Does Virtual Reality Makes You Better at First Person Shooter Games?

Abstract

This paper argues that Virtual Reality does not make the players perform better at First Person Shooter(FPS) games. The paper compared traditional FPS games and VR FPS games from four different aspects Control Scheme, Latency Issues, Cognitive Overload and Physiological Challenge of VR Headset, illustrating the limitations of VR in these aspects which cause poorer player's performance. In addition, the paper also discusses other researches' experiment on players' performance in traditional FPS and VR FPS, indicating that although players do prefer to play the latter, their performance in the former is significantly better. Finally, the article gives some thoughts on how to improve player performance in VR FPS, including enhance accommodation and comfort of VR headsets, specific methods to reduce latency and reduce motion sickness.
Keywords: Virtual Reality, FPS Games, Cognitive Overload, Motion Sickness

1. Introduction

I am a hardcore FPS gamer and have experienced a wide variety of FPS games. Yet, when I put on the VR headset to play Half-Life: Alyx for the first time, I was still deeply shaken by this fps game. This game is just so immersive, when you want to take out your gun, you have to take it out from your back using your controller; when you want to reload, you need to slide your other hand over the hand holding the gun to simulate the action of pulling back the pistol's slide; when you want to restore health, you need to use the controller to simulate the operation of pricking the syringe into yourself. In addition to the immersive experience brought by these operations, VR itself makes the game's visuals more realistic for players. In addition to the basic game environment, the performance of enemies in the game were also made more realistic, such as the "headcrab" in the game , which attacks by jumping into the player's face, which you can also dodge by turning sideways on display.

Indeed, virtual reality has made FPS games more immersive, but does it also make the players better at these?

I believe the answer to the above question is negative, because the VR devices will inevitably bring more latency compared to the computer, and using controller to simulate gun aiming is significantly less direct in feedback than using a mouse to aim. Moreover, overly immersive design can cause the players experiencing cognitive overload. In addition, all VR devices produced so far are bulky, difficult to carry and play for a long time, and may even cause motion sickness.

2. Controll Scheme

In traditional FPS games, aiming at the enemy is very striaghtforward, we simply need to move the screen's crosshair to the enemy through the controller or mouse, which provides very direct feedback on whether we are aiming accurately. However, the aiming of most VR FPS games is much more difficult than this. They need us to hold the VR headset's controller and aim as using real firearms. And in order to make the VR FPS games more immersive, most of them do not display the crosshair on screen, which make it harder for players to gauge their aiming accuracy.

The two pictures following are two very representative FPS games, namely APEX Legends on dektop and Half life: Alyx on VR.

Figure 1: Shooting in Apex

Table 1: Research simulating latency that tested for a connection to cybersickness.[1]

Research	System	Task	Measure	Condition	Result
Kawamura and Kjima, 2016	HMD DK2	Keep balance	Pressure plate	Absolute 1, 26, 39, 53, 66 ms	Latency disturbs human stand equilibrium
Stauffer et al., 2018	HMD Vive	Search	SSQ, physio	Added no latency, Added latency jitter	Jitter provokes sickness
Palmisano et al.,2019	HMD	Rotate head	FMS	Absolute 5, 46, 87, 128, 169, 212 ms	More latency, Increased cybersickness
Kim et al., 2020	HMD	Rotate head	FMS	Absolute 5, 46, 87, 128, 169, 212 ms	More latency, Increased cybersickness

Figure 2: Shooting in Half life: Alyx

We can see from the pictures that the former has a very clear crosshair while the latter does not have any intuitive aiming feedback. Comparing the two images, we can intuitively feel that in the former, we can get more direct feedback on whether we are aiming at the enemy, which is very important for shooting games and can significantly improve our performance.

In addition to the problem that aiming feedback is not intuitive enough, even if the game does display the crosshair on the screen, for FPS games that require quick response, tapping the left mouse button will also be faster than using the trigger button of the VR controller. Besides, adjusting the arm to aim as in the real world is more troublesome than moving a mouse or pushing a joystick on a controller.

