Comprehensive Creative Technologies Project: Investigating the role of haptic feedback in enhancing immersion and player experience in games.

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Abstract

Haptic feedback has been present in video games for years as a way to immerse players into games through their sense of touch. While video games already immerse the players sight and hearing, developers also look to immerse the players sense of touch to further draw the player in to their game. But what does haptic feedback do for the player in order to help with immersion and to what extent is it impactful in the grand scheme of the game. This can be tested through investigation and experiment, by testing players experience when exposed to haptic feedback and without haptic feedback, inferences can be made about the role of haptic feedback in players immersion. Haptic feedback helps the player feel more present in the world and therefore more immersed. When an already immersive experience is presented to players with the addition of haptic feedback, players feel more connected to the world, as well as clear up certain actions for the player and make certain activities feel fairer keeping players in a state of immersive flow. This shows that haptic feedback does have a role in enhancing the immersion of the player experience, with overall positive effects for the player. This shows that haptic feedback is

important for developers who want to draw players into their game even further on top of what they have already produced.
Keywords: immersion, flow, experimentation, haptic feedback

How to access the project (not included in word count)

Verdana, 9pt. Provide any **project URLs** and/or details of where/how to access your project, and the ***URL of your final video***. If we need access to servers / administration interfaces please provide credentials and URLs. What we cannot access we cannot mark. You can change passwords after you receive your mark.

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If there is a particular method for providing access to your project you will need to provide instructions here. Also if there is anything we need to know about the work that will not be self-explanatory, then also provide brief instructions here.

Github link: https://github.com/mattsummers7/hapticproject

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1. Introduction

Immersion in video games is an important aspect in the lifecycle of a game. Poor player retention is due to the players needs and wants when playing a game. If something isn't interesting, challenging, or fun then odds are the player will drop the game and finding something that will interest the player. By keeping the player immersed in the game they are playing, they will continue to play and enjoy what they are doing. This leads to huge benefits to developers such as positive reviews which spreads the word out about the game which attracts more players to purchase and play the game.

There are many ways to make a game immersive. Most commonly games try to become immersive through expertly crafted story telling or even music. However, one less talked about method of making a game feel more immersive is haptic feedback. Haptic feedback refers to the ways a developer would convey information to a user through touch. This is most common for video games through the use of vibrations.

From controllers to phones, most video games controllers or devices have built in components dedicated to vibrating the device on certain interactions. Developers can use this to their advantage by putting vibrations on certain events in their game to convey something happening to the player.

Recently, companies have even been investing in new haptic feedback technologies that further push haptic feedback in games beyond simple rumblings with increased tension on certain movements. So are companies right in this investment or is it hindering the industry with technology that has a negative impact on gameplay.

The main question is, does this really have an impact on the player and more specifically their immersion in a game? Does haptic feedback help the player feel more immersed or does it distract them from the greater video game and take away from their immersion? Does haptics have a similar role to music and storytelling in keeping the player immersed in the game they are playing?

2. Research questions

This paper will go over haptic feedback, its uses in current day video games and go in depth about how it can be used in video games effectively to enhance the player experience and immersion. Does haptic feedback have a positive impact on the players immersion or does it have a negative impact, instead working to take the players out the game and distract them rather than continue to pull them in.

The project objectives are:

- Find out whether using haptic feedback affects the players immersion in a positive way.
- Haptic feedback's role in enhancing the player experience and immersion.

3. Literature review

3.1.1. What is haptic feedback?

Haptic feedback is the use of touch to communicate with users (Ultraleap, 2019). More

specifically it refers to the computer's ability to touch the user.

This has been done through many methods however most commonly it is produced used vibrotactile haptics and is most common in electronic devices such as controllers or phones. It also however has use in a wide range of devices such as CO2 gas monitors which vibrate when exposed to CO2 gas in order to warn the user that the environment around them might not be safe. The most common method of providing this feedback is a vibration motor. A vibration motor is a cylindrical device that when powered will spin causing it to vibrate the device.

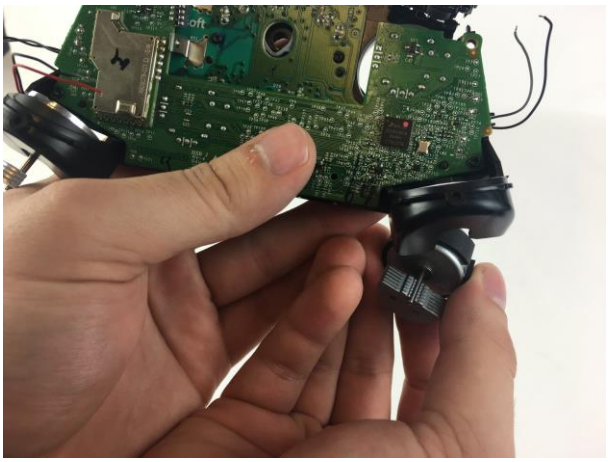

Fig 1: Xbox controller that has been taken apart to reveal is vibration motor in the handle of the controller.

There are many other types of haptic feedback as well that provide the feeling of touch to the user. Ultrasonic mid-air haptics are ultrasound waves which are combined to create a force that can be applied to the user's hand. Georgiou et al. (2018) describe using this technology to create rhythm games that use the hand directly instead of a controller and having touchless haptics being used on the hand to give the player some feedback of the players actions in game.

