



Evaluating enjoyment, presence, and emulator sickness in VR games based on first- and third- person viewing perspectives

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Abstract

Many virtual reality (VR) games are based on a first-person perspective (1PP). There are, however, advantages in using another perspective, such as the third-person perspective (3PP). Although there has been some research evaluating the effect of 1PP and 3PP in gameplay experiences, it is largely unexplored for VR games played via the new generation of commercial head-mounted display systems, such as the Oculus Rift. In this research we want to shed some light on the relationship between the different perspectives, when games are played using head-mounted display VR, and simulator sickness, enjoyment, and presence. To do so, we perform an experiment using two different perspectives (1PP and 3PP) and displays (VR and a conventional display) with a popular game. Our findings indicate that 3PP-VR is less likely to make people have simulator sickness when compared with 1PP-VR. However, the former is not perceived as immersive, but this might not be a problem because our data also show that presence is not mandatory for enjoyment. Also, the data suggest that there is no clear preference between 1PP-VR and 3PP-VR for gameplay.

KEYWORDS

first-person, gaming, head-mounted displays, immersion, presence, simulator sickness, third-person, virtual reality

1 | INTRODUCTION

The first idea that resembles what we take for immersive virtual reality (VR) was presented in 1965 by Ivan Sutherland, mentioned in the work of Mazuryk et al.,¹ as an artificial world that interacted with and immersed all our senses. Due to technological limitations, VR technology was neglected by the masses. In the recent years and with the release of affordable immersive VR technologies, VR rose from obscurity and is becoming mainstream. This rebirth left many companies, especially those in entertainment, wanting a market share. However, the best way to implement VR and how to make people less likely to suffer from side effects, such as simulator sickness,² is still being researched.

The gaming industry has rapidly moved to leverage VR technologies in order to enhance gameplay experiences that can come with higher feelings of immersion and presence. With the wide variety of genres, formats, and styles, there is a

need to know how to best increase gamers' enjoyment, and as such, research on player experience plays a big role in that industry.³

A factor that is essential for enhancing gamers' experience is the sense of being there, the feeling of being inside the game, also known as presence.^{3–5} It is suggested that in games, emotions are stronger with a higher level of perceived presence.⁴ One factor that promotes presence and is still underexplored in immersive VR is perspective.^{4,6} Perspective not only changes the sense of presence but also may have an impact on the player's physiological reactions.^{4,7,8} Such physiological reactions at the same time might affect the player's enjoyment of a game. In video games in general, two perspectives are available to the player: first-person perspective (1PP) and third-person perspective (3PP).⁹

In this study, we intend to analyze how the two different perspectives in a VR game can influence presence, enjoyment, and simulator sickness. We compare gamers playing a VR game in 1PP and 3PP while wearing an Oculus Rift head-mounted display (HMD). In addition, we use a traditional display (a TV) as a baseline in our experiment for comparative analysis.

2 | RELATED WORK

In this section, we will describe work related to simulator sickness, enjoyment, and presence.

Simulator sickness is a recurring problem in VR, so much so that there are different strategies to overcome this problem. It has been claimed that by adding movement to VR, it will decrease the likelihood for people to get simulator sickness.² However, the same researchers conclude that such strategy might not be the best option and does not have wide applicability. One other strategy is to add a small reticle in which the player can focus their gaze.¹⁰ This fixed point in which the player can look as a reference point could also be implemented as an avatar in a 3PP game.

In another work, Medina et al.⁷ have presented a study in which they looked at the performance of volunteers when walking in a device called VirtuSphere. This device is a “human size VR ‘hamster ball’” used for seminatURAL walking. In their study, they verified that users who engage in a virtual environment using 1PP usually suffer from stronger simulator sickness effects when compared with those who engaged in the same environment using 3PP.

