What Makes VR Different: Implementing Input Mechanics in an Immersive Experience

by

Xinyun Chen

Submitted in partial fulfillment of the requirements

for the degree of Master of Science in Game Science and Design

in the Graduate School of the College of Arts, Media and Design of

Northeastern University

May 2020

Table of Contents

Abstract

With the improvement of both hardware and software technologies, VR has become a popular and established field, which can provide more immersive experiences than other platforms. The current work seeks how and to what extent designing for and playing a VR game is different compared to a regular PC game. To accomplish this, we developed a game both in VR and on the PC and reflected on how to implement particular game mechanics and measured player experiences. We focused on input mechanics that have the same in-game effect but different input from players and applied several iterations in our game development to improve these mechanics through feedback from players. We measured the player experience scale and mechanics to see how these input mechanics influence players' experiences. As a result, we found that input mechanics with more hand interactions can provide more immersive experience. However, while physical rules are great to create realism, gameplay should also be considered during the design process.

1. INTRODUCTION

With the help of Virtual Reality (VR) technologies, players are allowed to have a shared, "better-than-life" experiences in online virtual worlds (Sherstyuk et al., 2009). There are already many VR games that provide great experiences, such as Beatsaber, Superhot, Boneworks, etc. These games are popular not only because of the mechanics, art, or game play, but also because of the experience of being totally immersed in a virtual world. For instance, the core mechanics of Beatsaber are the same as other music rhythm games, which involve making reactions at the right time according to the music. However, in VR it gives the actual feeling of holding two blades and cutting the cubes coming towards the player. While the game's cutting mechanics is technically feasible on other platforms, the same experience is difficult to provide on PC.

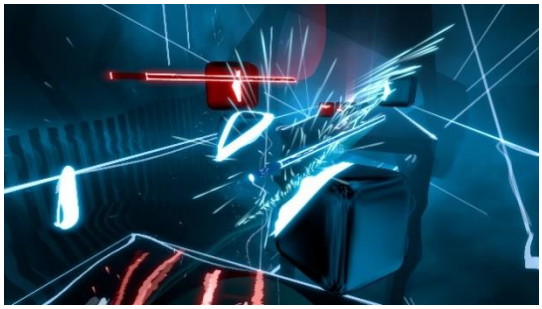


Figure 1. Beatsaber

Figure 2. Superhot

Previous work (Christensen et al., 2018) reveals that a majority of the aspects of player experience were rated significantly higher for the VR versions compared to the non-VR alternative. The result suggests that there is a gap in experience between VR and other platforms for the same game, just because of the nature of VR. In fact, a simple mechanic such as walking around a room and interacting with objects is enhanced in VR. Meanwhile, some traditional mechanics do not work well in VR, such as a fast movement, which may cause motion sickness (Munafo et al., 2017).

We wonder how the same mechanics influence the player experience differently in VR and in PC. Thus, we plan to study this topic through the development of a game. This game was originally focused on creating the experience of being a bat. The world is dark. Players can see objects and navigate the world through soundwaves, similar to a bat. We first built this game on PC, and then we changed the platform to VR. Most players felt more immersed in the game with the VR version, but we did not change any mechanics or scenes in the game.

Thus, in further developing this game, both on PC and in VR, we investigate (1) how similar game mechanics may need to be implemented differently in VR, (2) how the experiences are different between the VR and PC version as a result, and (3) what can be done to make the experience even more immersive in VR. Specifically, we kept the mechanics for these two versions the same, but due to the nature and affordances of both platforms had to implement these mechanics differently (Tosaki et al., 2003). For instance, players can pick up objects both in PC and VR, but the process is different. In PC, players only need to press a key, while in VR, they need to physically clench the motion controller as if they are grabbing something. We are more focusing on how the same game mechanic requires a different implementation through the kind of input provided from the player to perform actions. We call these mechanics *input mechanics* because they provide exactly the same function to the game but use a different way by the player – the input – to accomplish that function.

In our design research, we proceeded by examining how these input mechanics may be experienced differently between the VR version and PC version. Based on that information, we determined what kind of mechanics provide better immersive experience in VR while keeping the gameplay, art and everything else the same. Ultimately, through designing this game, we aim to find specific rules or principles to design input mechanics in VR.

2. BACKGROUND

There is much previous work discussing VR design pattern and VR experience already. We know from the work by Sherstyuk et al. (2009) that while the developing process of Virtual Environment (VE) of VR games is similar to building a 3D world in traditional games, the experience provided by VR could be extremely different. This process is similar to ours. We just simply change the platform to VR without any deliberate design, the experience is improved a lot. According to the research by Peng & Xiaotong(2017), the design patterns and mechanics that work for PC is also changed in VR. For instance, PC games may use mouse and keyboard for character movement and viewport, while console games may use joystick. The inputs are different, but they act the same in the game world. Some people may have different preference between the inputs and may lead to different experience for game. Using joystick for action-based game is comfortable, but for shooting game may be difficult. The design patterns will be different according to the input. Thus, in VR, if we choose physically movement as input, the design pattern will be changed, because the movement range is highly restricted.

Another benefit provided by VR is a body transfer illusion according to the research by Slater et al. (2010). Their experiment on immersive VR supports the notion that bottom-up perceptual mechanisms can temporarily override top down knowledge resulting in a radical illusion of transfer of body ownership. This kind of illusion is specific on VR. The reason is that when we are playing VR, the physically movement is exactly mapped into the VR world. This creates the illusion of controlling the virtual body for players. With hand movements realistically reproduced in VR, it also brings hand ownership illusion(Padilla et al., 2010), which also enhances immersion. Thus, it would be worth figuring out how these input mechanics act differently in the same game, and to seek if there is a pattern for mechanics design in VR.

The idea of our original project comes from Nagel (1974) about the experience of being a bat. For this experience, we used sound as the key method to detect the environment instead of seeing it directly. Consider the difficulty and expression, we decided to illustrate sound with visual element. To illustrate what players see

in the screen related to sound, we are inspired by the game “Perception”(The Deep End Games, 2017), a first-person survival horror adventure where a blind woman perceives the world using echolocation. The woman cannot see anything directly, but she can use her crutch to knock the ground, and the surroundings will be lighted up a little bit. The view that players see in the game is actually what they “heard”. Similarly, bats also use echolocation to locate things and navigate environment, so we refer to this mechanic as using soundwaves to light up the surroundings. The whole scene is dark and most objects in the world are white, because for a sound-base detection the color does not matter.

