Chapter 20
Immersiveness and Usability in VR: A Comparative Study of *Monstrum* and *Fruit Ninja*

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Abstract VR is a new medium, and standards and techniques for understanding the power of VR are just beginning to be adopted. The aim of this study is to look at the immersive potential of VR games physiologically and perceptually, using the horror game *Monstrum* and the arcade game *Fruit Ninja*. Players were run through *Monstrum* while talking aloud about the gameplay and then surveyed about their experience. To make a comparative study of VR and non-VR experiences, another study saw participants play *Fruit Ninja Mobile* and *Fruit Ninja VR* while recording galvanic skin response (GSR) during gameplay. It was found that, while *Monstrum* is immersive, issues like unintuitive UI and unappealing game AI dampened the experience, with motion sickness being a chief complaint. Meanwhile, *Fruit*

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Ninja VR was conducive for player engagement and immersion, with comparable instances of action gameplay sequences showing elevated numbers of GSR peaks per minute over the 2D Mobile version. This shows that emotional arousal for the same game is elevated in VR. Qualitative user responses corroborate the idea of a more immersive VR experience due to increased role taking over the 2D version, giving rise to possible design strategies for VR.

Keywords Video games · Immersion · VR · Virtual reality · Monstrum · Fruit Ninja

20.1 Introduction

VR technology faces various challenges, ranging from "enabling technologies [to] systems engineering and human factors." Consequently, there are questions surrounding best practices for designing for VR (Ali and Nasser 2017). Some studies focus on the best control schemes for VR (Martel and Muldner 2017), while others focus on storytelling, with relation to empathy and immersion that depends on participant personalities (Shin 2017). VR technology bears academic scrutiny to better establish standards, baselines, and usability for crafting the most effective and immersive experiences possible.

This study attempts to establish elements in VR experiences that are more or less conducive to immersion. A game in VR should be more immersive to players compared to a Mobile version, as it would give them a more intense feeling of being "in the experience," especially during action gameplay, where 2D games are emotionally isolating . Our initial study with *Monstrum* (2015) raised some important issues with control schemes as being highly impactful of end user experience, though this did not necessarily denote immersion. Rather, motion sickness was a factor that needed to be eliminated to get more cohesive results. Further, the inclusion of paired VR and non-VR gameplay allows a more controlled study of the physiological effect of the medium.

Fruit Ninja was chosen due to accessibility, familiarity to gamers, and lack of virtual movement, i.e., movement with a joystick, which contributes heavily to motion sickness. It was also thought that a comparison between the VR (2016) and Mobile (2010) versions of the game might lead to more coherent insights than a comparison between VR and PC, as Mobile is a more haptic experience than traditional mouse-and-keyboard inputs and creates less degrees of separation between player and game. If any major differences could be discovered, this would lend itself well to understanding the reason for VR's immersiveness.

20.2 Background

VR as a medium has been used in diverse settings such as architectural visualization, storytelling, and content creation where its ability to create immersive environments is unique. However, in relation to VR's role in gameplay, it is still relatively difficult to see what VR adds to the game experience other than a 360° display. To highlight the key differences, we must examine both VR and Mobile versions of the same game to gain insights about how VR changes aspects of gameplay interaction and elicits different physiological responses from players.

What marks out VR as a medium may be its ability to transport players to a setting where they otherwise would have no access to, be it in the real world or the virtual world. This allows us to gain empathy with a viewpoint that we previously did not have access to due to emotional response to the view from the headset (Torisu 2016). VR content creates greater engagement and empathy compared to 2-dimensional films (Schutte and Stilinovic 2017), leading to the question of whether this occurs in VR games vs. 2D games as well. It was found that VR facilitates perspective-taking in an experience involving color blindness (Ahn et al. 2013), raising the possibility that interactive experiences also produce psychologically different experiences in VR over 2D. Indeed, a study has shown that EEG beta-waves were elevated in frontal areas when viewing VR content compared to 2D video content (Kweon et al. 2017), suggesting physiologically different states when participants viewed content in VR.