In the work of Kallinen et al.,⁴ the differences between 1PP and 3PP are also described but under a different approach. In this work, simulator sickness is not evaluated, nor is any kind of immersive VR. They focused on the differences in the feeling of presence when playing in the two different perspectives. In order to perform their experiment, Kallinen et al.⁴ used a regular PC display and the Role-Playing Game (RPG) “Elder Scrolls 3: Morrowind” game. They found that even though 1PP generated a greater feeling of presence, gamers' experiences in 3PP were more pleasant. This result agrees with those in the work of Denisova et al.³—this paper's results also indicated that people were more immersed in the gameplay when viewing the game world through the eyes of the character (that is, in 1PP). According to this research, there is a correlation between viewing perspectives with perceived immersion. However, this aspect has not been explored in detail. In a meta-analysis of 83 studies about immersion presented in the work of Cummings et al.,⁶ only two looked at immersion from different perspectives and did not include VR technologies.

Lim et al.¹¹ reported a study where players were given a choice of avatar to explore their feelings of presence. It was found that their feelings of presence were, on average, the same in 1PP and 3PP. Gorisse et al.,⁵ studied the differences of perspectives and did so in an immersive virtual environment. Their results suggested that regardless of perspective, it was possible to have the feeling of “being there” (i.e., presence). They also investigated components of presence, the sense of ownership, and self-location and found that 1PP was preferred over 3PP. These results contrast with those in the work of Debarba et al.¹² but match those presented in the work of Kokkinara et al.¹³ However, in both papers, it was hypothesized that the measurements in the work of Debarba et al.¹² might lack sensitivity. What they mean by sensitivity is that whereas Gorisse et al.⁵ uses a questionnaire with multiple questions to assess the levels of both self-location and ownership, Debarba et al.¹² uses only one question for self-location and one for ownership. It was thought that the use of a single variable might lead to interpretation mistakes in a subjective question. A questionnaire with more questions might mitigate this kind of problem and can make the results more precise.

Salamin et al.^{9,14} took the analysis of 1PP and 3PP in VR using an innovative approach, one in which the cameras were strapped in a way that the VR world was the real world viewed from different lenses. The avatars no longer were digital but were the volunteers themselves. For the 3PP, the authors strapped a camera to the participants in a way that they would see themselves as avatars. For the 1PP, the users wore a kind of mask with a camera attached. In both cases, the participants would see the world only through an HMD. They would perform a ball catching activity in the environment. Surprisingly, 3PP facilitated some tasks.

Another experiment involving sports and perspectives in VR was reported by Covaci et al.^{15,16} This setup differs from the others mainly regarding the equipment used for the virtual environment. Instead of using an HMD, the authors used a cave automatic virtual environment-like system. For this experiment, they compared 1PP, 3PP, and 3PP+ (3PP with visual guidance) and involved participants in performing free throws in the three conditions. The results suggest that for basketball training, it is possible that the 3PP+ is better for novices.

Our work builds on these prior works. To the best of our knowledge, since the work of Medina et al.,⁷ the effects of perspective in simulator sickness have not been studied in VR. With much improvement made to HMD in the past few years, further investigation is needed given that most papers presented in this session evaluated users' performance in different perspectives but without giving too much attention to the general enjoyment when games are played in VR under different perspectives. Given the increasing popularity of VR HMD, our work is timely and can inform the design of VR games.

3 | STUDY DESIGN

To evaluate game enjoyment, immersion, and presence under different perspectives, our study was designed in the following manner. Volunteers would play a selected game under three conditions: 1PP-VR, 3PP-VR, and a baseline 3PP-conventional display (3PP-CD).

In order to move further, we formulated the following hypothesis based on the current literature:

- H1: The greater the presence, the greater the enjoyment;
- H2: People will feel less sick in 3PP-VR, when compared with 1PP-VR;
- H3: People will feel less sick in 3PP-CD, when compared with 3PP-VR;
- H4: Immersion in 3PP-VR and 1PP-VR should be greater in 1PP-VR;
- H5: Immersion in 3PP-VR and 1PP-VR should be greater than 3PP-CD.