3. Latency Issues

3.1. Cause

VR devices often encounter higher latency compared to traditional computers due to the challenge of providing users with consistent connectivity and high-quality content. Network lag alone in VR was three times more stressful for gamers compared to lag experienced while gaming on a PC.[2] Achieving a high Quality of Experience (QoE) and maintaining low interaction latency in VR games is difficult, especially given the limited computational power of these devices.[3]

More concretely, VR systems require very high frame rates for a fluent and immersive experience—usually somewhere around 90 frames per second. This is even more demanding than the 60 fps standard for desktop monitors, therefore puts a lot of pressure on the GPU and CPU. Additionally, VR games involve a complex 3D rendering of environments in real time, which inherently calls for more resources compared to the 2D content display. Besides, each eye requires a separate render to create convincing depth perception, doubling the graphics workload. Not only does this put a strain on the hardware, it also requires exact synchronization to prevent disorientation or motion sickness. Motion tracking can also cause lag. VR systems are supposed track the user's movements to interact with the virtual world and hence require immediate, precise responses, which means more computation and introduces more latency.

The above problems will be more serious when the VR headset is run as a standalone device rather than running in a streaming state. After all, VR needs to be portable, and its configuration is far inferior to that of high-end PCs.

3.2. Impact

The obvious impact of latency on game performance is that the user's operations will slow down, which is a serious problem for FPS games which require fast response. In addition, latency will aggravate the motion sickness problem caused by the VR game itself. The study

[1] found that latency in the display update has a severe impact on motion sickness and should be avoided or limited to very short latency, i.e. less than 30–35 ms. For latency in the Joysticks or hand controllers, much longer latencies can be tolerated and if it is kept below 0.5 s, it has a very limited impact on the motion sickness test.

The study above also write an overview of different studies that show that latency contributes to cybersickness shown as follow in table 1

Combined with the impact of latency caused by VR mentioned above, we can infer that such delay will make players' performance in VR FPS games worse. This study[4] digs into the impact of network latency on gaming QOE for an FPS VR game.

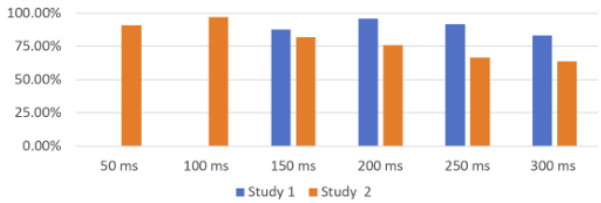


Figure 3: Willingness to Continue Playing in Given Network Conditions[4]

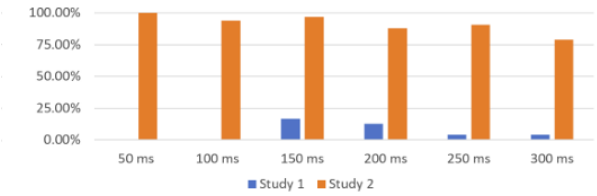


Figure 4: Survival Rate Per Latency Scenario[4]

In the figure above, Study 1 had 24 participants (8 beginners, 8 intermediate, 8 advanced; 10 females, 14 males) with an active co-player, undefined weapon choice, and used the 'Clumsy' latency simulator for 150-300 ms scenarios. Study 2 involved 33 participants (17 beginners, 14 intermediate, 2 advanced; 12 females, 21 males) with a passive co-player, specific weapons like 'Lasergun' showing full bullet paths, and 'Net.Shark' for 50-300 ms latency scenarios.

We can see from the figure obtained in the above paper that the delay caused by VR not only significantly worsens the player's experience, but also significantly reduces their performance in the game.

4. Cognitive Overload

Cognitive overload happens when someone is bombarded with more information than they can handle, resulting in decreased concentration, memory, and productivity. This issue arises from the finite capacity of our working memory, as explained by Cognitive Load Theory. Factors like complicated tasks, unclearly presented information, or personal cognitive limitations can contribute to this overload. To avoid it, it's essential to present information in a structured and straightforward manner. If not addressed, cognitive overload can impair our performance.