The use of VR in the game context compared with 2D involves the question of how well players can effect changes in the environment. A study showed that in a horror VR game, the ability to cope with fright (self-efficacy) is a determining factor in how fearful (and enjoyable) the game is (Lin et al. 2018). Because VR is closer to the real world than 2D games, it can bring about emotional reactions, which is determined by how well players can cope with their own feelings in the immersive environment. Avatars have been used to express the emotions of players using biometric sensors integrated with gameplay (Bernal and Maes 2017). A comparison of the GSR sensor activity during gameplay in VR (as opposed to non-interactive content) would allow us to surmise whether these arousing emotional states are associated with immersive gameplay in VR.

20.3 Methodology

Six graduate students with varying gameplay background from Northeastern University participated in the *Monstrum* experiment. Informed consent was obtained, giving info on procedure, risks, data acquisition, contact info, and participant rights. A 10-question survey was also given. For this experiment, the researchers used two computers in the Northeastern Usability Lab: one for letting participants play *Monstrum*, and the other for recording the gameplay and the player. An Oculus Rift headset was used to play Monstrum in VR, and a standard Xbox controller was used to interface with the game (the Oculus Rift controllers were incompatible). Recording is done in Morae software.

After giving informed consent, participants went through a relatively short segment of the game. They were asked to say whatever came into their minds during their experience, especially regarding the user interface and game progress. As one researcher closely recorded the verbal observations from think-aloud, the other took notes regarding qualitative nonverbal data. Each session lasted 10–15 min, varying with regard to how long players could either survive in the game or stomach gameplay before having to rest. A post-game survey and interview followed. This worked well for an initial assessment of VR immersivity and set a baseline for further investigation.

However, in light of the *Monstrum* study's shortcomings, it was decided a second study should be run where users play through both VR and non-VR versions of a game, allowing for a direct comparison of the media. This would allow researchers to more accurately correlate immersiveness with the medium (VR or 2D monitor). Additionally, a different game was chosen utilizing a different movement system to minimize player discomfort, as motion sickness was the foremost complaint for breaking immersion in *Monstrum*. *Fruit Ninj*a was the game selected for this, as not only did it support the use of the Rift touch controllers, but it also involved gameplay not requiring players to move virtually. Any movements they made would be one-to-one, which tends not to induce sickness in users.

Fourteen participants of varying levels of experience were run through *Fruit Ninja* and *Fruit Ninja VR*. After being briefed, participants were fitted with Shimmer3 wireless GSR (galvanic skin response) sensors, which provide real-time biometric feedback on a user's skin conductivity, measured by two electrodes attached to the fingers. Physiological arousal (stress, excitement, sadness, etc.) results in greater GSR activation, serving as a potential indication of a user's interest or emotional state at a given moment. Using Peak Analysis data (calculating where significant "spikes" occur in GSR conductance) researchers can further refine potential instances of arousal and begin to determine what stimuli might be resulting in increased user engagement.

After being fitted, participants were then asked to play both Mobile and VR versions of *Fruit Ninja* for however long they felt comfortable (though not exceeding 5 min per game). Half the participants started with VR, while the other half started with Mobile; this was randomly assigned. The Mobile version of the game was played on an iPad and recorded with a Tobii eye-tracking headset (for video only, as eye-tracking was not possible with VR and thus no comparisons could be made), while the VR version of the game was played using an Oculus Rift headset and an Oculus touch controller. Data (including screen footage and GSR metrics) was collected and partially analyzed in iMotions 7.0. Video, as well as Raw and Peak Analysis GSR data are then exported and analyzed in depth in R 3.6 using the pracma and signal libraries.

20.4 Results

With the *Monstrum* study, participants were able to provide their thoughts on many aspects of the game. All of them reported motion sickness caused by the game after 5–10 min of playing, and four out of the six participants mentioned that it may have been caused by the controls. *Monstrum* lets players use the Xbox controller stick to run and turn around in-game. Participants said the controls made the game feel “disorienting” and “not intuitive.” Those who tried to physically turn around instead of using the controller stick described the experience as “inconvenient.”