Because we wanted to investigate three different factors, we decided to use three questionnaires that analyze different levels of simulator sickness, enjoyment, and presence. The first one was the Simulator Sickness Questionnaire (SSQ),^{17,18} which contains two sessions, one for measuring the level of nausea, and the other for oculomotor issues. The second one was the Game Experience Questionnaire.¹⁹ We actually used a modified version of Game Experience Questionnaire, named In-Game Questionnaire, because at every interval, it would be repeated, and the Post-Game Questionnaire. The third questionnaire we used was the Immersion Experience Questionnaire.²⁰ We also used an adapted version of the Immersion Experience Questionnaire because we applied it in conjunction with the In-Game Questionnaire—some of the questions were similar, others were rephrased so they would fit the context of the other questionnaire, and some just did not fit the context of the game in our experiment. Overall, the participants answered a 43-question questionnaire with items using five-point Likert scales. There were 15 questions from the SSQ.

We recruited volunteers from a local university, regardless of their course of study. We had a total of nine volunteers—all men with an average age of 24.4 ± 4.2 , median of 23, mode of 22, and range between 19 and 32. All volunteers had normal or normal corrected vision.

Moreover, 88.9% of the participants had experience with the chosen game before but had never played it on a PC emulator or in any kind of VR systems, 66.7% of them already had experience playing other games in VR, and 77.8% played “regular” games at least once a week. Of these, 71.4% played at least three times a week.

We used an Oculus Rift CV1 as our HMD (Figure 1). Our PC was one with 16GB RAM, Intel Core i7-7700 k CPU @ 4.20GHz, and GeForce GTX 1080Ti. We used a Betop Pandora 2.4G Wireless Gamepad as the controller. We used it instead of the traditional Rift Touch Controller because the Betop could be used both with a HMD and without it.

3.1 | Game choice

We researched existing games that could be played in both perspectives, especially those games in which the mechanics would not change considerably depending of the point of view or kind of display. We looked also for games that did not explicitly appeal to a specific gender. For this reason, we focused on Nintendo games that, according to its former president, has a balance between male and female players.²¹

We then researched Nintendo games that could be emulated and played effectively in VR platforms using Dolphin VR emulator (version 5.0)²² (Figure 2).



FIGURE 1 The Oculus Rift CV1 and Betop gamepad controller used in the experiment

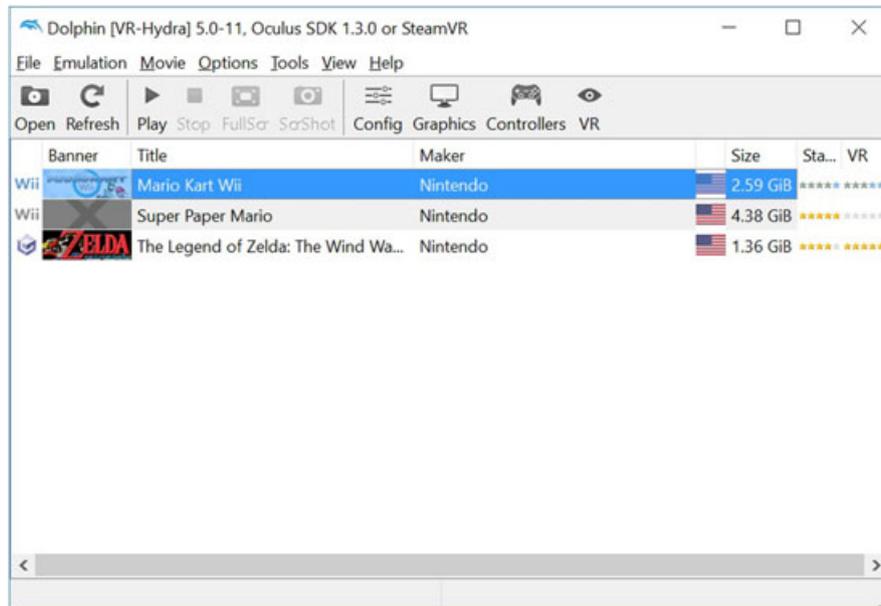


FIGURE 2 Dolphin VR 5.0 main screen with some of the games we tested

Our game of choice was Mario Kart Wii.²³ The races had roughly the same time length, so it would be consistent for the different designs we would be testing. Also, the game mechanics remain the same regardless of perspective or display. Further, because the game did not have a deep storyline, having played the game before or not would not have a big influence in the subsequent races. Thus, it is in the sense that no surprise or plot point would be “spoiled”.