Finally, force control also provides feedback through the use of mechanical devices that forcefully push back on the user to provide a unique sensation of force on the user. This method of haptic feedback has an important role in rehabilitation for those with restricted movement or disabilities to do with movement.

3.1.2. History of haptic technology in games and its growth.

In the 1970s arcade games started to feature vibrotactile feedback in order to level up immersion of their arcade cabinets. Fonz (Sega, 1976) was one of the first games to feature haptic feedback within its control through a rumble of the steering wheel when the player would crash into another player's bike on screen. This feature was widely received as pleasant and kickstarted other companies into thinking how they could incorporate haptic feedback into their games.

Console manufacturers began to start thinking about haptic feedback themselves too with Nintendo being one of the first to unveil the N64 Rumble Pak, an accessory to add vibrotactile feedback to games on the N64.

Other the years companies started to incorporate haptic feedback directly into their devices with PlayStation leading the way with their DualShock controller. Named after its dual vibration motors, the controller was directly built into the controller rather than an attachment run on battery power and would allow developers to add another layer of presence in their games.

Finally, PlayStation has further enhanced the user experience with haptic feedback through their recent DualSense controllers that provide high definition vibrotactile feedback as well as force feedback in the controller's triggers which allow developers to change the amount of force needed to allow a player to press the trigger.

3.1.3. How haptic feedback is being used in games.

Video games utilise haptic feedback in a variety of different ways. One of the most common ways haptic feedback is used is through button inputs in correlation to events on the screen. One example is first person shooter games. In FPS games haptic feedback is most common used when firing the weapon. For example, in Call of Duty Advanced Warfare (2014) the player would receive haptic feedback when they shoot their weapon. While a automatic weapon would provide constant short bursts of haptic feedback, a slower shooting weapon such as a pistol would provide bursts of vibration whenever the button would be pressed. This adds a sense of impression in the game world (U. Söderström et al. 2022) making the players actions while shooting feel more impactful then if it was turned off.

Another way games utilise haptic feedback is through story telling and the world environment. Events on screen such as explosions, doors opening or even certain sounds. Control (2019) uses haptic feedback when the player moves around in relation to footstep noises as well as when explosions happen on screen.

Recently, researchers have extended their scope to full body haptic feedback [M Khamis, 2019]. This involves using electric muscle stimulation based on what players were experiencing in game. For example, using stimulation in the arm and forearm to stimulate the hand to move when the player was shaking the hand of an NPC during a

cutscene. While it does not have much application in normal retail releases due to the matter of the availability of the equipment required, it does have a positive impact on gameplay making it feel "more realistic".

3.2.1. What is immersion?

Immersion is defined by the Oxford Dictionary as "absorption in some condition, action, interest etc." Therefore, when referring to video games immersion can be connected to ability to draw people in (Jennett et al. 2008). Well designed games have the ability to have players "lose" themselves in the world of the game leading to people losing track of what is happening around them such as the amount of time that has passed or another person calling the player's name.

The ability to immerse the player in the game is reliant on a variety of variables that the developer needs to consider when making their game. In their investigation, Emily Brown and Paul Cairns (2004) come up with a new model that explains the barriers to immersion.

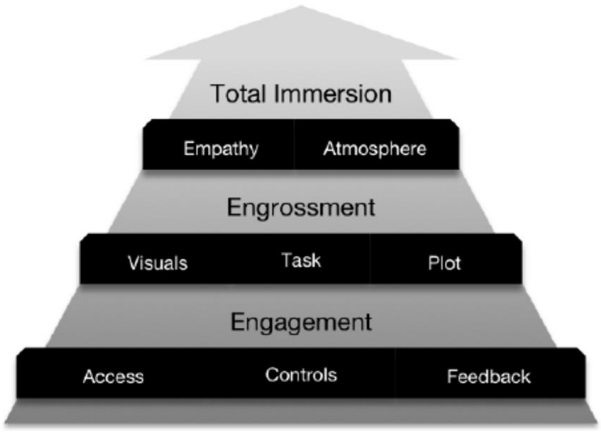

Fig 2: Immersion model of Brown and Cairns – shows the barriers to immersion from bottom to top.

The first barrier to immersion is engagement in which the player needs to be able to invest time, effort, and attention as well as fall into the players individual preferences. Next is engrossment which refers to the construction of the game itself such as visuals, tasks, or even emotional beats from the plot of the game. Total immersion is presence. The total combined features such as the graphics, plot and sounds combine together to create a meaningful atmosphere and overall immersive experience.

Therefore, when experiencing immersion in video games, it's important that every aspect of the game works together to provide a meaningful gameplay experience to provide the user with presence in the game world and that their actions are impactful.

3.2.2. Measuring immersion and flow state

It may be easy to describe the feeling of immersion however what is more difficult is quantifying and measuring immersion. This is where the flow state is important for the aims of this project.

Originally theorised by Mihaly Csikszentmihalyi (1990), flow state refers to a state of consciousness whereby the person experiences clarity of goals and knowledge of performance and complete concentration. This is very similar to the idea of immersion, with both referring to people "losing" themselves in their activity or objective and a complete focus on the task at hand.