Despite the fact that the participants were all satisfied with the graphics and sound, all six of them reported the game to be less immersive due to the lack of instructions. Participants mentioned they felt confused because the short tutorial section did not provide full instructions on how to use the controls before the game starts. They then had to spend extra time figuring out how to move around, open the inventory, use items, etc., making the gameplay experience poor.

Three of the six participants also commented on the floating text instructions in the game. Researchers initially thought minimizing floating text might increase immersiveness, though due to the lack of a dedicated tutorial level, testers indicated they actually wished there was more floating text to help guide them with where to go, what to grab, how to explore, and so on, despite the text’s non-diegetic nature.

With *Fruit Ninja*, both qualitative (user feedback and survey response) and quantitative (GSR biometrics) data were collected, to gauge participant engagement and immersion. Averaged GSR peak data over the entire trials of gameplay did not show significant differences between VR and Mobile ($p = 0.3209$). However, when focusing on 60-s segments of similar gameplay during fruit-whacking episodes, it was found that VR elicited a greater GSR response (peaks per minute) from participants (paired t-test, $p = 0.0197$, Fig. 20.1). This shows that subjects were aroused to a greater extent during VR gameplay over Mobile, making the experience more emotionally relevant for the participant during applicable gameplay sequences.

To see in depth how the GSR responses evolve over a trial, GSR conductances relative to the start of the trial are plotted for both VR and Mobile. After capturing the peaks of GSR responses, we then plot the GSR conductances integrated over the parts of the trial where GSR peaks occurred. As seen in Fig. 20.2, VR experiences generated greater GSR peaks integrated over the duration of the peaks, showing that VR produced sustainably more arousing responses over the course of a trial as well.

For qualitative data, participants both filled out a brief Google survey (20 questions) after having completed both the VR and Mobile portions of the study. Survey results indicated VR as being more immersive than Mobile (t-test, $p = 0.0001138$) when participants were asked to rank immersivity on a scale of 1–10 (one being least immersive, 10 being most immersive). Additionally, 64.3% of respondents indicated they preferred VR to Mobile.

The greatest vector for confusion in VR seemed to stem from the limited field of view and requirement for the player to utilize head movement in ascertaining the position of game elements (e.g., fruits and bombs). Two participants also commented on additional game mechanics in both Mobile and VR impacting their experience. One mentioned how a player can “accidentally bump things away with the flat of the blade you are given, which can knock fruits out of reach if you aren’t careful,” while the other also indicated “an omnidirectional blade like in Beat Saber” would perhaps have improved their game experience.

After completing the survey participants were also briefly interviewed, allowing them to provide more open-ended feedback and to express their final thoughts on