Figure 3. Perception

Based on this prototype, we are adding more elements to it, such as new mechanics and new levels, to make it a playable game. We will develop it in both VR and PC platform with same mechanics and same art style, to see whether the player experience will be different.

3. METHODOLOGY

3.1 ITERATIVE PROCESS

We built several iterations to study how changes influence the player experience as well as to improve our game. It was originally built in PC but based on suggestions we made a version in VR to explore how it would enhance the experience. It was this change that inspired us to further investigate VR for this game. According to the feedback from players, most of them preferred playing in the VR mode than in the first-person mode in the PC version, even though mechanics are totally the same. The lighting and fading mechanic were also highly praised by players. In order to extend on our project, we decided to make it a more playable game instead of just a walking simulator.

For our further development, we decided on an iterative design process, with input from players. To make our game more flexible to iterate, we just keep the lighting as is a key part of our game. We considered everything else are changeable, even the subject and the background of simulating the echolocation. For our iterative process, we added one or more new input mechanics, playtested this new version in order to receive player feedback, and then we modified, added and/or deleted mechanics to start a new iteration.

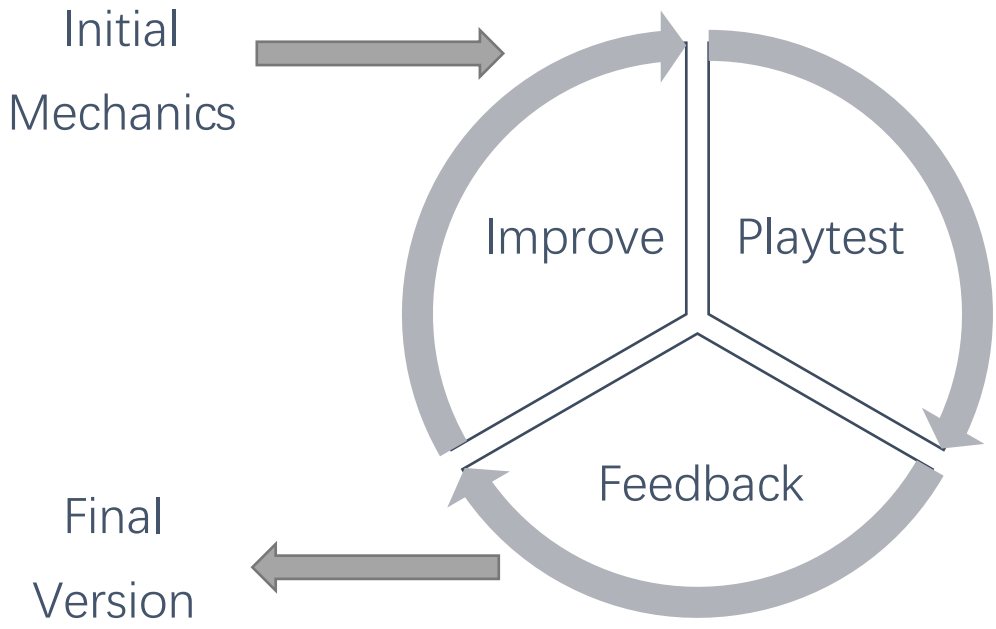


Figure 4. Iteration Process

Though we aimed to have as many iterations as possible, the period of iteration cannot be too short because improving present mechanics takes time. We made a timeline for our project that includes three iterations, ensuring the quality of each iteration as much as possible.

For the first iteration, we focused more on mechanics. We just made some basic mechanics and a playable level for the first iteration and launch playtest for it. Then we decided whether to keep or abandon the mechanics according to the feedbacks from players.

The second iteration was about a whole game. We tried to make a detailed level and did more polishing our game. We designed a complete process of playing to provide objectives for players instead of just wondering. We collected feedback on the overall experience to improve our game. The purpose of this iteration was to ensure that our game is good and fun to play so that the comparison of player experience will be on ground.

We did our experiment after our final iteration, and we had a more polished game with both better design in level and mechanics. Then we launched the final playtest to collect feedback and players runtime data for our research purpose.

Weeks	**Works**
Dec.1~Dec.14	Core mechanics and basic playable level;
Dec.15~Dec.21	First round play test; Feedback collected for **Mechanics**;
Jan.5~Jan.18	Definite and Implement mechanics; More detailed and designed level;
Jan.19~Feb.1	Second round play test; Feedback collected for **VR experience**;
Feb.2~Feb.15	VR experience improving;
Feb.16~Feb.29	Final round play test; Feedback collected for the **Difference** between VR and PC;
Mar.8~Mar.21	Final improvement on gameplay; Final level design;
Mar.22~Apr.4	Trailer;
Apr.5~Apr.18	Polishing;

Figure 5. Timeline

3.2 EXPERIMENT

To figure out what and how mechanics influence the player experience in this game, we made a PC version to launch a comparative experiment. The gameplay mechanics and scene are exactly the same as with the VR version, but the implementation is different. For instance, players can see their hands mapping in VR with motion controllers. Thus, they can pick up objects, like a dead rabbit, dear heart, bow and knife directly by grabbing these with their hands. For the PC, players need to press E to interact with these objects when they get close enough to them. The interactions are somehow restricted in PC version.

In order to measure player experience, we made use of the work by Abeele et al. (2020) who validated a scale on different player experiences aspects, which includes meaning, mastery, immersion, autonomy, curiosity, ease of control, challenge, progress feedback, audiovisual appeal, and goals and rules. We measured overall player experience through these nine aspects as our dependent variable. For the independent variable, we will focus on some specific mechanics. Then we implemented a simple regression for both PC and VR data, to see if they correlate. If so, then it suggests that VR or PC has influence on this aspect of the player experience. Due to the limited data, for these analyses we only look at these results visually, and do not calculate the statistical results (i.e., a regressions model, statistical significance of correlations).