Flow is constructed from a variety of different characteristics, initially outlined by Mihaly Csikszentmihalyi but expanded upon by Susan Jackson and Herbert Marsh (1996). First is a challenge-skill balance in which a person's skills is being fairly challenged and matched by the task at hand. This along with a clear goal also helps with flow giving a person in flow a strong sense of what they need to do. Next is action-awareness merging in which there is no awareness of self as actions just become spontaneous or automatic as total concentration of the task occurred. Loss of self-consciousness links to immersion as the concern for the self disappears allowing the person to become one with the activity as well as time altering as things either slow down giving the person time to think or time speeding up while doing the activity. Finally, are the end results of the flow state in which clear unambiguous feedback is given from the activity itself as well as an autotelic experience that leaves the person with a state of enjoyment or reward.

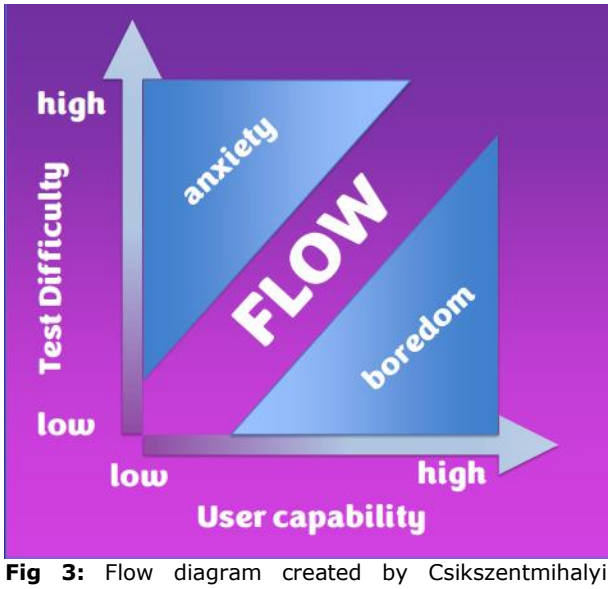

Fig 3: Flow diagram created by Csikszentmihalyi showing off how a high the tasks difficult and the users skill contributes to the flow state.

While similar, where immersion is difficult to measure and quantify, the different characteristics

of flow and the concept itself gives people the means to measure how well immersed the person is in any given task. For example, in an experiment done by Madison Klarkowski et al. (2015) a test was done using the 7-point Likert scale against each of the 9 different characteristics of flow. This allowed for a quantifiable value of flow to be collected and used to measure the flow of a game. Additionally, qualitative data can be used to get more detailed information of each of the flow characteristics from participants.

3.3.1. Previous experiments on the haptic feedback and immersion

While creating this project it is important to look at past examples of work to not only gather inspiration but also explore different types of experimentation in order to create something that will answer the aims of the project.

Qusim Saboor and their team write about using haptic feedback in a virtual gardening experience to evaluate the effect of haptic feedback on mental immersion (2017). This experiment used haptic gloves to help emulate different objects in the players hand while wearing a VR headset. The experiment results in a slightly higher response in player presence with haptic feedback compared to not. The idea of having participants test using haptic feedback and not using haptic feedback provides interesting results and the ability to measure how much having haptic feedback affects immersion.

In another experiment Chien-Min Wu, Chih-Wen Hsu, Tzu-Kuei Lee & Shana Smith created a haptic glove that tracked finger positions and postures and used micro-speakers to create simulated vibrations in VR. Using the Likert scale, it was found that participants preferred the virtual controller compared to using the physical keyboard showing that a virtual keyboard performs better than a physical keyboard in fully immersive VR environments.

4. Research methods and Ethics

For this project, experimentation with participant information is the best way to gather results on whether haptic feedback enhances the player experience and immersion. In order to know if haptic feedback has an impact, different people will need to try the gameplay and give feedback on their experience.

Therefore, observation and interviewing the participants is important to understanding their thoughts and opinions on the haptic feedback that has been involved. Additionally, certain data can be derived from the gameplay itself depending on what is created for the sake of the project.

Participant information will use both quantitative and qualitative data. Quantitative data will be used to measure different experiences of the participant while quantitative data will be used to justify those measurements in order to get a further understand of the participants feelings and experiences.

For the qualitative data the experiment will use Likert's 7-point scale as it suited to measuring opinions, attitudes, or behaviours.

Participants will be carefully chosen based on their experience in video games. The experiment will opt for more experienced video game players as they will understand the state of immersion and have more experience in understanding and explaining whether or not the experiment is immersive. The experiment will therefore try to match the participants skill in order to encourage the players into a flow state.

Information about the participant will be kept to a minimum, only their experience in video games will be asked. Therefore, information such as age, gender or race will not be collected.

Participants will need to sign a consent form acknowledging their involvement in the experiment along with being provided a participant information sheet and data collection privacy sheet. This will need to be signed and dated before they can be involved in the study and their results be used to draw a conclusion.

A sample size of about 10-20 people should provide meaningful results to draw a conclusion from.

While the project will be risk free to all participants, due to the nature of virtual reality, some may experience nausea. This is highlighted in the participant information sheet and participants understand that they can stop the experiment if they were to experience nausea of any kind.

The findings of this experiment will give data that will help either prove or disprove whether haptic feedback has a positive impact on the gameplay experience.

5. Practice

5.1. Outlining the experiment.

Before the development of the artefact can begin, it is first important to plan the investigation, understand what would be changing, what would be staying the same and what is being measured.

Therefore, the first thing that needed to be done was laying out the variables. These are the

independent variables, dependent variable, and the controlled variable.