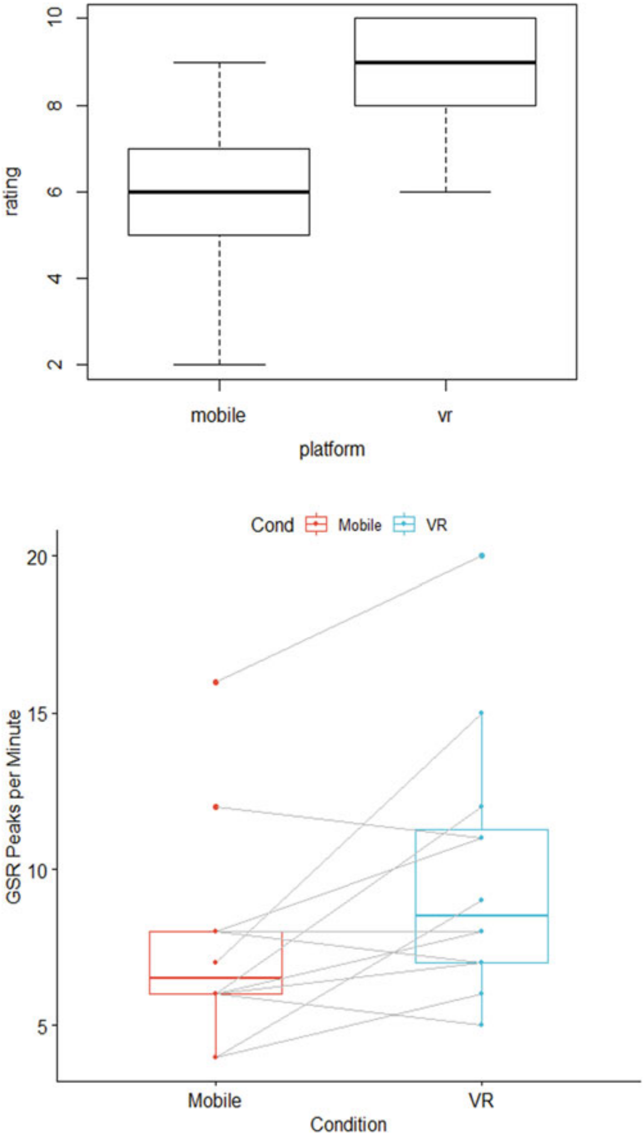

Fig. 20.1 The first figure depicts qualitative survey data scoring immersivity ("rating") for both Mobile and VR platforms. The second figure depicts GSR peaks per minute for 60-s fruit-whacking sample intervals for Mobile and VR gameplay of each participant in the Fruit Ninja study

the games and their experiences. From here, feedback was compiled and coded, as illustrated in Tables 20.1 and 20.2.

Of the 13 collected interview responses, seven cited VR as being objectively more immersive than Mobile. Six also cited VR as being more realistic than Mobile,

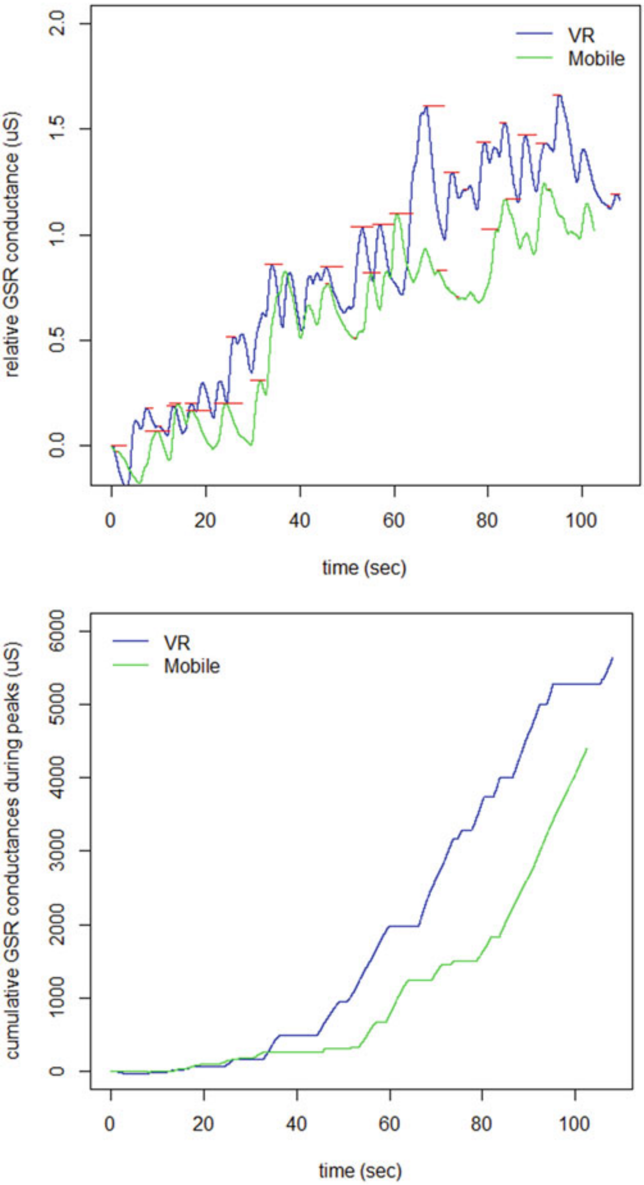

Fig. 20.2 Example GSR traces for participant 14, showing entire trial of VR and Mobile gameplay in real time (up). Red bars are GSR peak periods used to compute the plot on the down. GSR conductances (in micro Siemens) are integrated over periods of the peak calculate on the left. VR gameplay showed greater integrated conductances, indicating a greater overall GSR response over the course of the trial (down)