3.2 | The chosen game

As stated, the game we chose for the experiment was Mario Kart Wii (see Figures 3 and 4 for screenshots of the game), a racing game developed by Nintendo. The game would normally be played in 3PP. The main goal is for a player to arrive first to the finish line. The chosen circuit for all races had three laps and would take around 11 min to finish in the 150cc difficulty level. During the race, the players could acquire different items, which varied in power and usefulness. When the player is in a better position, the power and usefulness of the item would likewise be lower.

We asked all participants to play as Mario using the Standard Kart shown in Figure 4 below, because this was one of the most balanced options available. All players played in the Mushroom Cup against 11 computer adversaries. They all used the same configuration for all the three cases.

For the game to be playable in 1PP in Dolphin VR, a few adjustments had to be made. The head-up display distance was set to 0.01 m, the head-up display 3D closer was set to 1, the camera forward was defined as 600 m, and the camera pitch was set to 15 degrees up. For the 3PP, all parameters were kept the same except the Camera Forward and Camera Pitch, which were both set to 0; the differences are visible in Figure 3.



FIGURE 3 Different perspectives of the game in our experiment (upper left was the first-person perspective virtual reality, upper right the third-person perspective virtual reality, and lower middle the third-person perspective conventional display)



FIGURE 4 Screenshot of Mario Kart selection screen showing the selected kart for our experiment

The controls were adapted to match the Betop configuration. Buttons A, B, X, and Y from the emulator were set to match its nominal values on the controller. Control stick was set to match the left analog in Betop Controller. L, R, and Z were set as LT, RT, and LB, respectively.

3.3 | Procedure

On arrival, all participants were assigned to one order in which the perspectives would be played—the order was organized based on a Latin square design. They were asked to fill a questionnaire to collect information, such as name, age, frequency in which they played games, if they had ever played VR games, and whether they had ever played Mario Kart.

They were then introduced to the controller and asked to sit in front of the monitor and play the circuit once so that they would get familiar with the game and controller (Figure 5). After this brief introduction, they were asked if they would like to stop and rest for 5 min.

After the training, each started playing the initial condition. If that was one of the VR perspectives, the volunteers would have a researcher initially positioning the HMD on their heads and asking them to adjust it in a way that the image was the clearest and that it sat comfortably (Figure 6). The researcher would then give the controller to the player and guide



FIGURE 5 Picture of a participant during controller and circuit adaptation

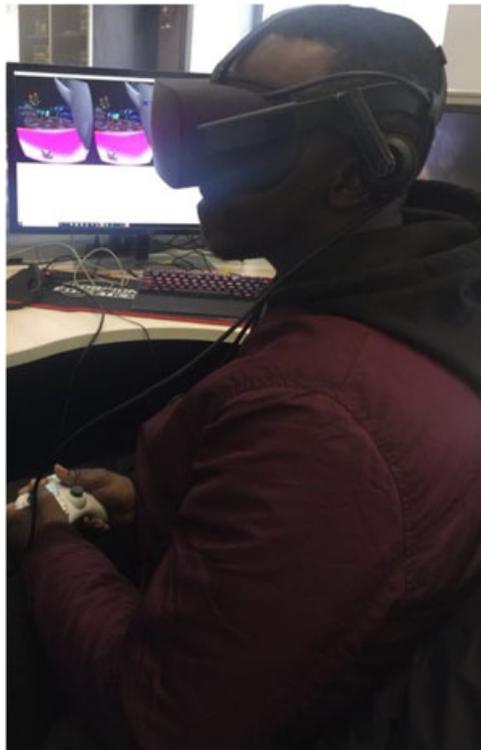


FIGURE 6 Picture of a participant playing first-person perspective virtual reality version of the experiment

the player's choice (difficulty level, character, kart, and circuit) until the beginning of the race. All the steps were the same for the 3PP-CD of the test apart from the HMD being positioned on the participants' head.