Ideally, we implemented a between-subjects experiment where players would play one of the two versions (PC or VR) randomly, because the previous experience may influence the immersion and control of the next. We expected to have 15 participants for each group. However, because of COVID19, it was difficult to run the experiment as planned. As a result, we implemented a within-subjects experiment where we let players play both versions. We randomized the order to avoid an order effect. After the final version was complete, we ran experiment to get feedback and data about the game experience. Our data was not sufficient due to the limited number of participants ($n = 7$), but we can still find interesting trends from it.

3.3 MECHANICS

We focus on three specific mechanics: navigating, shooting and object grabbing.

Because of the potential motion sickness in VR, there are several substitutes, such as physical movement. While our game has a large space to explore, it is

difficult to just use physical movement. Thus, we kept using joystick to navigate as in other traditional games, and we also reduced the speed of the player to help relieve the motion sickness. As part of our data collection, we focused on feedback on navigation, especially with regards to motion sickness and how this is related to the immersive experience.

Picking up objects is especially different in two versions. Except that players can grab objects in VR, they can also throw them, and the objects will simulate physics to make it more realistic. This will bring more autonomy in the game. Under this setting, when players need to put hearts onto the altar, they can also throw them there, as long as they are accurate enough. Players can even throw and grab continuously between their both hands. With this physical simulation, they can also interact with other objects, like trees and stones in the world. We will relate the feedback on this mechanic with autonomy and immersion to see to what extent they are related and affected.

The last mechanic studied is the shooting mechanic. It is similar to the picking up mechanic; players can have a more realistic experience in VR when they are simulating the action of shooting. However, players need to learn and master it to complete the game. We put a projectile trajectory in the PC version to help with aiming targets, but we did not make such trajectory in VR version. We think that in real life process of shooting, people do not actually have an aiming aid. They need that because they have no idea of the position and direction of the bow in the game. However, in VR, these are under control and more direct to players.

4. GAME DEVELOPMENT

4.1 ORIGINAL WORK

In the first version, our aim was to create the experience of being a bat. Players could move and fly in the world and use echolocation at any time. At the first part of the game, the whole level is dark. Players cannot see anything without echolocation. When they detected anything through echolocation, the object will be lightened up for a short period of time, then it turns to dark gradually. Players need to continuously send out echolocation to lighten up the environment to "see" the world. We made a rough level that includes mountains and valleys, with numerous trees and bushes on it. Players can explore in this level to feel the experience of being a bat. To make it a bit more interesting, we also put three colored trees in the world as a task that player need to find and reach all these special trees.

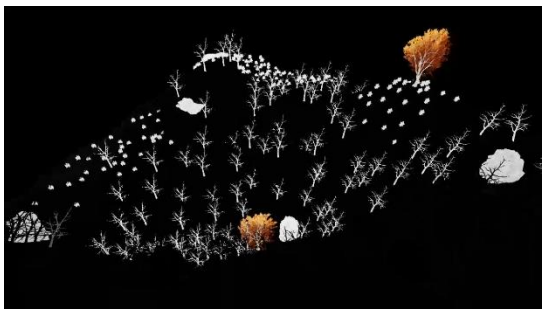


Figure 6 & 7. Our prototype. Players can light up environment with echolocation

We did several iterations for this game, and we collected feedback through survey questions that ask players about the experience. The original game was developed on PC, and many players did not get the feeling of being a bat. Then we built a VR version for this game, as opposed to the previous versions, more players thought it was clear that the character is a bat. Though it was the same game, most players think the viewport from the VR to see objects being lighten up from near to far is much more impressive than on PC.

Meanwhile, we had quite a few issues on the mechanics and game designs. It was reflected by the question that asked them what feeling they got while playing. Most felt eager to explore, but some reported feeling stressed because they felt a little disoriented by the controls. A few people also suggested changing the flying mechanic to make it more responsive so that the player was better able to focus on the direction they wanted to go in.

Overall, the experience and visual effect was impressing among players, which inspired us to work further.

4.2 FIRST VERSION

According to the data and feedback we collected from the original version, we changed some settings and mechanics in the game. First, we changed the subject of the game to a blind hunter, no longer a bat. The reason is that flying is hard to simulate but crucial for a bat experience, while it limits the things that players can do. A hunter could shoot arrows, use knives, interact with objects in the world, and most importantly, they could walk on the ground, which could cease motion sickness when the player is exploring. We also made the ability of sending out soundwaves automatic. When the player is navigating the hunter in the world, they will make tiny footsteps to enlighten the environment a little bit. This change could save players from pushing one key again and again, because in this dark game players could not see anything without sound.

Since the subject changed to a blind hunter, we can put more interactive objects in the world. We put a dog as a reliable friend of the blind hunter, who could move fast in the world, catch other animals and make noise to light up surroundings for the player. We added some deer as prey in the world as objectives. Players need to hunt down these deer with the help of the dog. Deer have high sensitivity of surroundings and could run faster than players. As a hunter, players also have access to a bow and arrow to shoot the deer from distance.

To make the whole game more impressive, we made a preliminary level design. Players would start at a small cave at the very beginning to get used to the control. Outside the cave players could see a dog on the mountain. At this time the dog was not an ally of players, but players could still make noise to attract the dog. Players would also hear growls from an unknown creature. These growls would also lighten objects, like bushes and trees in the level, thus players could

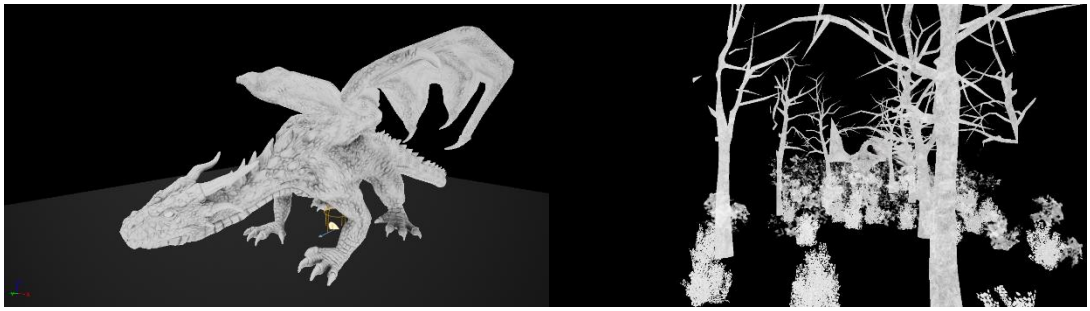


Figure 8 & 9. First Iteration. There was a dragon spreading fire.

trace the origin of the growls according to the order that objects are being lit up.