Table 20.1 An example of how interview data was coded

Feedback	Mobile	VR	General
Creates two different experiences Mobile is 2D, more control VR: Never know what is coming Forget you are slicing with a sword in Mobile More realistic in VR VR is more immersive In the environment Feel like actual ninja Arm movements	More control, less thematic	More realistic, limited view, more immersive	Two different experiences

Table 20.2 Coded interview data

Mobile	VR	General
All info on one screen, more clarity	Limited view, weird camera	
	Sound and visuals, intuitive, interactive	
	Harder than Mobile, more realistic, added physics mechanic	
More control, less thematic	More realistic, limited view, more immersive	Two different experiences
	Limited view, different dimension, more complex, more engaging, more immersive	Two different experiences
	More realistic, limited view, different dimension, interactive, fun, more immersive	
	Less control, no outside distractions, physical hardware limitations, more immersive	
Boring	More immersive, more realistic	
All info on one screen	Harder than Mobile, needed clearer instructions, more immersive	
	Intuitive, physical hardware limitations, needed clearer instructions, different dimension, added physics mechanic	
	Limited view, added physics mechanic, more immersive, worse gameplay	
More control, better feedback	More realistic, graphics	Two different experiences
Engaging	More realistic, harder than Mobile, minimal UI	

with four of these specifically attributing this to being able to see and swing around a sword in-game (one respondent mentioned that Mobile lacked this aspect, thus somewhat separating the experience from the theme of “being a ninja”).

Five respondents also noted that, given the 3D nature of the VR game, this resulted in a limited field of view at a given point in time (versus Mobile where all information is presented on one screen). Interestingly, opinions were split as to whether or not this was a good thing: one participant cited this as an explicitly negative thing, while two thought this added to the experience and two were somewhat on the fence (more neutral).

20.5 Discussion

When looking at the first study, *Monstrum* (and VR games in general) are relatively immersive simply by virtue of the medium, as the vast majority of this study's participants stated VR directly impacted their experience. However, perhaps one of the biggest factors contributing to confusion among players was a lack of clear direction on mechanics and controls. Gameplay needed to be discovered through experimentation, and some players were not even able to perform simple tasks like opening their inventory without prompting from the researchers. A more minimalist UI would negatively impact the game experience, therefore indicating that properly indicated directions and HUD elements are important to minimizing confusion and increasing immersion. It should be noted that *Monstrum*'s UI is a mixture of diegetic elements (e.g., pulling up readables in the player's journal) and spatial elements (e.g., floating text in the game world explaining how certain game mechanics work, such as crawling under furniture to hide). Diegetic elements exist within the diegesis of the game world, and spatial elements exist outside of the game's diegesis but are still present within the game world's geometry (Stonehouse 2014).

Sound and graphics were most well-received when players were questioned about what they found most appealing in the game. These likely had a positive impact in increasing player immersion. Conversely, the game's AI was the most negatively received, though this was likely due to minimal contact with said AI, and in all but one case that contact being a sudden and non-telegraphed player death. This lack of clear feedback on what had gone wrong, how the AI operates, and how players can adapt in the future likely was detrimental to the experience.

One of the most impactful aspects of *Monstrum* in regard to player experience was motion sickness. Every participant experienced some degree of discomfort during play, largely owing to the smooth artificial locomotion system (using thumbsticks to navigate through the game's world). This movement system likely induced a temporary vestibular mismatch (perceiving movement while remaining stationary), resulting in headache, dizziness, nausea, and other adverse effects on testers (Carbotte 2018). *Monstrum* also did not support Oculus Rift Touch controllers, which would have provided a more natural way of engaging with the game world.