VR FPS games are more likely to induce cognitive overload compared to traditional FPS games due to their immersive nature and the richness of sensory information presented. In the VR environment, players experience a simulated world that closely mimics real-life interactions, requiring them to simultaneously process visual, audio, and sometimes haptic cues. This multisensory experience demands constant attention and quick decision-making as players navigate the game space, track moving targets, and respond to threats from all directions.

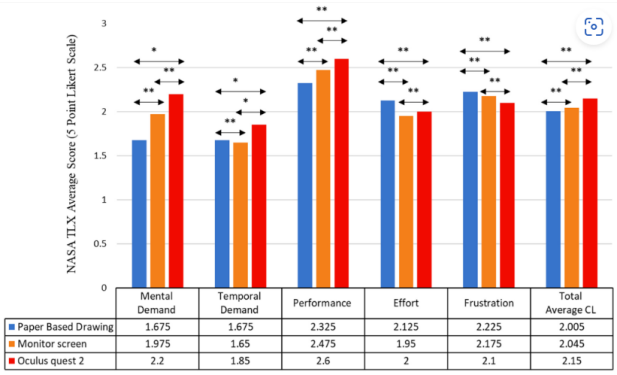
Unlike traditional FPS games, which are played on a flat screen and generally only require players to focus on visual and auditory cues within a limited field of view, VR FPS games envelop players in a 360-degree environment. This full immersion means players must constantly be aware of their virtual surroundings, leading to a higher cognitive load. The need for physical movement or gestures to interact with the game, rather than just using a mouse or controller, adds an extra layer of complexity and cognitive demand.

Figure 5: Headcrab in Half-life: Alyx
(Imagine this jumping towards your head from nowhere when you are wearing the VR headset)

In addition, the realistic environments and interactions in VR can provke deeper emotional responses, leading to an increase in cognitive load. For example, during playing 'Half-Life: Alyx,' the fear of a headcrab Fig 5 jumping directly onto my face and attacking me is significantly more intense than the fear of ordinary enemies attacking

me in a conventional FPS game. During a certain period of time, the sensation and fear elicited by the headcrabs to me could be comparable to that of a horror game. The brain has to process not only the game mechanics and strategy but also the vivid sense of presence and emotional engagement, which can further amplify cognitive load.

In previos study[5], the researcher looks into the imapact of VR on User's performance and cognitive behavior for typical task, they conduct a experiment which measured cognitive load across traditional paper-based, monitor-based, and Oculus Quest 2-based design review tasks. They use the Kruskal-Wallis H test in the experiment to measure user's performance.



	Mental Demand	Temporal Demand	Performance	Effort	Frustration	Total Average CL
Paper Based Drawing	1.675	1.675	2.325	2.125	2.225	2.005
Monitor screen	1.975	1.65	2.475	1.95	2.175	2.045
Oculus quest 2	2.2	1.85	2.6	2	2.1	2.15

Note: *Significant Difference, **Insignificant Difference

Figure 6: Cognitive load score of participants in the different groups[5]

The experiment result shown above indicates that no significant mental demand differences between paper and monitor but found the Oculus Quest 2 environment to be the most cognitively demanding. Data from the NASA-TLX indicated that non-immersive virtual environment participants experienced lower cognitive load than those using immersive virtual environment methods.

5. Physiological Challenge of VR Headsets

5.1. Ergonomic Challenges

Although VR has made games significantly more immersive, and most people find it more interesting to play games on VR than on conventional devices. Most people who own VR devices will still choose to play games on PC or mobile devices over VR most of the time. A non-negligible factor is the bulkiness of VR headsets. Whether it is the latest Quest3 or the newly released Apple Vision, they cannot support long-term wearing. Beyond the issue of weight, long periods of use can lead to overheating. Additionally, if the room space is limited, it might not be suitable for most VR games that require a large play area. Furthermore, for users who wear glasses, despite VR devices being highly advanced, most do not have automatic adjustments for myopia, necessitating the purchase of expensive accessories. If users opt not to buy these and instead wear their glasses under the headset, the experience can be significantly compromised, with the headset pressing the glasses tightly against the face.