The dependent variable is the easiest to answer, with the investigation being whether or not haptic feedback would enhance the player experience and immersion. Therefore, the participants experience with the experiment is the dependent variable.

While it would be simple to ask whether or not the player thought haptic feedback had positive impact on their experience, the participant would have nothing to compare their experience to. Therefore, the independent variable would be the enabling or disabling of haptic feedback. This would mean the player will be able to compare their experience between the two variables.

Based on the independent and dependent variables, the controlled variable would be important to make sure the results are as reliable as possible. First of all, the environment and atmosphere the experiment takes place in would need to be the same. As the experiment focuses on immersion, having a calm non distracting environment is essential so that the participant isn't distracted by external factors outside the artefact. Furthermore, the device that the artefact is developed on would need to be the same across all experiments so that the player experience is as similar to each other as possible. The questions about the player experience would also need to be the same across all participants.

After the variables for the experiment were outlined, the experiment itself needed to be decided. Using examples of similar haptic experiments, it was decided that participants would have a singular level to play through. The level would have different applications of haptic feedback throughout and would incorporate the concept of flow. This would mean the level would be progressively more challenging as the player progress in correlation to their own skill. For example, the player may have a task to complete that teaches the player a mechanic, after that, the player would then have to use the mechanic in a similar way. P Strojny explains this idea in their paper on player involvement as a result of difficulty (2023) using Motivational Intensity Theory (MIT) as a way of explaining video games player's enjoyment and motivation to continue playing a game as the difficulty increases. This links to the idea of flow as if the task were to become too uninteresting and boring then it would stand to reason that the player would not feel challenged and therefore not immersed in the experiment.

Building on top of the concept of flow, the level will also be some sort of time trial. As one of the characteristics of flow is a clear goal, therefore, having a overarching goal of completing the level as fast as possible should in theory help the player achieve flow and therefore help immerse themselves in the game.

The main aim of the project is to see if haptic feedback enhances player experience and immersion, so it is important to have a project that is immersive to begin with and then introduce haptic feedback in order to investigate if it has made an impact.

5.2. Virtual reality and the Unity XR Toolkit.

After the experiment had been fully clarified, the level that the participants were playing could be started. However, as part of the controlled variable, the platform had to be decided for the project.

Although some platforms had more tools for haptic feedback, such as PlayStation which had their DualSense controller, in order to immerse the player as much as possible the platform of VR was chosen for the project.

Virtual reality's market has seen massive growth in recent years with its estimated market size being around 59.26 billion USD in 2022. This increase has led to more and more people having commercial VR devices in their homes.

C Zhang describes the why, what and how of immersive experience in VR (2020) and talks about how virtual reality submerges the perceptual system of the users and engulfs their senses. While in virtual reality, three of people's five senses are immersed. The headset display takes the users sense of sight, forcing them to investigate the virtual world with the addition of being able to move their head and still be submerged in the virtual world. Commercial virtual reality headsets also take over the users hearing through speakers in the headset that sit right next to the users' ears. Finally, virtual reality also uses the users sense of touch, usually through a pair of controllers. With three senses immersed in the process of virtual reality, it seemed clear that it was the best platform to test immersion as being in virtual reality is already an immersive experience on its own.

JK Gibbs (2022) also weighs in to talk about presence in virtual reality and its benefits. Presence talks about the players actions within a world and whether or not the player has any impact in it. They explain how presence is almost like "being there". This is a great thing to incorporate into the playtest level as this is very close to the feeling of immersion. Additionally, Kaul et al. (2017) talks about how haptic feedback can improve presence which lends itself nicely to the aim of this experiment.

In particular, the Oculus Quest 2 VR device presented itself as the best device for this experiment. The Quest 2 is capable of both Unity and Unreal Engine 5 development, tools that help with the development of projects as well as built in haptic feedback that can be adjusted or changed within projects. This would allow specific actions in the level to have different intensities of vibrotactile feedback at different lengths based on different actions the participant would take.
Before committing fully to VR development for the experiment, some investigation needed to be done into what was feasible to create in virtual reality so that the planning for the level could begin.

Unity was the engine chosen for VR development due to the tools included in it's XR Toolkit. The XR Interaction Toolkit is a Unity package containing different systems and components to creating VR experiences.

The XR Toolkit components available help with development of VR experiences with ready made scripts and settings. For example, the XR Grab Transformer script allows objects in VR to become grabbable by the player.