Results from the *Fruit Ninja* study were far more promising, as both the Touch controller and motion sickness issues were rectified through choice of game, while running a paired study allowed for direct comparison between a VR and non-VR experience. The majority consensus among participants, both through survey and interview, is VR felt more immersive. Being able to see and physically interact with in-game elements (the sword being the most commonly cited and praised) led users to feel they were engaging in a more realistic experience, therefore strengthening the game's core premise (in this case, "being a ninja"). These results seem to indicate VR heavily feeding into players' sense of ilinx, this being "the pursuit of vertigo" and "an attempt to momentarily destroy the stability of perception" (in other words, play in an attempt to stimulate the senses through such means as excitement, adrenaline, fear, etc.) (Caillois 2006).

GSR responses in *Fruit Ninja VR* during VR action gameplay sequences are significantly higher than responses in Mobile, but when averaged over the entire course of experiments, they do not differ. This shows that VR is only effective when players are asked to adopt particular roles (such as a ninja whacking fruit). This suggests that self-efficacy of actions in VR make the VR experience more arousing. The trial-by-trial analysis also shows that VR appears to activate greater GSR responses when integrated over the entire trial, showing that the effect of VR may not lie at the beginning of gameplay, but rather further into the experience, when subconscious role taking takes effect, and the actions become more arousing than they would be in Mobile. However, this can also be due to the Mobile version feeling more like a toy compared to the VR version, where players actually adopt the idea that they are ninjas.

This carries through into qualitative data, which shows the majority of participants emphasized they felt a high level of immersivity in VR, both when surveyed and interviewed. Many of these respondents specifically cited being able to see and swing around a sword as contributing to this higher level of engagement. As one participant stated, "There is less of a disconnect between you and the gameplay (you really feel like you're swinging a sword around, rather than just swiping a screen with your finger)." The addition of a fully realized and tracked 3D environment also seems to have impacted users' experiences (some positively, some negatively). These two factors contributed to creating more realistic game experience in VR compared to Mobile.

Some of the negative pushback to the added dimension, and the requirement for head movement to navigate that dimension, may have to do with hardware limitations; VR is still not on the same level as real-world vision and interaction, and limited field of view or headset calibration might have contributed to a somewhat suboptimal experience. An adjusted FOV may have remedied some of these concerns, though the possibility of players missing information because it appeared outside their range of vision is still a major issue which might call for more robust haptic (e.g., controller vibration) or audio cues.

There may have been some bias in participants, as almost all had previously had experience with the Mobile version of the game (some participants indicated they may have had extensive experience with the game prior). While this lent itself well to running the study with little need to coach participants, this may have also impacted their engagement with the Mobile portion of the study.

In future research, a similar study could be run involving the collection of other biometric data (such as EEG (Electroencephalography), eye-tracking, facial expression analysis, etc.). This would allow researchers to gauge the charge of participant responses to stimuli (either positive or negative) as well as gauging the type of brain activity present during gameplay. Additionally, running another horror game (or a game meant to stimulate a more pronounced emotional response) might benefit further GSR collection, as this would likely lead to more dramatic peaks. One study does just this, utilizing both GSR and EEG to gauge VR immersion using a virtual roller coaster, with their findings indicating overall higher engagement in VR (Farnsworth 2017). By applying these biometrics tools to more interactive experiences, the hope is both researchers and developers can more accurately pinpoint what makes VR so immersive, and how VR game design can better deliver a given desired experience to users.

20.6 Conclusions

This study studied how VR game experiences affect us physiologically and perceptually. We showed that gameplay usability such as UI and motion sickness affect the immersiveness of VR experiences. In a comparative study of the same game in VR vs. Mobile, we found greater arousal in players during action sequences, as well as greater GSR responses integrated within a trial. What's more, players appear to adopt their roles in the VR game better, taking actions with greater deliberation, and using the limited point of view as indicative of increased immersion in their character.

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Ludography

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