Mixed Reality and Tactility: The Space Between Two Perceptions

Phillip Carpenter

A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Design

University of Washington

2019

Committee:

Axel Roesler

Audrey Desjardins

Barbara Mones

Program Authorized to Offer Degree:

Design

University of Washington

Abstract

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Phillip Carpenter

Chair of the Supervisory Committee:

Annabelle Gould

Design

Common access to virtual reality and augmented reality is just around the corner. How might we anticipate interaction beyond sight and sound? My thesis focuses on the exploration of tangible interfaces: how the sensation of touch affects our exchange with virtual environments. Further investigation seeks to discover insights into the negotiation of simultaneously existing between two perceptions, one environment known as “reality” or the real world, and the other known as “virtual” or virtual reality. The basis for these insights comes from the creation and observation of two iterations of a working tactile VR experience on public display for a period of roughly one month in an art gallery and an art museum. The title of the experience is “The Space Between Two Perceptions.” The creation process is explained as well as the resulting insights.

Mixed Reality and Tactility:
The Space Between Two Perceptions

Phillip Carpenter
Master of Design Thesis

Introduction

About a year ago I started to engage with thoughts around how tactility could be transposable and adaptive on surfaces. How might we complete a desire to touch something that might otherwise be untouchable? As my research and explorations evolved around this idea to include the context of Virtual Reality, I wondered how this might emotionally affect our experiences in virtual environments and how we perceive them. Virtual reality devices and platforms are becoming more accessible and are evolving to be more capable. They will likely

become more ubiquitous and potentially an aspect of daily-use technology one day. People are curious about VR and it has finally reached a commodifiable device-level where people can afford It and it's easy to set up and enter. Although virtual reality is highly immersive, when in a VR environment, most people still maintain varying degrees of awareness or connection to their physical existence outside of VR. Methods for interacting with and through VR is evolving and therefore it's important to study what motivates people to interact in, with, and through these virtual environments and how responsive tactility effects these experiences so that we might better understand the potential of virtual reality as a whole.

In what we know as "the real world", if we see something that we want to pick up or grab, for the most part we can reach out with our hands to touch and confirm that goal from the tactile response of feeling the object. Most people are able to have this tactile confirmation and then proceed with the rest of the interaction. Goals for this kind of interaction could simply be to move something or it could be for the purpose of gaining knowledge about some aspect of the object through touch. Is it rough or is it smooth? Is it cold or is it hot? In virtual reality, objects are visible in the environment and we have the capability of interacting with them but for the most part we cannot actually touch them and receive tactile confirmation. It is this dilemma that provides the basis for my thesis work.

Secondary Research

For my secondary research I explored previously created examples that focused on mixing virtual reality and some form of touch within the experience. I mainly settled on works made by a company called The Void. The Void is a franchise of mixed reality entertainment attractions.

The Void is described by some as being creators of a virtual reality "theme park", creating virtual reality experiences leveraging a combination of head-mounted displays with motion tracking, haptic feedback and special effects systems to allow patrons to freely explore and interact with virtual settings within the confines of specially-designed environments. The Void's first location was established in Pleasant Grove. In July 2016, The Void debuted a Ghostbusters-themed virtual reality attraction at Madame Tussaud's in New York City. The company subsequently began a partnership with the Disney Accelerator program, and subsequently developed attractions based on Disney films such as Rogue One: A Star Wars Story. ("The Void")

This company, backed in part by Disney's partnership, combines visual experiences possible in virtual reality such as 6 degrees of freedom movement, multiplayer; where you can exist in virtual space with others, and the concept of aligning real world physical objects with various graphics in the virtual world for the purpose of providing some perception of touching objects and feeling them in virtual reality to heighten the immersion. For example, a person will walk around a physical location with walls that align to real walls and they might see a control panel with buttons that they might want to interact with. The elements of the control panel will be present in real life, aligning with the virtual word. This provides the sensation of resistance when trying to touch a wall or a button. The work of The Void is highly visible and many

examples exist online as they seem to be the most prominent experience creators working with in this format. The next task was for me to create some experience that would allow me to gain some insights into these kinds of experience as well as hopefully make some further revelations.

Documentation

I'll now describe what I created as an experimental platform from which to explore these questions.

The basic principle behind the experience is for participants to be able to touch objects in virtual space and feel that contact with the object by aligning the graphics of the virtual objects to real world objects as they move. I'm curious how this effects the experience and how touch enters this virtual environment known for mostly being non-tactile.

Over the course of several iterations, which I will describe, I ended up with a physical artifact in the form of a spatial environment that was interactable and could be freely used by anyone who wanted to participate.

A first iteration was created in the Winter quarter with had the lightbulb and pedestal and no walls. A virtual landscape stretches out all around the dimly lit environment which was lit by the virtual night sky and the lightbulb. A dozen cubes were spread out stretching off into the landscape as an animated spikey green object rotated far off in the distance. I will go into further detail to describe the second and final iteration.