After each version, the players were asked to fill the questionnaires. This process would take around 10 min. If the questionnaire was answered in less time, we asked the participants to wait a little before going back to the game. This was done not only to encourage participants to answer the questions without rush so as to increase accuracy of their answers

but also to give the players a break, especially after playing the VR versions. We wanted to ensure comparability between participants.

The participants took around 75 min each to complete the experiment. In the end, they were offered water, fruits, and nuts and were asked to stay on the couch in the laboratory for a few minutes in case they had any side effects. Before every game session, the participants were informed that if they felt any kind of sickness and wanted to stop, they could do so at any moment.

4 | RESULTS AND DISCUSSION

After the experiment, we had 27 completed questionnaires, 3 for each participant representing a different perspective of the game. Because of the terminology used in the questionnaires, in this section, the terms presence and immersion will be used interchangeably.

We calculated the scores of each questionnaire following the procedure explained in their respective sources.^{17–20} We used IBM SPSS software²⁴ to calculate the Pearson's correlation on the scores.

The results showed that there was a correlation between how many times someone played games in a week and their positive experience in VR in both 3PP ($r = .703, p < 0.04$) and 1PP ($r = .768, p < 0.02$). This same correlation was not present in 3PP-CD. We hypothesized that this might be because VR Mario Kart was a new experience, whereas Mario Kart in 3PP-CD was very common and did not bring any strong feelings.

Table 1 shows the correlation of flow (a good indicator of mental engagement with any activity including games¹¹) with immersion. Even though flow scores in both 1PP-VR and 3PP-VR had a correlation with positive effect ($r = .818, p < 0.01$ and $r = .797, p < 0.02$, respectively), only flow scores in 3PP-VR correlate to immersion in the same version and 3PP-CD ($r = .912, p = 0.001$; $r = .696, p < 0.05$, respectively). Because we were unable to generate a 1PP-CD (i.e., 1PP in conventional display), we believe that this correlation was due to the same perspective being applied in both kinds of displays, especially because competence in 3PP-CD correlates to competence in 3PP-VR ($r = .783, p < 0.02$).

Regarding the participants' perceived level of simulator sickness, the results from the SSQ corroborated those reported in the work of Medina et al.⁷ and our hypothesis H2 and H3. In our experiment, the maximum possible scores were 27 for nausea and 18 for oculomotor. On average, people felt sicker in 1PP-VR (7 ± 7.7) than 3PP-VR (5.3 ± 4.4), with a 77.7% score lower in 3PP-VR (see Figure 7). However, in the oculomotor session of the questionnaire, there was virtually no difference in average scores 1.7 ± 1.5 for 1PP-VR and 1.4 ± 1.5 for 3PP-VR.

It would appear that this average difference might be caused by the possibility of looking at a fixed point in 3PP-VR (i.e., via Mario's head). This could be validated by findings from the work of Clarke et al.¹⁰ regarding their fixed point. Clarke et al.¹⁰ used a reticule that the player could gaze. When the players had a place to look, it was less likely that they would feel sick, if they did feel sick, and the sickness was not as strong as in the previous experiment in which they did not have a place to fix their look.

TABLE 1 Correlation between flow in third-person perspective virtual reality (3PP-VR) and immersion

		Correlations			
		Flow-3PPVR	Immersion-NonVR	Immersion-1PPVR	Immersion-3PPVR
Flow-3PPVR	Pearson Correlation	1	0.696*	0.299	0.912**
	Sig. (Two-tailed)		0.037	0.435	0.001
	<i>N</i>	9	9	9	9
Immersion-NonVR	Pearson Correlation	0.696*	1	−0.042	0.832**
	Sig. (Two-tailed)	0.037		0.914	0.005
	<i>N</i>	9	9	9	9
Immersion-1PPVR	Pearson Correlation	0.299	−0.042	1	0.413
	Sig. (Two-tailed)	0.435	0.914		0.270
	<i>N</i>	9	9	9	9
Immersion-3PPVR	Pearson Correlation	0.912**	0.832**	0.413	1
	Sig. (Two-tailed)	0.001	0.005	0.270	
	<i>N</i>	9	9	9	9

* = Correlation is significant at the 0.05 level (two-tailed).