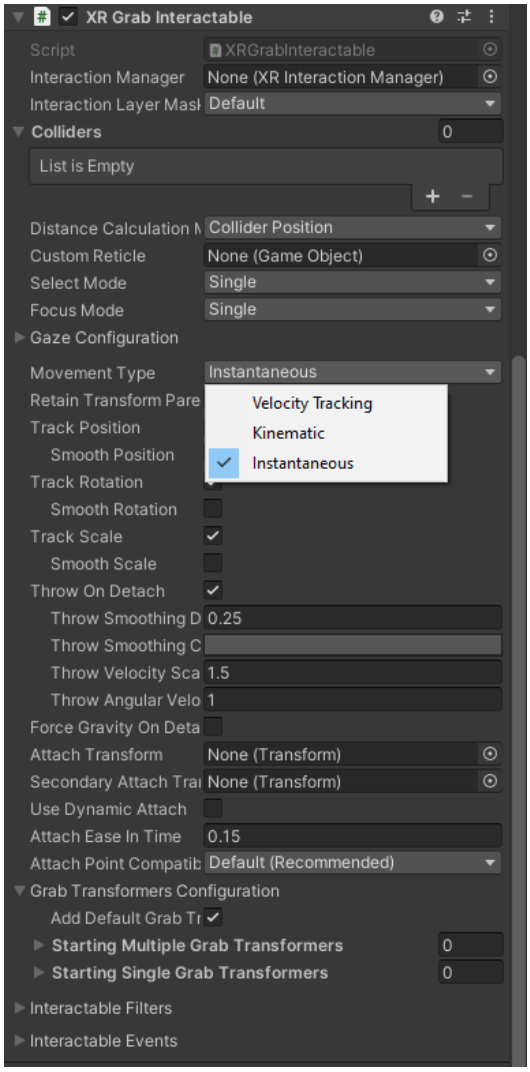

Fig 4: Unity XR Grab Interactable Script.

The Grab Interactable script allows players to not only grab game objects but also decide on how the player will hold the object with attach transform as well as the movement type of the object. Kinematic movement updates the game objects rigidbody every fixed update, instantaneous directly transforms the object and velocity tracking moves the object by setting the velocity of the rigidbody.

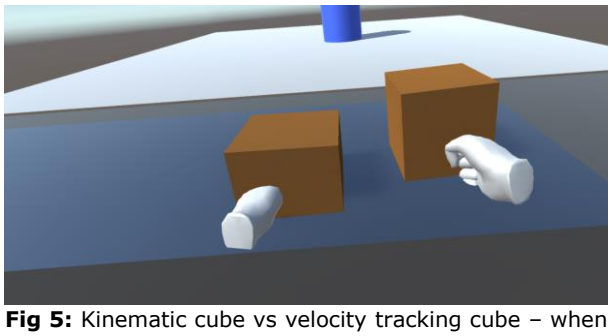

Fig 5: Kinematic cube vs velocity tracking cube – when grabbed the kinematic cube can phase through objects while the velocity tracking cube does not.

As this project is testing the effects of haptic feedback it is important to know how Unity

enables the developer to use haptic feedback to create meaningful haptic interactions. The first way haptic feedback can be implemented is through the XR Direct Interactor script that is found on the hands of the haptic player controller.

Fig 6: Haptic events that can be triggered on the hands of the player controller.

This is the most simple and basic form of haptic feedback implementation. When the boxes are checked the developer has the ability to modify the haptic intensity and haptic duration of any of the actions. For example, whenever an object that can be interacted with is hovered, the controllers will vibrate based on the values chosen by the developer. This method of haptic implementation is very basic, apply a single setting to all the interactable objects present in the game. This can however lead to problems with some objects gaining haptic feedback when it is not necessary and other objects having the wrong intensity of haptic feedback. Although it does however have the plus side of targeting the individual controller when the haptic feedback is triggered.

```
Unity Script (1 asset reference) | 1 reference
public class HapticConstant : MonoBehaviour
{
    [SerializeField] private XRBaseController leftController;
    [SerializeField] private XRBaseController rightController;

    public static bool isOn = false;
    Unity Message | 0 references
    private void Update()
    {
        if(!EndGame.endFunction)
        {
            if (isOn)
            {
                ActivateHaptic();
            }
        }

    }

    1 reference
    public void ActivateHaptic()
    {
        leftController.SendHapticImpulse(1f, 1f);
        rightController.SendHapticImpulse(1f, 1f);
    }
}
```

Fig 7: Example of script based haptic feedback.

Under the XR Toolkit, haptic feedback can also be accessed within scripts. All that is needed is a reference to the controller and the developer would be able to send a haptic impulse to the controller based on certain parameters. This is a method of providing haptic feedback to a wider variety of gameplay events rather than just certain button inputs on the controller. However, a problem that occurs is how do you isolate a haptic impulse to one controller. For example, if you wanted an impulse every time you picked up an item, there would be no way of finding out which controller is being used to pick it up. Therefore, when picking up an item with the right controller, haptic feedback would be received in both hands.

```
Unity Script (14 asset references) | 0 references
public class HapticInteractable : MonoBehaviour
{
    [Range(0f, 1f)]
    public float intensity;
    public float duration;

    Unity Message | 0 references
    private void Start()
    {
        XRBaseInteractable interactable = GetComponent<XRBaseInteractable>();
        interactable.selectEntered.AddListener(TriggerHaptic);
        interactable.activated.AddListener(TriggerHaptic);
    }

    2 references
    public void TriggerHaptic(BaseInteractionEventArgs eventArgs)
    {

        if(eventArgs.interactorObject is XRBaseControllerInteractor controllerInteractor)
        {
            TriggerHaptic(controllerInteractor.xrController);
        }
    }

    1 reference
    public void TriggerHaptic(XRBaseController controller)
    {
        if(intensity > 0)
        {
            controller.SendHapticImpulse(intensity, duration);
        }
    }
}
```

Fig 8: Haptic interactable script capable of triggering haptic feedback on a specific controller based on whether it is grabbing an object or not.

The solution to the problems of both the haptic events on the hands of the player and the scripting example is a combination of both. Not only does this example of haptic feedback allow the developer to target a specific hand based on which is being used but it also allows the developer to tie haptic feedback to specific events. The code in figure 8 looks for when an object is grabbed and then fires off certain events based on what actions are taken. In this example, when the trigger or activate button is pressed when an object is being grabbed, the haptic impulse is fired off to the controller that is holding the object. This script is important for firing off haptic impulses on specific events while being targeted to the correct controller.