When player goes up the hill, they would see a dragon flying up and spreading fire to the mountain. Players need to make noise to attract the dog to protect it from being burned by the dragon. After that, the dog would become players' friend and help players with hunting.

Players would see deer after they go down the mountain. The deer is sensitive but weak to the dog. If players succeeded to save the dog, the dog would catch the deer easily after it sees the deer. Otherwise, players need to shoot the deer accurately from distance. After being hit, deer would escape and move to a lower place and leave footprints on the ground. Players need to trace the footprint on the ground to hunt down the deer.

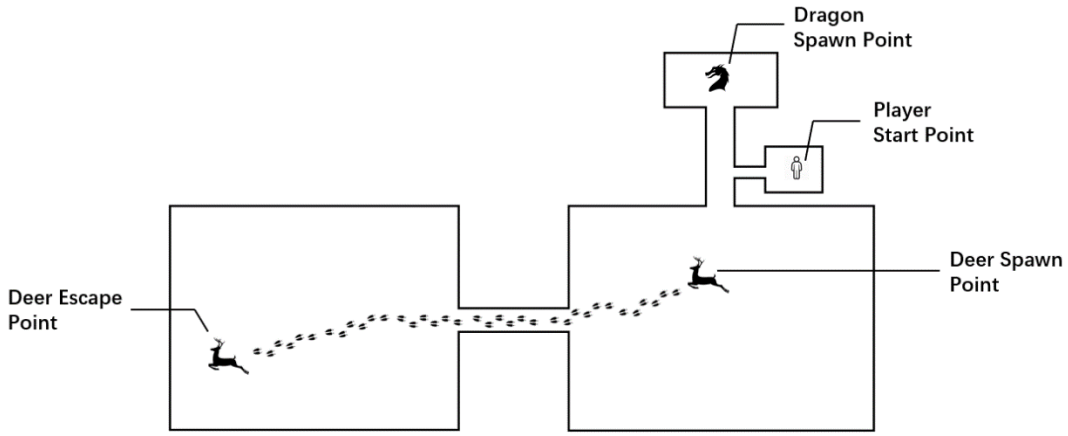


Figure 10. First Level Design

From this version, we received numerous suggestions and feedback on the gameplay. The learning curve of the game was too high for players because we gave them everything at the beginning of the game. We need to make the process of the game also a process of learning, which is not too hard at first. The dragon was great on visual effect, but not reasonable at the beginning phase. Almost everyone tried to use arrows to kill the dragon when they say it the first time. The space was too open for just hunting a deer and many people lost their direction. The instructions of the game were mostly we told them so that if put players directly in the game, they do not know what to do at all.

Although there were a lot of problems, the whole style of the game and some key mechanics were praised on our first play test. We continued and for our final version, we remade the whole map and interactions.

4.3 FINAL VERSION

We added a background story and extended the game process. We gave players a clearer objective to hunt some animals in the area and bring them back to an altar. The altar would then start tolling and lighten up a large area. The altars are permanently lightened so that without instructions, players will go to the only lighted spot in the dark world. We used this trick as latent instructions in the game, without any other text hint. We also added other kinds of enemies, as well as a new weapon to make the game more playful.

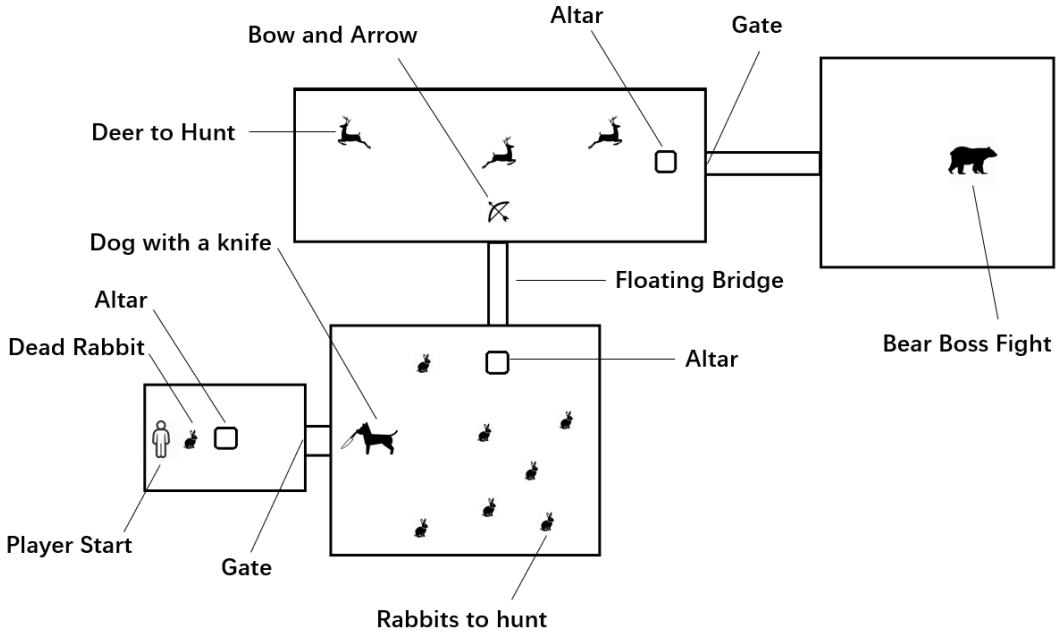
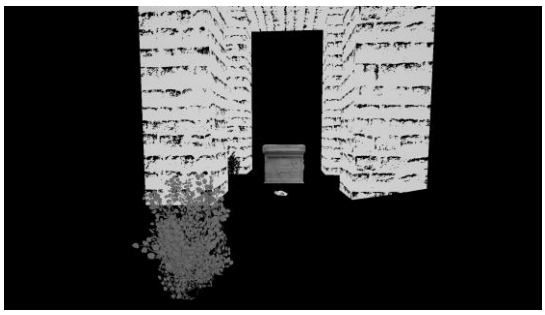