** = Correlation is significant at the 0.01 level (two-tailed). 1PPVR = first-person perspective virtual reality.

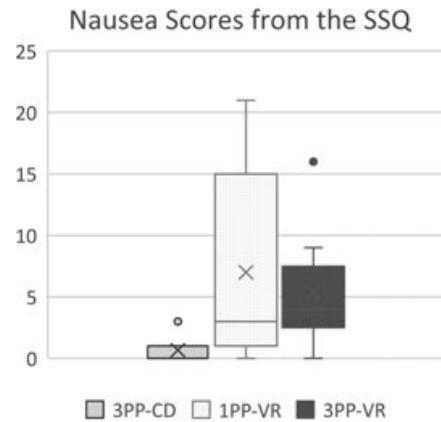


FIGURE 7 Boxplot of the perceived level of simulator sickness for the three groups measured by the Simulator Sickness Questionnaire (SSQ). 3PP-CD = third-person perspective conventional display; 1PP-VR = first-person perspective virtual reality, 3PP-VR = third-person perspective virtual reality

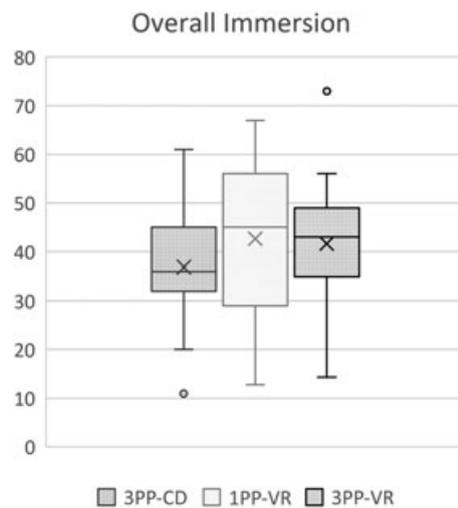


FIGURE 8 Boxplot of the overall immersion scores for the three groups. 3PP-CD = third-person perspective conventional display; 1PP-VR = first-person perspective virtual reality, 3PP-VR = third-person perspective virtual reality

In terms of the overall perceived immersion level questionnaire data from a total of possible 77 points, the 3PP-VR scored 44.3 ± 14.3 , and this was actually less immersive than 1PP-VR (45.7 ± 12.8) as predicted by H4. Both were higher than 3PP-CD in immersion (39.4 ± 11.0) as in H5 (see Figure 8). Only one participant gave higher scores in the overall immersion for the 3PP-CD.

In H1, we hypothesized that greater presence would lead to greater enjoyment. However, this was not apparent in our data. The biggest enjoyment score was for the 3PP-CD group, 3.0 ± 1.1 , compared with 2.3 ± 0.6 for 1PP-VR and 2.5 ± 0.8 for 3PP-VR. 3PP-CD had the lowest average overall immersion, transport (2.1 ± 0.8), and temporal dissociation (0.1 ± 0.5) especially compared with 1PP-VR (3.1 ± 1.0 and 0.9 ± 0.7 , respectively). That is, enjoyment levels were not dependent on presence levels. Nevertheless, there seemed to be a correlation between enjoyment and immersion for 3PP-VR ($r = .930$, $p < 0.001$) and 3PP-CD ($r = .870$, $p < 0.003$). Figure 9 below shows the relationship between immersion and enjoyment for 3PP-VR.