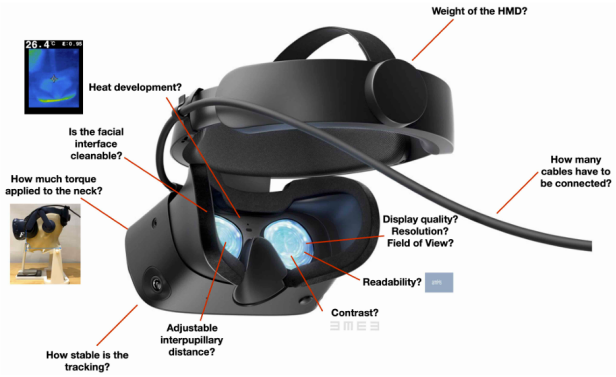


Figure 7: Overview of the VR Metrics[6]

This research[6] analyzes the user experience of different mainstream VR headsets from various dimensions shown in the figure. The analysis angles includes: heat development, weight, torque applied to the neck, cables needed to be connected and other corresponding problems. These issues are all unique to VR headsets and are not encountered by other gaming devices.This research also analyzed the VR Metrics of different mainstream VR headsets, as shown below:

Table 2: Comparison of Heat, Torque, and Weight Across Different VR Headsets[6]

Headset	Heat Measurement (°C)	Torque on Neck (Nm)	Weight (g)
Samsung Odyssey+	31.4	0.708	610
HTC Vive Pro	37.4	0.777	814
Oculus Rift S	32.3	0.737	584
Pimax 5k	28.6	0.902	593
HTC Vive	27.6	0.866	732
Samsung Odyssey	30.8	0.837	662
Lenovo Explorer	37.6	0.502	419
Dell Visor	32.2	0.635	613
Acer WMR	35.2	0.494	464
HP WMR	33.8	0.647	530

We can see that these issues with mainstream VR headsets are significant and cannot be ignored. They will undoubtedly reduce the players performance in FPS games.

5.2. Motion Sickness

Motion sickness caused by 3d games and VR is a long-discussed topic. Motion sickness mostly occurs due to a difference between actual and expected motion. 3d FPS games themselves can already cause motion sickness to many people, and FPS games on VR have aggravated this motion sickness. It is very common for users to experience them, "With contemporary commercially available VR systems, the incidence of motion sickness after only 15 minutes is anywhere from 40 to 70%," said Thomas Stoffregen, a kinesiologist at the University of Minnesota.[7] Columbia University conducted a experiment which involves 30 participants, it reports 80% sicknes with DK2 in Tuscany.[8]. Even if you are one of the lucky guys who have not experienced motion sickness in 3D games or even VR games, there is a high probability that you will experience motion sickness after playing VR FPS games for a long time.

FPS games often cause motion sickness because players perceive a discrepancy between visual movement cues and the lack of vestibular cues that correspond to actual movement. Without the body's natural balance adjustments, rapid movements on the screen can cause symptoms such as dizziness and nausea.

VR makes this much worse by providing a strong illusion of being present in a 3D space, with the whole user field of vision filled by the world they are looking into. Previous research done by Alireza Mazloumi Gavgani and colleagues[9] find out that the majority of VR-induced cases of motion sickness are more likely a result of the immersive character of VR, producing convincing 3D spatial illusions. This is one kind of virtual reality characterized by the complete surrounding of the field of view of a user with a virtual environment. It increases the sensory conflict between visual and vestibular inputs. VR exposes the visual system of users to dynamic, highly attractive, and sometimes even convincing motion and depth cues. This action serves to further heighten the conflict of the discrepancy between what is seen and how the body literally feels. Especially, the fact that there are no corresponding physical moves in real life leads to more conflict, since the involvement of the vestibular system is not being activated by actual moves. It brings about brain dissonance of coordinated efforts. This deep sensory contradiction is one of the dominant causes of the greater incidence of motion sickness in VR in comparison to traditional, relatively loose immersion 3D gaming effects and less grave sensory contradiction.