Figure 11. Final Level Design



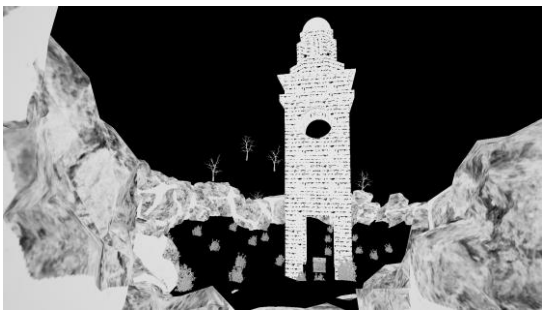


Figure 12 & 13. When the rabbit is put on the altar, it will be activated

At the start place, we put a dead rabbit in front of players, and an altar behind the dead rabbit. We supposed that players will pick up the dead rabbit and put it on the altar. Then the altar will be activated and lit up a large area. Meanwhile, the gate in front of the altar will open. It will send out soundwaves and make

noise to tell the player that there is a hidden way here and now it is open. With these kinds of implicit guides, players will be led to the place that we want them to go.


Figure 14 & 15. The dog comes to players with a knife

After the stone gate opens, players can see an overview of the next area with a thunder trigger. When they jump and step on the next area, the dog will come towards the player with a knife in its mouth. After it gets close to the player, it will put down the knife on the ground and sit down there, waiting for player to interact. Once players grab the knife, the dog will back stand up and become aware of the prey around. If there is no prey, the dog will follow players. There are some rabbits around in this area, but without the help of the dog or the knife, players cannot catch them. Players can see another altar in the distance and will know to put a dead rabbit on this altar because of the previous experience.

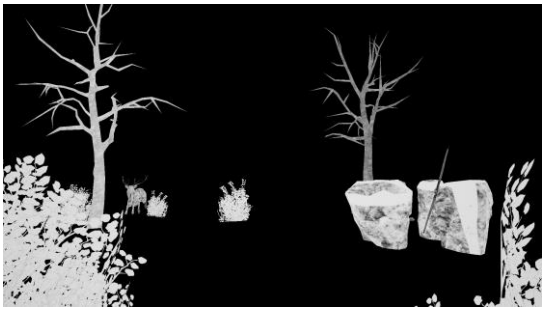



Figure 16 & 17. Put the rabbit on the altar, players will see the bridge float up

When players worship another dead rabbit on this altar, a bridge consisting of pieces of stones will float up the river piece by piece. Players can see a bow lying among the rocks when they go through the bridge. Inevitably, they will walk on bushes, which will make noise and the three deer around will escape in different directions. Players get to know that walking on bushes will make noise and alert the deer. They can also see another altar on a small slope that is light, so they need to get the bow and hunt deer back.

The arrows can also make tiny soundwaves that helps scouting. The dog is further a great help with the hunting. It can bite the deer and keep it from escaping so that player hit it easier. We made a small difference on the deer that players need two shots in total to hunt it down. When the deer falls down, it will


Figure 18 & 19. Shooting also lights up the environment

be struggling on the ground. If players get closer, they will hear a tiny sound of a heartbeat, which suggests it has not died yet. Players need to use their knives to execute it. After that, the deer will stop struggling and players can see a red heart inside its body. Players are supposed to bring this heart back instead of carrying the whole deer to the altar.

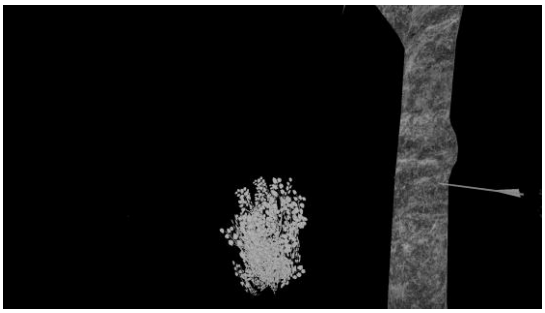



Figure 20, 21, 22 & 23. Players need to hunt the dear in darkness. The dog will help players.

The same as previous, once players bring the heart back to the altar, a stone gate to the next area will open. But this time players can hear strong thunders and it starts to rain. All the objects in the world will be lightened randomly every second. Players can go through the stone gate, following the small stones on the

ground and will see a bear in the end of the road.


Figure 24 & 25. Put the heart on the altar, it starts raining

As the boss fight, the bear will roar after it sees players or hears any noise players make, even with a single arrow. The bear will charge towards player and cannot be stopped by arrows. If the bear reaches players, it will start biting and players cannot move at this moment. The dog will run to the bear and fight the bear to free players for the first time. The bear can fight of the dog easily, and then return to chase players. Thus, players need to use their arrows to hit the bear as many times as possible. If players get caught again, the only way to escape is to use the knife to hit the bear's eyes. The bear will fall down in pain, free players and give them a long time to attack. The boss fight makes the game more challenging and it covers everything that players get or learned from the previous game process.

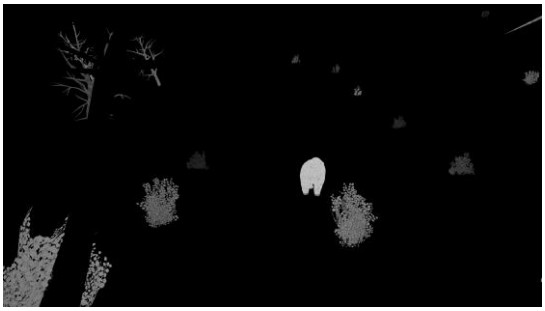



Figure 26, 27, 28 & 29. Final Boss Fight

4.4 INPUT MECHANICS

During the iterations of the game, we also iterated on our input mechanics to make them more feasible.

For the first version, the navigating in the game was flying in the world. Because we wanted to simulate flying as a bat at first, players can control the height of flying by pressing space bar. Since we changed the subject to a hunter later, players cannot fly and jump anymore. They can just walk on the ground. To prevent players entering some places like the river, we added invisible walls to limit their movement. Players can use the joystick to navigate at first, with the left joystick controlling the movement and the right joystick controlling the direction. This setting is common in traditional PC games. But after the second iteration, we found it may cause motion sickness when players use the right joystick to change the direction in VR. We changed the design in VR so that players cannot use the right joystick anymore. Instead, they can turn their head mounted display to control their direction. This change reduced the autonomy, but is more intuitive and caused less motion sickness.

