaming platform. The authors found support for the notion that VR gaming would lead to a greater game UX satisfaction, when compared to traditional desktop gaming.

The purpose of the current study was to conceptually replicate and expand upon the study of Shelstad et al. [3]. Specifically, we were interested in investigating whether VR gaming experience differed from traditional desktop gaming in UX satisfaction within the context of a first-person shooter (FPS) game. In the current study, participants played an FPS game on three different platforms, namely desktop PC, Oculus Rift, and HTC Vive, and self-reported their sense of presence and satisfaction with the experience. It was predicted that VR gaming platforms would evoke greater presence levels, compared to the desktop gaming platform (Hypothesis 1). It was also predicted that VR gaming platforms would yield greater levels of video game UX satisfaction, relative to the desktop gaming platform (Hypothesis 2).

II. METHOD

A. Design

This study used a between-subjects design with three conditions. The independent variable was the type of gaming platform used by the participant with three levels: the Oculus Rift, HTC Vive, or desktop computer platforms. We chose to employ a between-subjects design because we were interested in comparing game UX satisfaction as a result of first-time exposure to the game across the three conditions. The dependent variables were the subjective sense of presence, measured using the Presence Scale [2], and the level of self-reported game UX satisfaction by the participants, measured using the Game User Experience Satisfaction Scale [4].

B. Participants

Participants were recruited from the undergraduate student population at a Northeastern university in the U.S. A total of 48 participants (24 females), with an average age of 20.6 (SD = 2.28), took part in the study in exchange for extra course credit.

C. Materials

1) Presence Scale

Sense of presence was measured using the Presence Scale [2]. The Presence Scale includes a total of eight items, rated on a 7-point Likert scale. A presence score was computed for each participant by averaging the responses to the eight items. Greater scores in the questionnaire indicated greater sense of presence. The scale demonstrated good reliability in the current study (Cronbach's alpha = .88).

2) Game User Experience Satisfaction Scale

Gaming satisfaction is a multidimensional construct and involves various facets. In the current investigation, gaming satisfaction was measured using the Game User Experience Satisfaction Scale (GUESS), which includes nine dimensions that all contribute to video game satisfaction [4]. These dimensions include Usability/Playability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity, and Visual Aesthetics [4]. GUESS includes a total of 55 items, rated on a 7-point Likert-scale. Given the nature of the FPS game used in the current study, the dimensions of Narratives and Social Connectivity were not applicable, and thus, were excluded from the questionnaire. In line with the scale's scoring guide [4], an average subscale score for each of the remaining seven dimensions was computed, which were then summed up to calculate an overall GUESS score for each participant. The reliability estimate of the GUESS was very good in the current study (Cronbach's alpha = .92).

3) Gaming Platforms

The platforms that were used in this study included a desktop computer (Windows PC) and two VR headsets, Oculus Rift and HTC Vive. Both Oculus Rift and HTC Vive are VR systems that make use of an HMD and keep track of the user's position. Both VR systems also allow the user to control their actions with wireless controllers. For the purpose of this experiment, however, a standard keyboard and mouse were used along with these two VR platforms to match the controllers to those used in the desktop computer condition.

The Oculus Rift headset was first developed in 2012, but it was not until 2016 that the first commercial version was released [2]. With the first model appearing in 2012, Oculus Rift brought about a revitalization of VR technology [2]. While not as old as the Oculus, HTC Vive was developed through a partnership with *Steam*, a gaming company, and HTC [2]. This partnership brought about the development of a VR headset with the main focus being on video games. Given that Oculus Rift was one of the first HMDs to reach consumers and that HTC Vive was developed specifically for gamers, it is important to use these two headsets when investigating how VR might affect the gaming user experience.

4) Video Games

All participants across the three conditions played the same video game, *Serious Sam: The First Encounter*, through *Steam*, an online game platform. Participants in the VR conditions played the VR version of the game [16], while participants in the desktop computer condition played the desktop version of the game [17]. *Serious Sam: The First* Encounter is an FPS game, a game genre in which players interact with the game environment in first-person perspective. The reason for this choice is that FPS games are considered to be more immersive on the grounds that the player, in a way, becomes the game character, controlling and experiencing the game from that character's perspectives [6, 13].