Using a VR headset for extended periods of time can make this issue worse. With prolonged exposure, the brain constantly tries to make sense of the conflicting information between perceived movement and body stillness. Over time, motion sickness symptoms can increase and are exacerbated by the discomfort of wearing a headset. This includes things like eye strain and neck strain due to the weight and pressure of the device.

6. Performance Evaluation

Undoubtedly, VR makes FPS games more interesting, most players tend to find that playing in this immersive environment is more attractive. The experiment conducted by Lugrin et al. [10] found a a strong preference of users for the immersive setting (72%), which is also clearly confirmed by their self-reporting. The experiment conducted by Michael Carroll[11] also found that regardless of the game genre, participants in the VR gaming condition experienced a greater level of sense of presence than did those in the desktop gaming condition. The experiment data is shown as below:

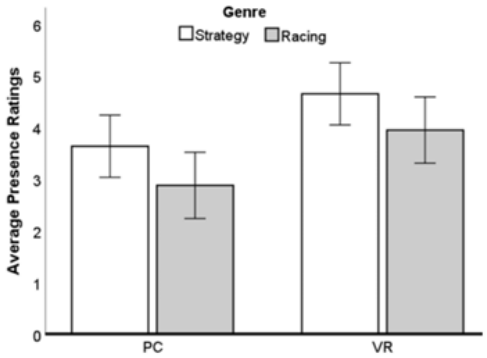


Figure 8: Sense of Presence Levels[11]

This higher level of sense of presence suggests that the immersive nature of VR contributes to a more engaging experience by making players feel more present within the game environment.

Despite the fact that VR indeed makes First Person Shooter Games more enjoyable, as we have analyzed in the previous sections, VR does not enhance our performance in them.

The study done by Lugrin et al. [10] involved a controlled experiment comparing player experience and performance in an immersive VR environment to a traditional desktop setting using the Unreal Tournament 3 game. Participants engaged in a 5-minute FPS 'Death Match' game

under both conditions. The VR setting was realized through a four-screen CAVE™-like setup with a bespoke VR middleware integrated into the game's engine, providing real-time head and hand tracking.

Performance was assessed using in-game metrics along with subjective questionnaires to gauge user preferences and experience. Thirty-nine regular male gamers participated, ensuring a sample representative of the typical FPS player population. The research got data demonstrating the disparities in performance between the two platforms as shown in the following figures.

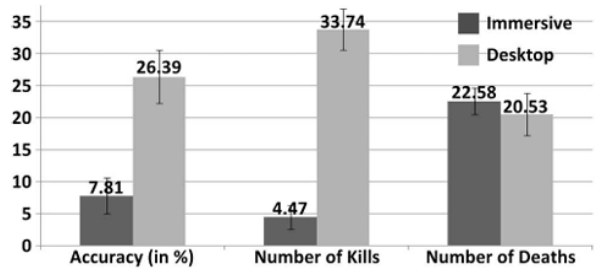


Figure 9: VR vs. Desktop Performance[10]

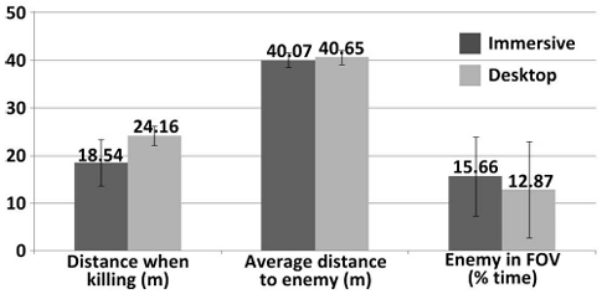


Figure 10: Aiming and Shooting Metrics[10]

From the two figures above, we can clearly see that the performance of playing FPS games on Desktop is significantly better than playing FPS games on VR devices in all aspects. Regarding accuracy, which is most important for FPS game performance, the former is four times higher than the latter. Regarding the overall performance, that is, the number of enemies killed and the distance at which they are killed, the former also has a very significant improvement.These also reveal the challenges VR presents in terms of control and interaction compared to traditional desktop gaming.