These seemingly divergent results would seem to show that greater enjoyment might lead to a greater sense of presence but not the other way around. Other factors might be more important to the enjoyment. For instance, the participants who reported higher levels of nausea in 1PP-VR reported greater enjoyment in 3PP-CD, even though they reported greater immersion in 1PP-VR. This was not easily observable because no linear correlation was present. To spot possible factors, we had to change the way we were analyzing our data. Instead of purely looking at the scores, we ranked those scores in a way that we could see the order that each volunteer perceived the different perspectives for each component. For instance, participant A scored for flow 3.5 in 3PP-CD, 3 in 3PP-VR, and 4.5 in 1PP-VR, so his flow rank would be

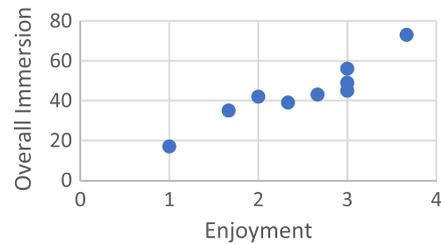


FIGURE 9 The immersion versus enjoyment graph in third-person perspective virtual reality shows a positive correlation

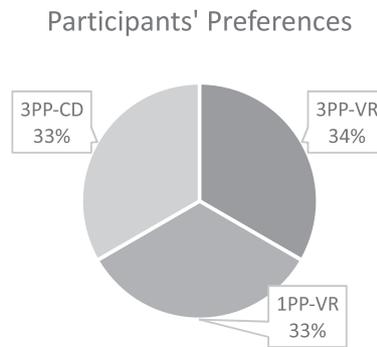


FIGURE 10 The participants' preference chart shows an equal preference for the three groups. 3PP-CD = third-person perspective conventional display; 3PP-VR = third-person perspective virtual reality; 1PP-VR = first-person perspective virtual reality

1PP-VR > 3PP-CD > 3PP-VR. We did this for all the components (i.e., Flow, Negative Experience, Enjoyment, etc.). This allowed us not only to observe the relation nausea had with enjoyment but also to find a way to predict a user's preference based on their perceived enjoyment (i.e., they liked the way of playing the game more).

By using this approach, we found that the best predictor for participants liking/disliking a game was the ranked scores of the *perceived negative experiences*. When a version had a higher score than the other two versions in perceived negative experience, it would not be selected as the preference (which would translate in them liking it). However, in only 66.7% of the cases, the version that scored the lowest in this component was the player's preference. This prediction did not work for positive components (i.e., positive experience, flow, enjoyment) because, regardless of scoring higher or lower than the other versions in these components, a version could be the player's preference. In short, this analysis would suggest that, just as important as creating a good experience, trying to avoid creating negative experiences in VR would also be important, if not more important, because the good experiences may not necessarily make a player like a game, but the bad ones would in all likelihood make a player dislike it.

Finally, the last questions in the questionnaire asked for participants' preferred perspective. Their answers indicated that, even though immersion was clearly higher in both VR groups and the simulator sickness tests showed better results for 3PP-VR than for 1PP-VR, no clear preference was found for either 1PP or 3PP. Exactly one third of the participants preferred each of the three versions they interacted with (see Figure 10).

5 | SUMMARY AND CONCLUSIONS

In this paper, we present a short review on studies comparing 1PP and 3PP when playing computer games. We run an experiment to evaluate if previous studies still held true for current VR HMD technologies, such as the Oculus Rift goggles. We explore if there is a difference in the levels of enjoyment, presence, and simulator sickness when people are playing 1PP-VR and 3PP-VR.

The results of our experiment have not showed a clear pattern and indicate that both 1PP-VR and 3PP-VR have their pros and cons. 3PP-VR is less likely to make people emulator sick when compared with 1PP-VR. However, it is not as immersive, even though this difference is not large. No clear preference for either 1PP-VR or 3PP-VR is found because participants like them equally.

One limitation of our study is that we do not include a 1PP-CD and is due to technology limitations. However, this does not affect our experiment and results because we are mainly comparing 1PP and 3PP in VR gaming. Also, our experiment only has male participants. Despite these limitations and as far as we know, this is the first study to compare a fully functional game, using the current HMD technology under different perspectives. Our results shed some light on gamers' perceived presence, immersion, and simulator sickness of VR games. We plan to conduct future studies to examine how we can decrease the level of sickness and increase the feeling of enjoyment of VR games.

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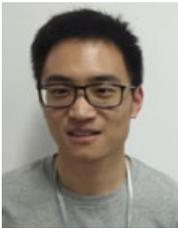
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