D. Procedure

Upon arrival in the lab, participants were briefed about the study and were presented with an informed consent form. They were then randomly assigned to one of the three conditions, Oculus Rift, HTC Vive, and desktop computer. Depending on their assigned condition, participants were given a short demo as to how to navigate and play the game, using the controllers (keyboard and mouse). Participants were then left alone in the experiment room to play the game for 10 minutes. After the 10-minute gameplay, the experimenter reentered the room and directed the participants to the online questionnaire containing the measures used in the current study, which they, again, completed alone. Once the questionnaire was completed, participants were debriefed and offered the opportunity to ask any questions before concluding the study. The entire experiment was completed in less than 30 minutes.

III. RESULTS

To test the hypotheses that guided the current study, we conducted several descriptive and inferential statistics tests. Table 1 presents a summary of these for each of the dependent variables.

Hypothesis 1 predicted greater presence levels in the VR gaming platforms as measured by the average score on PS, compared to the desktop gaming platform (Figure 1). A one-way analysis of variance (ANOVA) was conducted to examine the effect of gaming platform on average presence ratings. The assumption of homogeneity (equality) of variances, as assessed by Levene's test ($p > .05$) was met. Results revealed no significant effect of experimental condition on the presence ratings, $F(2, 45) = 1.287$, $MSE = 40.14$, $p = .166$, $BF_{01} = 5.8$. These results indicate that, contrary to Hypothesis 1, the three groups did not significantly differ in their sense of presence in the game.

Table 1. Summary of Descriptive and Inferential Tests

	M (*SE*)	*F*	*MSE*
GUESS		1.87	40.14
Desktop PC	35.51 (1.14)		
Oculus Rift	32.31 (2.17)		
HTC Vive	33.49 (1.23)		
Usability/Playability		3.95*	.819
Desktop PC	5.21 (.23)		
Oculus Rift	4.31 (.22)		
HTC Vive	4.78 (.22)		
Play Engrossment		.141	1.48
Desktop PC	5.26 (.29)		
Oculus Rift	5.21 (.38)		
HTC Vive	5.04 (.22)		
Enjoyment		2.04	1.33
Desktop PC	4.91 (.16)		
Oculus Rift	4.19 (.35)		
HTC Vive	4.21 (.32)		
Creative Freedom		.740	1.41
Desktop PC	4.70 (.26)		
Oculus Rift	4.27 (.39)		
HTC Vive	4.24 (.22)		
Audio Aesthetics		1.45	1.59
Desktop PC	5.39 (.27)		
Oculus Rift	4.77 (.40)		
HTC Vive	5.45 (.26)		
Personal Gratification		1.91	1.28
Desktop PC	5.60 (.20)		
Oculus Rift	4.82 (.39)		
HTC Vive	5.17 (.23)		
Visual Aesthetics		1.70	1.87
Desktop PC	5.44 (.24)		
Oculus Rift	4.75 (.42)		
HTC Vive	4.60 (.34)		
Presence		.129	2.06
Desktop PC	3.85 (.43)		
Oculus Rift	3.98 (.38)		
HTC Vive	3.72 (.24)		

* $p < .05$. $n = 16$ in each condition (total $N = 48$).

Hypothesis 2 was that VR gaming platforms would yield greater levels of video game UX satisfaction as measured by the total GUESS score, relative to the desktop gaming platform (Figure 2). A one-way ANOVA was conducted to examine the effect of gaming platform on total GUESS scores. The assumption of homogeneity (equality) of variances, as assessed by Levene's test ($p > .05$) was met. The results of the ANOVA revealed no significant effect of experimental condition on the GUESS scores, $F(2, 45) = 1.287$, $MSE = 40.14$, $p = .166$, $BF_{01} = 1.72$. These results suggest that, contrary to Hypothesis 2, the three groups did not significantly differ in overall video game UX satisfaction levels.