5.3. Level concept and mechanics.

With the experiment planned out and virtual reality chosen as the platform, the concept of the level and its mechanics had to be decided. The level had to have mechanics based around using haptic feedback. The level also had to be engaging for participants, involve some sort of timing mechanic that encouraged players to complete the experiment as fast as possible as well as have the parts necessary to induce a flow state.

Firstly, deciding a setting for a level was important not only for engagement but also for designing the mechanics taking place. The setting of the level had to be appropriate for VR development with the tools discussed in the previous section. VR games have a tendency to focus on collection and puzzle

solving with realistic 3D environments. With all this in mind, the experiment was decided to be a VR heist simulation.

A heist level would have the ability to incorporate different mechanics and some of the VR tendencies already seen in previous VR games as inspiration. A heist level would also work well as a timed mechanic, as players would feel motivated to complete the level as fast as possible before being caught.

With the concept decided, the mechanics were next to be decided. A heist level has the advantage of having lots of inspiration available from other games. Payday: The Heist (2011) and GTA V (2013) are both popular games that the experimentation level can draw inspiration on. These heist games normally follow a simple structure consisting of, the entry, the collection, and the escape. This would act as the structure for the experiment project. The heist games also contain mechanics that can be used in the experiment project. Both games contain gun combat that not only act as weapons to clear areas but also used to solve certain puzzles and complete objective.

Fig 9: Payday: The Heist screenshot from official steam page showing off a bank vault the player needs to steal from.

Using inspiration from these games, the mechanics of the game can be decided. The project would start in a bank vault with the player tasked with using a gun to take out the surrounding cameras. After taking out the surrounding cameras, the player has the task of collecting all the valuables in the bank vault. Once the gold is collected the player will have the task of escaping. The player will leave the bank vault and scale a climbable wall. Once reaching the top the player will jump across the rooftops until they reach a dock where a boat will wait and take the player away from the area and complete the heist.

5.4. Designing the level.

The first mechanic that needed to be developed was the shooting aspect of the level where the player had to destroy cameras around a bank vault.

```
Unity Script (3 asset references) | 0 references
public class FireBullet : MonoBehaviour
{
    [SerializeField] private AudioSource gunShot;
    public GameObject bullet;
    public Transform spawnPoint;
    public float FireSpeed = 20f;

    Unity Message | 0 references
    void Start()
    {
        XRGrabInteractable grabbable = GetComponent<XRGrabInteractable>();
        grabbable.activated.AddListener(ShootBullet);


    }

    // Update is called once per frame
    Unity Message | 0 references
    void Update()
    {

    }

    1 reference
    public void ShootBullet(ActivateEventArgs arg)
    {
        GameObject spawnedBullet = Instantiate(bullet);
        spawnedBullet.transform.position = spawnPoint.position;
        spawnedBullet.GetComponent<Rigidbody>().velocity = spawnPoint.forward * FireSpeed;
        gunShot.Play();
        Destroy(spawnedBullet, 5);
    }
```

Fig 10: Gun script for firing bullets.

The gun uses a simple script that instantiates a bullet at its barrel that moves forward and destroys the bullet after 5 seconds. When the bullet collides with the camera, the camera and bullet are destroyed, and the player comes a step closer to completing the task of destroying all the cameras.

An issue with the gun was the grab position of the weapon. With the base grab interactable script, it allows for the player to snap the gun to the hand making it look natural when grabbed but this only works with one hand. Therefore, an override script was made to enable two attach transforms depending on what hand grabs the gun. The gun also allowed for interesting applications of haptic feedback. Using the haptic interactable script described in figure 8, the player would feel haptic feedback when shooting the gun, something many games use when also incorporating haptic feedback in games of similar genres.

```
Unity Script (3 asset references) | 0 references
public class XrGrabInteractableTwoAttach : XRGrabInteractable
{
    public Transform leftAttachTransform;
    public Transform rightAttachTransform;
    public Transform holster;

    public bool Attached;

    0 references
    protected override void OnSelectEntered(SelectEnterEventArgs args)
    {
        Attached = true;
        if (args.interactorObject.transform.CompareTag("RightHand"))
        {
            attachTransform = rightAttachTransform;
        }
        if (args.interactorObject.transform.CompareTag("LeftHand"))
        {
            attachTransform = leftAttachTransform;
        }

        base.OnSelectEntered(args);
    }
```

Fig 11: Grab interactable override script to allow two attach transforms.

After the cameras are destroyed, players need to run round an area to collect the valuables, or gold, before making their escape.

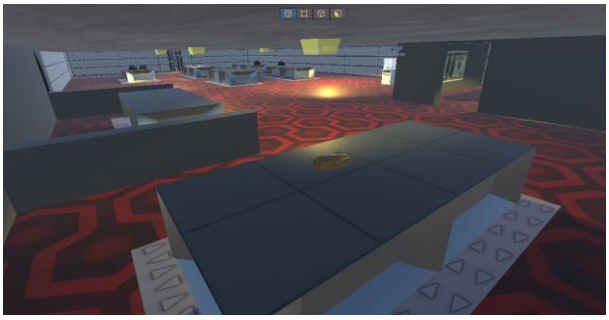

Fig 12: Bank vault area in the level designed for the experiment.