7. Thoughts on How to Improve

From the analysis of the above sections, we can learn that VR makes FPS games more fun, but some defects caused by VR itself will make our performance decline in these. So how can we improve these shortcomings to make VR FPS games enjoyable and improve player performance in them? Here are some thoughts of mine:

7.1. Improve Wearability of VR Headsets

As illustrated in Figure 7, wearability of VR headsets can be enhanced from these dimensions, including the weight of the HMD, heat development, torque applied to the neck and cables needed to be connected etc. Besides that, former study conducted [12] proposed 3 more advenced and innovate strategies to improve accomodation and comfort in head-mounted displays.

They suggest that most discomfort when wearing HMD is caused by VA conflict, which means when the eyes adjust and converge (adjustment of the focus points of the two eyes) in the visual system to different distances. They found that equipped the HMD device with focus-adjustable lenses can reduce the VA conflicts significantly, besides, setting different focal distances for each eye and using Depth-of-Field (DoF) rendering can also reduce the VA conflicts.

7.2. Reduce Latency by Changing Rendering Strategies

To improve the comfort of wearing, VR headsets need to be designed lightweight, which results in their ability to render complex game graphics being absolutely inferior to consoles or computers. Even when using VR headsets in streaming mode, where graphics are rendered by the console or computers and then transmitted to the VR headset via Wi-Fi or a cable, there will inevitably be some delay. Besides, VR headset needs to render 2 high-resolution displays for 2 eyes separately instrad of one. Therefore, it seems that the only solution to reduce latency is to improve the rendering strategy for game graphics on the headset. A common strategy is that since users wearing the headset can only focus on a specific part of the screen, for the other parts of the screen, there is no need to render them in great detail. So we can track where they are looking at and only render this part fine and a rough outline graphic of the rest section will suffice. This method is known as the "Forveated Rendering"

Based on the theory mentioned above, this research conducted by Sebastian Friston[13] proposes two more advanced methods to improve rendering on VR. One main idea is using real-time ray casting over tradintional rendering

method and the other one is the implementation of the technique on FPGAs which offers parallel processing capabilities that significantly accelerate the rendering process. To be more specific, real-time ray casting means computing the color and intensity of each pixel by tracing the path of light as rays, which interact with objects in the virtual environment. This method inherently allows for the dynamic update of the rendered image in response to user movements. The final renderer they designed based on these two ideas only has a latency of about 1ms from tracker to pixel.

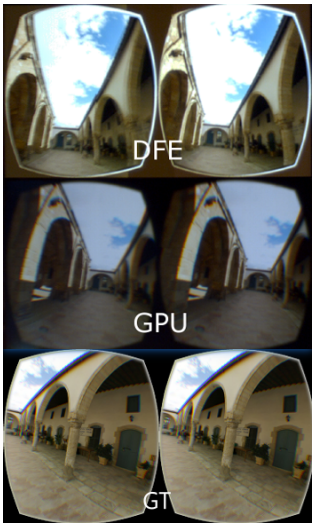


Figure 11: Example frames from two of the capturesof the HMD screen(13 ms exposure)[13]

The above figure shows the experimental results of this study, where DEF denotes Dataflow Engine, which is the rendering result obtained using the technique on FPGAs, and GPU denotes Graphics Processing Unit, which is the traditional rendering result. By comparing the two rendering results, it is evident that the former renders images closer to the ground truth more quickly, indicating a lower latency.

7.3. Reduce Motion Sickness

In section 3.2, we alreay discussed that reduction in latency in section 7.2 can reduce the phenomenon of motion sickness. Besides that, I also have some other methods.