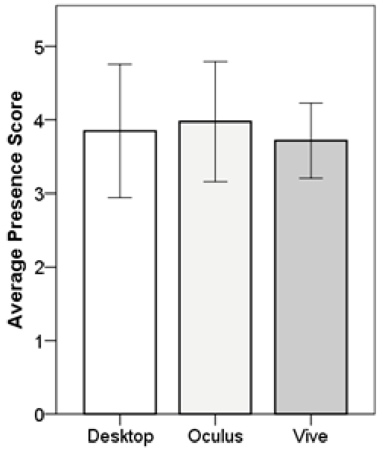

Fig 1. Average presence scores as a function of group. Error bars represent 95% confidence intervals.

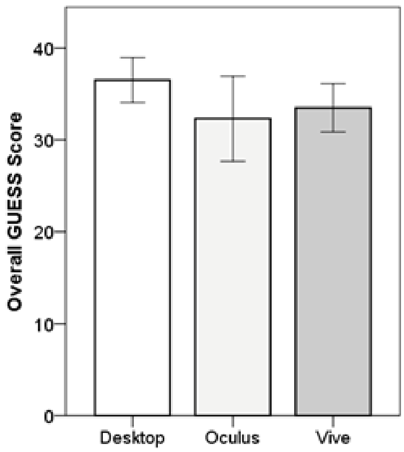

Fig 2. Overall GUESS scores as a function of group. Error bars represent 95% confidence intervals.

To further explore the influence of factors contributing to video game UX satisfaction, we compared the three platforms with respect to the dimensions of video game UX satisfaction included in the GUESS measure. These dimensions were Usability/Playability, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, and Visual Aesthetics.

Regarding the comparison of the three platforms on Usability/Playability scores, results revealed a statistically significant difference among the three gaming platforms, $F(2, 45) = 3.95$, $MSE = .819$, $p < .05$, $\eta^2 = .15$, $\omega^2 = .11$, $BF_{10} = 2.4$. Considering the effect size measures, the amount of variance in the Usability/Playability scores explained by the manipulation of gaming platform was considerably large.

Planned contrasts showed that the Usability/Playability score for the game was greater in the desktop condition, compared to the two VR conditions, $t(45) = 2.40$ $p < .05$ (one-tailed). The Oculus Rift condition and the HTC Vive condition, on the other hand, did not significantly differ from each other in the mean Usability/Playability scores, $t(45) = 1.46$, $p > .05$ (one-tailed). In relation to the rest of the GUESS dimensions, the results of ANOVA (Table 1) revealed no significant differences across the three groups in Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, and Visual Aesthetics.

A hierarchical multiple regression analysis was performed to assess the utility of sense of presence in predicting game UX satisfaction levels, after controlling for the effect of experimental condition. Experimental condition was entered at Step 1, which did not significantly contribute to the model (consistent with the ANOVA results above). After entry of presence scores at Step 2, sense of presence positively predicted (*beta* = .52, $t = 4.16$, $p < .001$) and explained 27% of the variance in game UX satisfaction levels, $F(2, 45) = 9.87$, $p < .001$, $R^2 = .31$, $R^2_{\text{adjusted}} = .27$. This indicates that those players who experienced a greater sense of presence in the game environment were more satisfied with the game UX, providing support for the key role of sense of presence in game enjoyment.

IV. DISCUSSION

The purpose of this study was to conceptually replicate a prior study in the literature [3] by investigating whether VR and traditional desktop gaming differed in video game UX satisfaction. Results showed that, contrary to our hypotheses, playing a video game using a VR headset did not lead to greater video game UX satisfaction scores, compared to playing the same game on a desktop computer. Results also revealed no significant differences in presence levels across the three conditions, indicating participants in the VR conditions reported feeling no greater levels of sense of presence in the game environment than those in the desktop gaming condition.

These results are contradictory to those obtained in the Shelstad et al. study, in which they found that compared to desktop gaming, VR gaming led to a greater level of video game UX satisfaction [3]. While our null findings indicate that we failed to replicate the same effect, the two studies were different in certain aspects that should be considered when interpreting the current results. To begin with, participants in the current study played an FPS game, as opposed to a strategy game. It may be the case that VR gaming is more enjoyable than desktop gaming when playing strategy games, but not when playing an FPS game. One reason for this distinction could be that FPS games are in themselves immersive to the extent that playing them on a VR headset and desktop computer are comparably enjoyable. Future research could compare the effects of different game genres on game UX satisfaction.