While some gold in the area is easy to find, some pieces of gold required more effort. This would lead to an increase in difficulty as players find more gold. Additionally, one piece of gold is locked behind a puzzle that players would need to discover a code to access. When collecting the gold, the player would receive a haptic impulse to communicate that the gold had been picked up and collected.

After the gold has been collected, the player will have to leave the bank vault through a hole in a wall and have to scale a wall.

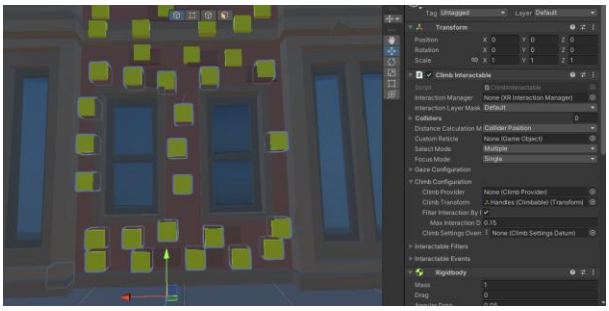

Fig 13: Climbable VR wall.

The wall is made up of yellow cubes that act of climbable handles. While the yellow cubes may not look realistic, it would help to guide the player on the direction they would need to go. While climbing the wall, the player would receive a haptic impulse every time a handle was grabbed to reaffirm that a handle was grabbed. This was important as if the player was half-way up the wall and did not have any handles grabbed the player would fall to the bottom and start over again. Therefore, the haptic feedback, in theory, should enable the player to feel better about their actions when climbing. Without haptic feedback, the activity should in theory feel unfair which could potentially take players out of the flow state compared to with haptic feedback.

After climbing the wall, the player would need to jump from roof to roof. The gaps between the rooves would grow larger and larger as the player progressed to increase difficulty. At the end of this section the player will get into a boat and escape from the heist. The player will then be shown their final time, and the experience will be over.

5.5. Problems faced during development.

During development of the level, there were issues with framerate drops that led to nausea. In order to make the level, asset packs were used to develop the visuals of the scene. In particular the Synty City pack was used to make the environment seen outside the bank. This environment made the area more engaging and sold the idea of a bank located in a big town. However, the amount of assets in the scene caused massive framerate drops. Joseph j. LaViola Jr (2000) discusses cybersickness in virtual reality and explains how lag can lead to cybersickness due to the delay from action to display.

Cybersickness has the problem of taking the player out of the experience and reducing the immersion. Therefore, an active effort needed to be made to increase frames but also still have a nice environment for the players. The solution to this problem is Unity's ambient occlusion. Using ambient occlusion affects the camera by only rendering what the player is looking at on screen rather than the everything in the scene.

Area of map	Average FPS before ambient occlusion	Average FPS after ambient occlusion
Inside bank vault	50fps	70fps
On top of roofs	20fps	60fps
At boat	45fps	70fps

Fig 14: Table on the average framerates in certain areas of the map before and after ambient occlusion being enabled.

After the main level was done, it was clear that some of the levels of immersion weren't quite being met. Not only did players not have a chance to understand the controls but the lack up plot may negatively affect the immersion of the playtest level. Therefore, a tutorial area was added that gave players access to all the tools and controls they could use as well as a quick summery of plot to give the player a little bit of backstory and an idea of what they needed to achieve.

6. Discussion of outcomes

The questionnaire for this experiment (see Appendix E) was created using Jennett, C et al. (2008) original questions on measure and defining the user experience of immersion. Similar to J Rigby et al (2019) the questions posed by Jennett would be changed and built upon to match what feedback is important for this study. The first part of the questionnaire would focus on whether an

impactful immersive experience was created using the Likert scale and qualitative responses while the second part of the questionnaire would focus on the participants feelings on haptic feedback in the project.

The results of the experiment (see Appendix E) did come to show positive improvements thanks to haptic feedback. For starters, the times of both playthrough were shown to have improved. The biggest improvement seen was participant C with a decrease in time of 149 seconds. This implies that due to the inclusion of haptic feedback, the times of the players decreased because it helped them engage more with the world and immerse themselves further into their actions and reach that flow state. However, similarly, there was a participant that actually had a high time compared to the first. This may be explained in the interview section of the experiment where they admitted to not being engaged in the game because they didn't really enjoy the genre or tasks they had to complete. This links the barriers to total immersion, specifically the idea of engrossment in which the player needs to resonate and have interest in the tasks they are doing to be immersed in the first place. In a similar sense, some participants admitted that their better time was partly because of the inclusion of haptic feedback but also partly because the tasks completed were very similar to the first playthrough, so players already knew what they were doing. In future, to prevent these issues occurring, it may be worth looking closely at the participant pool to make sure that they have common interests in what they are playing. Additionally, a different level may be useful for testing haptic feedback, so players don't know what to expect the second time they play through it.

Question	Median	Mean
1	6	5
2	5	5.5
3	7	6.375
4	6	5.375
5	1	1.5

Fig 15: Median and mean results for the first 5 questions of the questionnaire that were answered based on the Likert scale.