Figure 30 & 31. Picking from distance

The object grabbing was applied in a simple manner at first. Players simply need to reach the object first, then click the trigger to grab it. We applied physical rules to objects so that players can throw objects away with hand movements or do other physical simulations with objects. However, it was hard to reach the objects exactly, especially when the object is on the ground. Players have to bend over to grab it, which is inconvenient and redundant. Thus, we made it easier to grab objects from distance instead of touching them directly. Although this does not apply physical rules strictly, it did not break the gameplay.

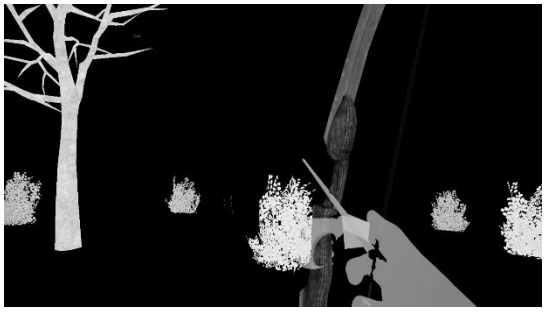



Figure 32 & 33. Shooting direction is actually restricted

For the shooting mechanic, we had several plans to do this in VR. We made the bow and arrow interactive items at first. Players need to attach and grab them first, put the arrow on the bow next, then pull the bow and shoot the arrow out. This process is the same as real life, but it is not convenient for a game. Thus, we enabled players to summon a bow in their hand directly when they click the left trigger. After that, they can summon an arrow by clicking right trigger. We also made some changes in controlling the directions. We made players able to control the direction by pulling the bow first, but it was hard to control in the game because most players cannot hold their hand stable to shoot the direction they want. As a compromise, we lock the axis of the arrow in later iterations. Players can only shoot the direction where the bow is facing, and they can change the direction by moving the bow. This was much easier and acceptable, and most players even did not figure it out that we have locked the axis. Because they can still change the direction.

We made these iterations on our input mechanics to make them more feasible for players, thus we can get more convincible data for our experiment.

5. RESULTS

5.1 OVERALL PLAYER EXPERIENCE

We use a 7-point Likert scale survey questions to measure according to the scale model of Abeele et al.(2020). The survey questions include nine aspects, with three questions in each aspect. Then we calculate the sum of points in each aspect to get a general idea about the overall player experience.

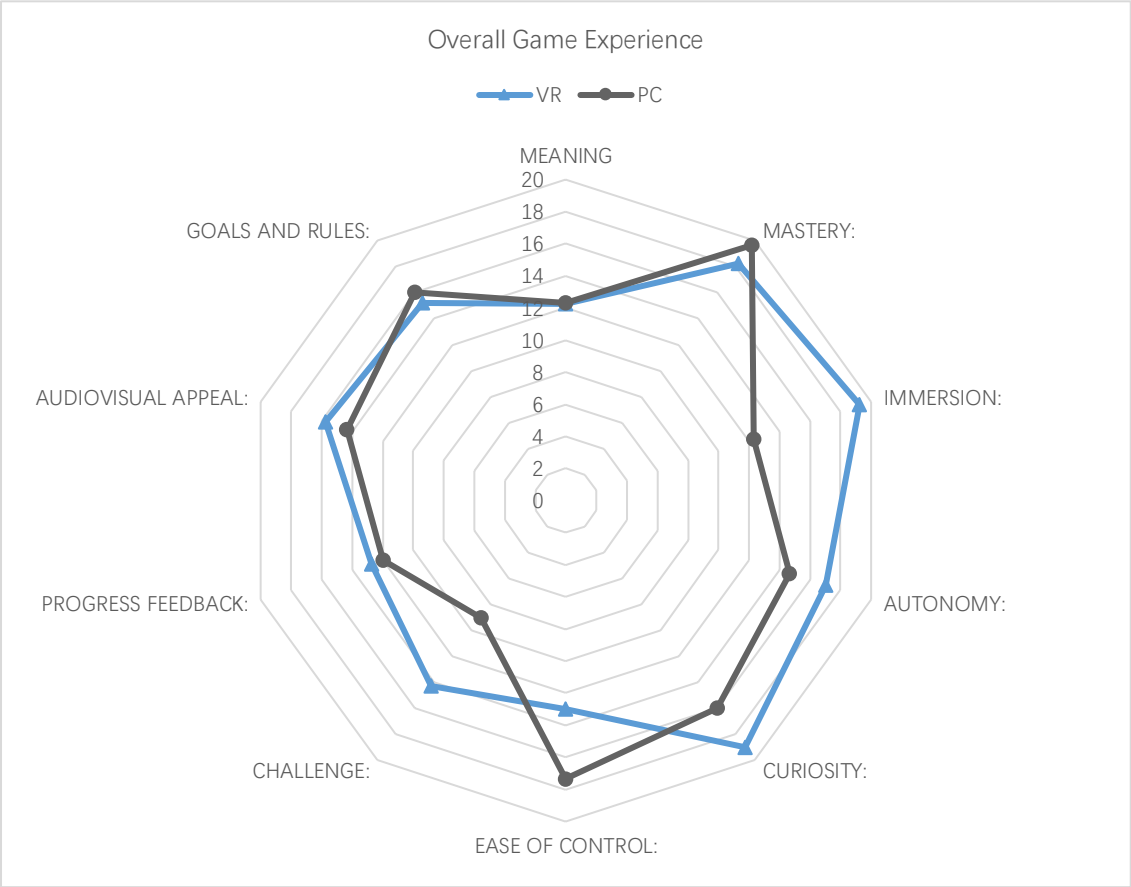


Figure 34. Game Experience in Nine Aspects

We can see from the figure that the VR version has nearly the same points in each aspect with the PC version, except for the ease of control aspect. For the immersion part the VR version has a great advantage to the PC version. The ease of control is lower may attribute to some players are not familiar with motion controller, and the lack of shooting aim. We can assume that it is too easy for players to shoot in the PC version. Thus, the VR game really enhanced the game experience a lot, even if the game mechanics are the same.

5.2 RELATIONS

After that, we looked how the mechanics may have influenced the experience. As we mentioned before, we will focus on the correlations from one mechanic to one aspect.