Another way in which the current study differed from Shelstad et al.'s study was that our participants played the game using a keyboard and mouse, instead of an Xbox controller, as was used in the Shelstad et al. study [3]. This choice was made to match the controllers used in the VR conditions to those used in the desktop computer condition. Notwithstanding the choice of controller consistency across the three conditions, it could be argued that the use of native, highly-interactive VR input devices, such as Oculus Touch or HTC Vive Controller, is crucial to fully experiencing the immersive gaming experience during the VR gameplay. As a matter of fact, the results showed that participants in the desktop gaming condition found the game significantly more usable than did participants in the VR gaming conditions. This could possibly be due to participants' experience with using a keyboard and mouse to interact with a desktop computer. Also, desktop platforms for gaming have been around for a long time, and thus, they are more mature than VR platforms. There may have been a certain level of familiarity concerning the desktop condition where the participants were used to interacting with a desktop computer and playing games using just the mouse and keyboard. This familiarity factor could have impacted the experience of playing the game in VR using a keyboard and mouse, which could have been perceived to be unnatural by the participants because they were not able to physically see their hands through the VR headset. It is, hence, possible that VR gaming would be perceived to be more enjoyable when such native input devices are used to play the game, which remains an open question for future research into VR gaming experience. Specifically, future studies could be conducted to investigate the interaction effects of gaming platform (e.g., VR vs. desktop gaming) and controllers (e.g., native VR input devices vs. keyboard/mouse) on game UX satisfaction.

In relation to the putative effects of game controllers on presence, Tamborini et al. [10] reported an unexpected trend toward increased presence during traditional desktop gaming, compared to VR gaming. Similar to the current study, Tamborini et al. [10] did not use naturalistic VR controls, indicating that the controllers used to interact with the game might in fact affect presence levels, and thus game satisfaction. That said, Eastin and Griffiths [9] found that presence levels during gameplay were greater when the game was played on a desktop computer compared to when it was played in VR. Unlike the current study and [10], Eastin and Griffiths [9] had participants play the game using a joystick gun, a fairly naturalistic control. Taken together, while it is reasonable to argue that game controllers used in the current study might have affected the results, mixed findings from previous studies highlight the importance of dissecting the interaction effects of game controls and game platforms.

Of note, the current study revealed no significant differences in presence levels across the three conditions. This finding is inconsistent with [2], which revealed a greater sense of presence during an FPS gameplay in the VR gaming condition than in the desktop gaming condition. It is possible that the non-significant difference in presence across the three gaming platforms in the current study may explain the null findings regarding the effects of VR gaming on game UX satisfaction. In fact, the regression analysis revealed that sense of presence significantly positively predicted game UX satisfaction levels and explained a considerable amount of variance in satisfaction levels. This indicates that those players who experienced a greater sense of presence in the game environment were more satisfied with the game UX, providing further evidence for the influence of presence on game satisfaction [6, 10-13].

As pointed out earlier, one limitation of this study was the use of a keyboard and mouse for all conditions, instead of using the native VR controllers in VR conditions. Another limitation was the use of a single FPS game. With various game genres available on the market, future studies could be conducted to determine whether the type of game affects game UX satisfaction. It is also important to note that the current study used self-reported measures of video game UX satisfaction, as is commonly done in the literature, but more and more studies are being conducted to measure satisfaction levels using physiological measures [6, 13, 18]. Further research incorporating physiological measures of video game UX satisfaction in VR is warranted.

On the whole, the current study provided no support for the notion that VR gaming would lead to a greater sense of presence and greater video game UX satisfaction levels, compared to traditional desktop gaming. Taken together, these results indicate that VR gaming may not always be a better alternative to traditional desktop gaming in terms of video game UX satisfaction. Nonetheless, sense of presence was shown to be a strong positive predictor of video game UX satisfaction. Future research is needed to better understand the gaming experience in VR environments and how it might differ, if at all, from traditional desktop gaming.

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