7.3.1. Pleasant Gaming Environment

Previous study finds out that players experience less motion sickness in a pleansant environment than they do in a horror environment.[14] The participants in their experiment are exposed to two different virtual environments: a pleasant environment (VE1) and a frightening environment (VE2). After experiencing both, the Simulator Sickness Questionnaire (SSQ) was administered to determine the subject's symptoms of motion sickness. The questionnaire included indicators such as Nausea(N) and Oculomotor(O) issues to quantify the degree of motion sickness. The data they got is shown in the following figure:

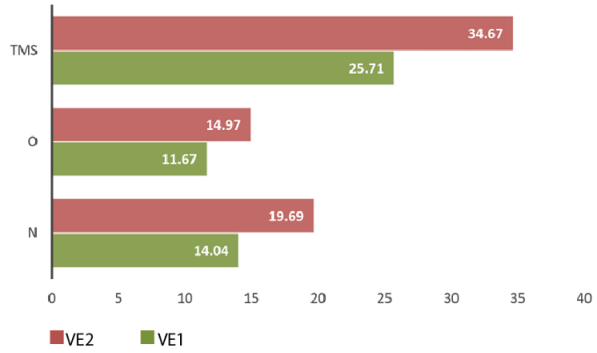


Figure 12: Motion Sickness Scores in VE1 and VE2[14]

From the figure above, we can see that in the VE2(the frightening environment), the scores of N, O and TMS monitored were all much more higher that these in the VE1(the pleasant environment). This clearly shows that frightening environment is more likely to provoke symptoms of motion sickness.

So in order to prevent motion sickness, VR FPS games should try to make their environment more pleasant instead of attempting to create a scary atmosphere in the scene.

7.3.2. Game Design

Some design strategies on game systems can also reduce the occurrence of motion sickness. In the previous study[15], they find out that making sure to maintain the immersion from the start to the very end of the experiment, adding a frame reference, treating VR as theatre instead of a film(avoiding camera animaitions and tricks) all contributes to reduce the symtons of motion sickness in VR. In one experiment they conduct, the participants in the experiment were placed in two different VR environments, one with forced camera movement and one without. The experiment monitored a series of physiological indicators by recording participants' ECG data. These indicators can reflect the participants' stress level and the activity status of the autonomic nervous system, that is, whether they have motion sickness.

The data they get is shown in the following

figure, HR (Heart Rate), RMSSD (Root Mean Square of Successive Differences), and LF/HF (Low Frequency/High Frequency ratio) are all monitored. "WOICM" denotes scenarios without involuntary camera movements and "WICM" indicates scenarios with such movements, "WOC" denotes without Cockpit and "WC" denotes with cockpit.

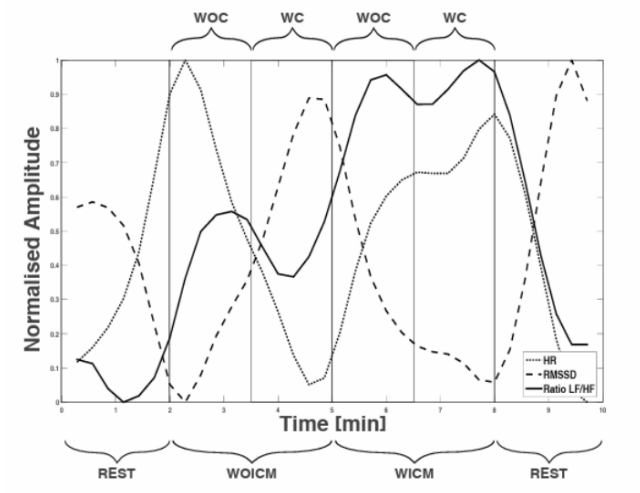


Figure 13: ECG results[15]

he results indicate a significant increase in HR and LF/HF ratio, along with a decrease in RMSSD during "WICM" scenarios, suggesting higher stress and sympathetic nervous system activity, which indicate that the camera movements on VR does provoke motion sickness. The result also shows that the presence of Cockpit also lead to less stress which indicates less symtoms of motion sickness.

8. Conclusion

This paper comes to a conclusion that Virtual Reality does not make the players perform better at First Person Shooter games. The paper prove this by comparing traditional FPS games and VR FPS games from four different aspects: Control Schemes, Latency Issues, Cognitive Overload and Physiological Challenge of VR Headset. By analyzing these four aspects and looking into the corresponding experiment results, it proves the limitations of VR in these aspects which cause poorer player‘s performance. In addition, the paper also prove its idea by discussing other researches‘ experiments on player performance in traditional FPS and VR FPS, indicating that although players do prefer to play the latter, their performance in the former is significantly better. Finally, the article presents some ideas on how to improve players‘ performance in VR FPS, including enhance accommodation and comfort of VR headsets, reducing latency by changing rendering strategy and reducing motion sickness by pleasant FPS gaming environment and changing design of the game system.