We made the point of players' willingness to picking up objects as independent variable, and the feedback on immersion aspect as dependent variable. Then we did a simple linear regression on the several data points to see if there is correlations between the two variables. We can see from the chart that the VR trend is higher than the PC, which is not a surprise because we expect that VR has overall great immersion. The slope of the trend is positive, while for the PC trend, the slope is almost zero. This is an interesting outcome. It indicates that this certain mechanic, picking up objects, indicates how players feel immersed in VR, and that comparatively players who do this more so feel more immersed in the VR than the PC version.

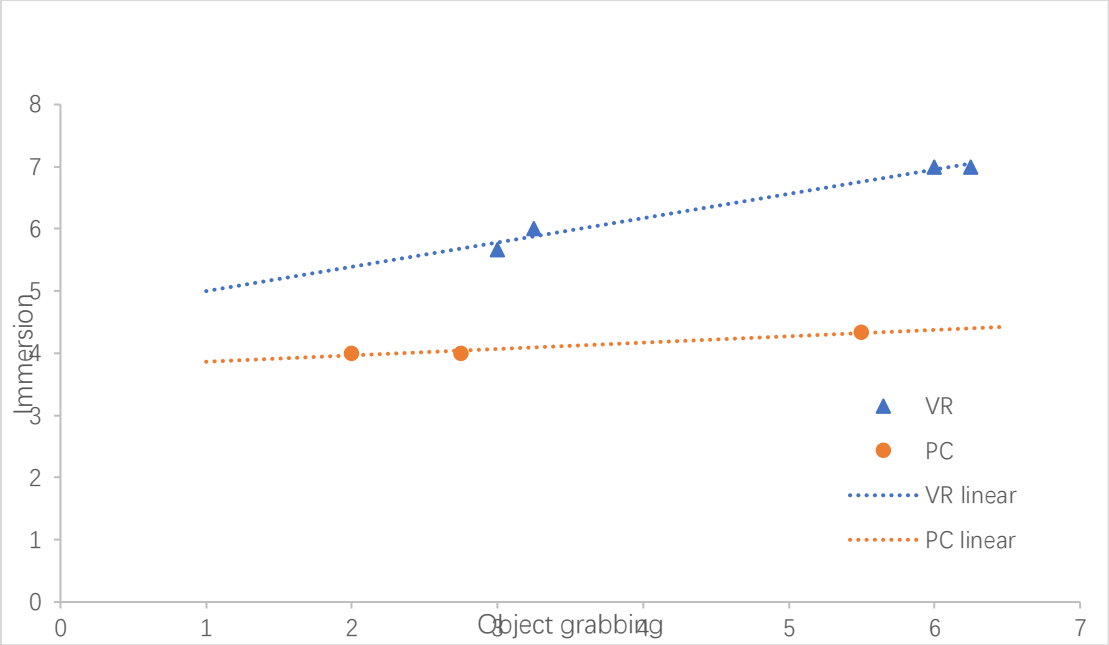


Figure 35. Relation between object grabbing and immersion

Another example is the correlation between arrows and mastery. Similar to the previous one, we make the players' preference of shooting as the independent variable, the mastery as the dependent variable to see the relations. We can see from the chart that in the PC version, these two are almost not related. In VR, they have a linear relation that the more players like the shooting, the more mastery they feel about the game. Although someone does not like the shooting

mechanics will feel less mastery on the game compared to the PC version, it gives a positive feedback when players become familiar with the mechanic.

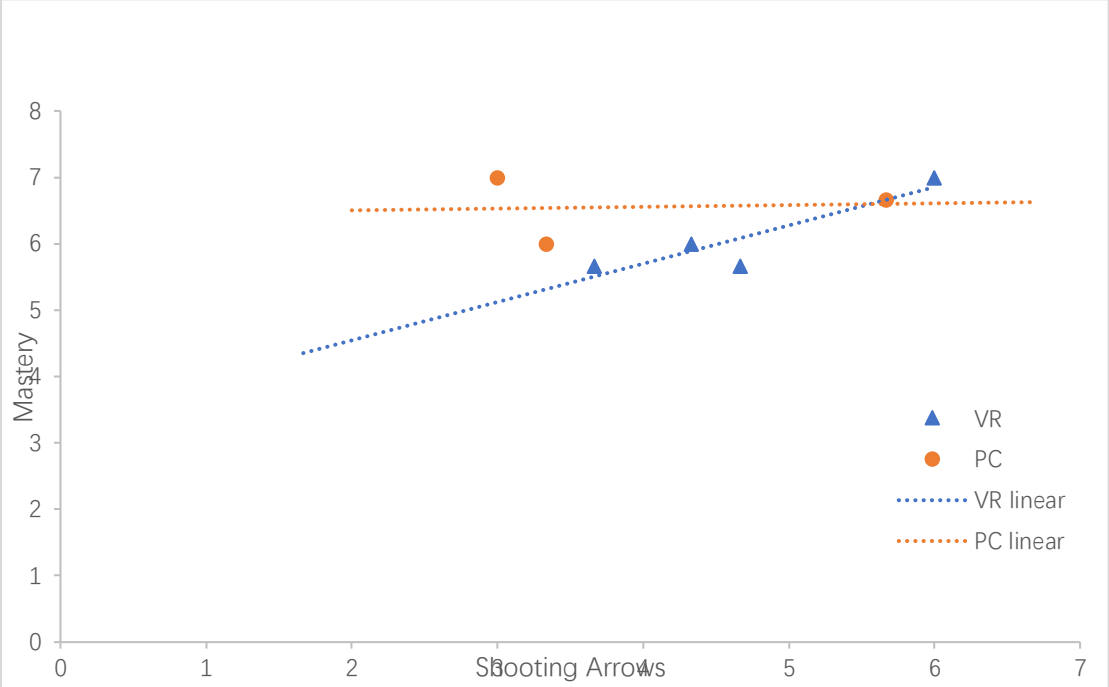


Figure 36. Relation between shooting arrows and mastery

6. DISCUSSION

6.1 INPUT MECHANICS FOR VR

We have developed different input mechanics for VR and PC in our game and collected feedback and data on these mechanics. Here we will discuss two key insights from developing the input mechanics in VR based on our game and the results of the experiment: realism and gameplay. Designers will need to balance these in designing input mechanics for VR.