The first five questions on the questionnaire were to establish whether or not the experience was immersive or not. Looking at the figures alone, all figures indicate high levels of immersion in the playthrough. In particular, players admitted in question 3 that they did experience a transformation of time in which time had altered and sped up to make the experience feel quicker than it actually was. This links back to the characteristics of flow discussed previously. This shows the project, for participants who felt engaged with the playtest, was in fact immersive. However, because players were asked after the second playtest, it may stand to reason that their experience on immersion was based on their second playthrough with haptic feedback enabled rather than the gameplay as a whole. While this may help back up the aims of this project, it doesn't give detailed enough results on the impact of haptic feedback on the levels of immersion. In future, the interview segments for at least the first 5 questions, would be repeated after both playthroughs to get a better understanding of the impact of haptic feedback. Some participants gave feedback that confirmed that haptic feedback did have an impact on players flow. One participant said that "the climbing section on the first playthrough felt unfair" compared to the second. This was because of the haptic feedback. The challenge of the activity felt too high on the first playthrough resulting in a loss of flow however with haptic feedback the mechanic felt easier to understand and the flow state was restored.

Questions 6-10 focused on haptic feedback itself. Each of the questions asked something about haptic feedback and whether it was effective in creating a better feeling game that was more immersive. Firstly, all participants described one or two ways in which certain mechanics or items were improved with haptic feedback. Some mentioned how the gun "felt better to shoot" while other mentioned how the climbing section felt fairer and "easier to do". Haptic feedback also had a positive impact on their gameplay experiences with some mentioning that certain mechanics such as the climbing wall were made much better. The participant who had a higher time on their second playthrough also praised the inclusion of haptic feedback mentioning how the gun felt way more fun to use. On top of player experience, the haptics also had a positive impact on player presence. Participants mentioned how certain actions "had more of an effect" thanks to haptic feedback. All participants were happy with where haptic feedback was included and finally, they all mentioned how their times were made better, partly because of the haptic feedback. Some participants did however mention that their times decreased because of their knowledge of the level more than the haptic feedback.

Overall, based on the second half of questioning, there is definitely an argument to be made that haptic feedback at least had a positive impact on player experience. Question 8 in particular showcases how haptic feedback gave the player more presence in the world making them feels more invested and immersed on what they were doing which eventually contributed to a better time.

While the questionnaire did help shed light on immersion within the project and haptic feedback in the project, it fails to consider how they work

together. While some questions do dive into how haptics affect the player's immersion, many of the questions just ask whether or not the haptics felt good rather than if they made the player feel more immersed. In the future, the questionnaire for the project would need to find a way to combine questions about immersion and haptic feedback to get a better understanding of whether haptic feedback has had a direct impact on the player.

While the questions may not be clear, there is enough evidence here to infer that haptic feedback has had a positive impact on the player's immersion. The times going down shows improvement in the players abilities thanks to how haptic feedback makes the player feel more present in the game world. The results of the first five questions show levels of immersion present in the game as well while the second half of the questionnaire shows that haptic feedback definitely had a positive impact on immersion based on participants results.

7. Conclusion and recommendations

Based on the experiment findings, it is clear that haptic feedback does have an impact on player experience. Haptic feedback has been shown to make give another type of stimulation to the player beyond sight and hearing to make players feel the game world and what is happening around them further bringing in the player and drawing them in making them feel more immersed. This shows an enhancement of immersion compared to when not using haptic feedback as well as players entered a flow state easier. This was due to the fact the challenge felt fairer in regard to their own skill.

The research process was not perfect. The gameplay involved in the section did fail in parts to properly immerse the player and the questionnaire wasn't through enough to gain specific results about the impact of haptic feedback.

In future, it may be worth considering multiple levels with different mechanics to test haptic feedback so that participants don't have the luxury of knowing the level to contribute to their times improving. Additionally, the questions presented need reviewing to incorporate the first and second half of the questionnaires together to know exactly what impact haptic feedback is having on immersion.

From this knowledge, developers can see the impact that haptic feedback can have on their own games. In particular, it shows a huge improvement on player experience in virtual reality. Additionally, the money invested into haptic technology seems to be important in improving player experience based on the results of this experiment giving more reason for companies like PlayStation to keep on improving haptic feedback in their controllers and beyond.

Until recently, haptic feedback has not been something that has been worth developing, improving, or even implemented however from this paper it is clear that it does have a place in improving player experience. Not only does it improve player experience, but it also helps players stay immersed and playing the game for long. For people to play a developer's game for as long as possible and stay immersed is such an important aspect for developers so using all the tools at their disposal including haptic feedback is very important to do so.

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Appendix A: Project Log. (not included in word count)

Appendix B: Project Timeline. (not included in word count)

Appendix C: Assets used in the Project. (not included in word count)
This is a list of project assets: all source materials used in the project. Clearly state which were produced by yourself and which were not. If not produced by yourself, include their reference, and status with regard to copyright/ creative commons licensing.

Appendix D: Consent form, participant info sheet and data private sheet.

Appendix E: Questionnaire and it's results.

Further Appendixes D, E … if applicable* (not included in word count)
What could go here?

- Ethics: participant info sheets, consent form, interview questions, anonymized matrices, other anonymized summaries or analyses
- Any important design documents too large to insert in the main text
- Any important code sections not already on GitHub
- Any impotant large tables or diagrams
- Other relevant materials

*only insert meaningful materials here, please don't just bulk this report up. Your main text should be able to stand on its own, without relying on information contained in appendixes. Check with your supervisor beforehand.