References

[1] J-P Stauffert, F Niebling, and ME Latoschik. Latency and cybersickness: Impact, causes, and measures. a review. *Frontiers in Virtual Reality*, 1:582204, 2020. Received: 10 July 2020; Accepted: 30 October 2020; Published: 26 November 2020.

[2] Vodafone. The impact of latency on vr gamers, 2021.

[3] Xiaonan Liu and Yansha Deng. Learning-based prediction, rendering and association optimization for mec-enabled wireless virtual reality (vr) networks. *IEEE Transactions on Wireless Communications*, 20(10):6356–6370, 2021.

[4] Sara Vlahovic, Mirko Suznjevic, and Lea Skorin-Kapov. The impact of network latency on gaming qoe for an fps vr game. In *2019 Eleventh International Conference on Quality of Multimedia Experience (QoMEX)*, pages 1–3, 2019.

[5] M. Umair, A. Sharafat, D. Lee, and J. Seo. Impact of virtual reality-based design review system on user's performance and cognitive behavior for building design review tasks. *Applied Sciences*, 12:7249, 2022.

[6] Arian Mehrfard, Javad Fotouhi, Giacomo Taylor, Tess Forster, Nassir Navab, and Bernhard Fuerst. A comparative analysis of virtual reality head-mounted display systems. *CoRR*, abs/1912.02913, 2019.

[7] Why you feel motion sickness during virtual reality, 2019. Accessed: 2023-03-29.

[8] Ajoy S Fernandes and Steven K. Feiner. Combating vr sickness through subtle dynamic field-of-view modification. In *2016 IEEE Symposium on 3D User Interfaces (3DUI)*, pages 201–210, 2016.

[9] Alireza Mazloumi Gavgani, Frederick R. Walker, Deborah M. Hodgson, and Eugene Nalivaiko. A comparative study of cybersickness during exposure to virtual reality and "classic" motion sickness: are they different?

Journal of Applied Physiology, 125(6):1670–1680, 2018. PMID: 30284516.

[10] Jean-Luc Lugrin, Marc Cavazza, Fred Charles, Marc Le Renard, Jonathan Freeman, and Jane Lessiter. Immersive fps games: user experience and performance. In *Proceedings of the 2013 ACM International Workshop on Immersive Media Experiences*, ImmersiveMe '13, page 7–12, New York, NY, USA, 2013. Association for Computing Machinery.

[11] M. Carroll, E. Osborne, and Ç. Yıldırım. Effects of vr gaming and game genre on player experience. *2019 IEEE Games, Entertainment, Media Conference (GEM)*, 2019.

[12] G. A. Koulieris, B. Bui, M. S. Banks, and G. Drettakis. Accommodation and comfort in head-mounted displays. *ACM Transactions on Graphics*, 36:1–11, 2017.

[13] Sebastian Friston, Anthony Steed, Simon Tilbury, and Georgi Gaydadjiev. Construction and evaluation of an ultra low latency frameless renderer for vr. *IEEE Transactions on Visualization and Computer Graphics*, 22(4):1377–1386, 2016.

[14] Umer Asghar Chattha, Uzair Iqbal Janjua, Fozia Anwar, Tahir Mustafa Madni, Muhammad Faisal Cheema, and Sana Iqbal Janjua. Motion sickness in virtual reality: An empirical evaluation. *IEEE Access*, 8:130486–130499, 2020.

[15] Bruno Patrão, Samuel Pedro, and Paulo Menezes. How to Deal with Motion Sickness in Virtual Reality. In Paulo Dias and Paulo Menezes, editors, *22o Encontro Português de Computação Gráfica e Interação 2015*. The Eurographics Association, 2020.