Realism

Realism is the basis of providing immersion to players in VR. To achieve this, it is important to make mechanics more intuitive. For instance, when players see a bow, they will never suppose using the joystick to pull the bow and pressing a key to shoot. When they see something on the table, they are more likely to grab it rather than press a key to interact. The better way is to simulate how it works in real life. Applying physical rules is also good for creating immersion. According to our experiment results, most of the players like to pick up objects, because these objects have physical rules such as that they can be throwed away. They also prefer the mechanic of grabbing and shooting in VR than in PC.

Gameplay

While making the game as realistic as possible, the gameplay part cannot be ignored. In our development process of input mechanics, we tried to make the mechanics the same way as in real life, but that just made the game hard and uncomfortable. It is important to find the balance between realism and gameplay. We need to make the mechanics easy and feasible for players, while not breaking the immersive experience. For example, we found we needed to make it easier to grab objects in VR. Players can then reduce their movement but still get the feeling of getting objects in their hands.

6.2 DEVELOPMENT REFLECTIONS

Overall, our game received positive feedback from players, but there are still a lot of issues. First, there are quite a few hard decisions that we had to make during the development. For instance, to decide whether to keep the old theme of a bat or change to a hunter's story was critical for us at the beginning. The previous one is more conserve and the latter one is risky. We chose the latter because our game needed more playable elements. While we added a lot of interesting stuff,

like the dragon and footprint system in the game during the first iteration, we also made a tough decision to cut these things off. The dragon was rather popular among players, but we decided to remove it because it is weird to have a dragon after you hunt rabbits and deer. We decided to replace the dragon with the bear. Although it brought more work, but we kept on doing that and finally we made the game better.

Second, we should have a balance between efficiency and effects. Though we had a long time for the development, the time between each iteration is not enough for us to make every detail perfect. In the first round of playtests, we were too focused and spent too much time on the dragon's flame. There were a lot of small runtime bugs in the first playtest and most of the players did not have the experience that we expected to provide them. This shows the importance of a project manager to coordinate the design process and task assignments.

Last but not the least, it is important to listen to players. When we are developing and testing by ourselves, we know each detail in the game and the process of the game, and we often believe that players will play in the same way. In fact, most players play our game differently from our expectations. We assumed players would see the dog and then use whistles to lead it, but most players try to attack it with arrows. On the one hand, the lack of introduction and guidance enables players to explore in their own ways. On the other hand, when we are developing, we are often trapped by our own thoughts. Hearing more from players will escape us from these mind traps, and also enlighten us with other ideas. We were fortunate to have several playtesters and experts play our game and give advice during our development. Thus, we saved a lot of time and make the game more acceptable for others.

7. CONCLUSION

In summary, VR games can provide a similar game experience for players but exceed in some aspects. Designing mechanics for PC may not work the same way as for VR. The same mechanic with different input can result in a more immersive feeling in VR.

Players can see their hands, and feel the object is in their hand. They can also interact with the object the way they want, like throwing it away, or pulling the bow. While objects around are all accessible to players, no matter they can touch, grab or do other interactions, it will create more realism and more immersion. Players will feel they are wondering a real world, but not just in a game. This suggests the mechanics in VR is better to be more interactable and touchable.

Applying physical rules is also important to create a realistic experience, but gameplay is the priority. As we mentioned before, we make some changes to our mechanics. The pattern here is to include as many physical rules as possible, while not ruin the gameplay experience.

In the future, we will add more elements to our game. We are not going to have other mechanics, because every mechanic in VR needs to be deliberately tested before we add it into the game. We will focus on level designs and art with our current mechanics. We will also extend the length of our game and polish it more.

REFERENCES

Abeele, V. V., Spiel, K., Nacke, L., Johnson, D., & Gerling, K. (2020). Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences. *International Journal of Human-Computer Studies*, *135*, 102370. https://doi.org/10.1016/j.ijhcs.2019.102370

Christensen, J. V., Mathiesen, M., Poulsen, J. H., Ustrup, E. E., & Kraus, M. (2018). Player Experience in a VR and Non-VR Multiplayer Game. *Proceedings of the Virtual Reality International Conference - Laval Virtual on - VRIC '18*, 1–4. https://doi.org/10.1145/3234253.3234297

Munafo, J., Diedrick, M., & Stoffregen, T. A. (2017). The virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects. *Experimental Brain Research*, *235*(3), 889–901. https://doi.org/10.1007/s00221-016-4846-7

Nagel, T. (1974). What Is It Like to Be a Bat? *The Philosophical Review*, *83*(4), 435. https://doi.org/10.2307/2183914

Padilla, M. A., Pabon, S., Frisoli, A., Sotgiu, E., Loconsole, C., & Bergamasco, M. (2010). Hand and Arm Ownership Illusion through Virtual Reality Physical Interaction and Vibrotactile Stimulations. In A. M. L. Kappers, J. B. F. van Erp, W. M. Bergmann Tiest, & F. C. T. van der Helm (Eds.),

Haptics: Generating and Perceiving Tangible Sensations (pp. 194–199). Springer. https://doi.org/10.1007/978-3-642-14075-4_28

Peng, C., & Xiaotong, L. (2017). Analysis of Artistic Language in the Virtual Reality Design. *Proceedings of the International Conference on Video and Image Processing - ICVIP 2017*, 259–263. https://doi.org/10.1145/3177404.3177446

Sherstyuk, A., Vincent, D., & Treskunov, A. (2009). Towards Virtual Reality games. *Proceedings of the 8th International Conference on Virtual Reality Continuum and Its Applications in Industry - VRCAI '09*, 315. https://doi.org/10.1145/1670252.1670322

Slater, M., Spanlang, B., Sanchez-Vives, M. V., & Blanke, O. (2010). First Person Experience of Body Transfer in Virtual Reality. *PLOS ONE*, *5*(5), e10564. https://doi.org/10.1371/journal.pone.0010564

The Deep End Games. (2017). *Perception*. The Deep End Games.

Tosaki, K., Himoto, A., Oikawa, A., & Sugahara, H. (2003). *Input device, game device, and method and recording medium for same* (United States Patent No. US6517438B2). https://patents.google.com/patent/US6517438B2/en