"The Space Between Two Perceptions"
1st Iteration
The Jacob Lawrence Gallery

"The Space Between Two Perceptions"
2nd Iteration
The Henry Art Gallery

For the second iteration, a white power cord is suspended from the ceiling dangling a lightbulb at eye level. This single lightbulb hanging down emits a soft orange glow onto a pedestal just below and onto the white walls of an art museum gallery, in an otherwise dimly lit room. The room measures roughly twenty-four feet by twenty-three feet and has one entrance in the form of a doorway with decorative profiled white door trim surrounding the passageway. On the pedestal under the lightbulb rests a headset used for Virtual Reality which is tethered by a 15 foot cord which travels to the base of the pedestal and underneath where it is invisibly secured. The gallery room has only one entrance doorway, and three sealed off doorways on the opposite walls. The sealed off doorways (3) are still recognizable because the white decorative door trim outlines where the passageways would be if they were not sealed off. The walls are clean with no text other than a small card on the wall next to the entrance door which lists the title of the work and the creators, Phillip Carpenter and Jose Pacio my technical collaborator. The VR headset contains the visual access to a virtual environment that allows one to see the virtual components of the experience. Upon putting on the headset, participants see in front of them an environment made up of digital elements. They are now viewing a fully digital world which is graphically flat and fairly lo-resolution, but not pixelated, as compared to the real-world. The first thing usually in view is a lightbulb in the virtual space hanging down

from a cord which holds the lightbulb at roughly eye level. Below the virtual bulb is a virtual pedestal, the same dimensions as the one in the real world. If participants choose to look around, they see that they are in a virtual room much like the one in the real world. It is also dimly lit, appearing to be mostly lit by the virtual light bulb again with a soft orange glow.
A wall is directly behind the pedestal as well as walls to the left and right of them appearing to be in the same place as the real-world walls which are no longer in view, now replaced by these virtual walls. The scale of everything virtual is a 1:1 comparable ratio to elements in the real world. Two doorways exist a few feet to either side of the pedestal on this front wall behind the pedestal. These two doorways appear in same location as the sealed doorways in real life, except these virtual doorways are have openings. The side walls to the left and right of the front wall each have open doorways as well. These four doorways all contain visual access to a different view through each opening. A large-scale video plays inside the door to the left showing a hand touching a lightbulb similar to the one in real life. The hand appears to be exploring the lightbulb by grabbing and holding the illuminated lightbulb in different ways. The door to the extreme right of the pedestal reveals a life-size video which shows a view of the back of a trash collection truck and two city workers in bright yellow uniforms collecting trash and throwing it in the back of the truck. This street scene appears to be in a European city. On the wall in front of the room behind the pedestal, the two doorways open to revel different landscapes. The left door shows a view into a flat dark night digital landscape with cubes dispersed out into the landscape creating a sense of depth as they spread back and to the sides. The other door contains a view of another night landscape but this one has a digital mountain. To the rear of this view, one can see that the fourth gallery wall has been removed revealing a flat infinite landscape which extends off into the horizon and reveals a night environment with a dark blue sky that fades into a subtle gradation as it touches the horizon line. This view also reveals stars above which span the entirety of the sky and reveal that there is no ceiling. A full moon reflects brightly overhead. The final element is revealed upon movement of the participants hands. Virtual hands appear in the same location as their real hands, which are now out of view, also replaced by these virtual hands. The hands freely move in unison to the real-world hands, complete with localized finger movements. The entirety of all these elements make up the experience and museum goers are free to participate at whatever level they feel compelled to engage. Hidden from view and perception inside the pedestal is a laptop computer running the VR application build, running the experience live. There’s a computer fan inside the pedestal to keep it cool as the computer runs constantly to maintain the experience.

The summary of the experience is that someone can see a lightbulb in VR that was in the real world, see and control hands that match their own, and touch the lightbulb having it respond to them by swinging in the virtual world. The visual weight, tactility, and response from the lightbulb is the starting point for the experience.


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Before I discuss the reaction to this experience in the primary research section, I will explain the process involved in its creation.

Creating Virtual Reality

In the Fall quarter of this last year I began taking some courses offered as part of the computer animation capstone in the school of computer science and engineering. This capstone program accepted 15 students for the year and would be a 9-month commitment to classes. The goal of the class was to learn the tools and methods needed to create high quality 3D computer graphics to animate into a movie, much like something Pixar might make. Alongside of this class, a new VR class had been created the previous year to start experimenting with storytelling in virtual reality. Both classes overlapped in useful knowledge and shared many things between the two that were necessary for each outcome. Much of what I'll discuss next is what was learned over the course of 3 quarters in these animation and virtual reality classes.

<u>The creation pipeline of basic skills and equipment needed for creating Virtual Reality:</u>

• A computer (with an advanced graphics card capable of VR)
The Headset used in this project is the HTC Vive. As of this date, all VR headset with six degree of freedom require being tethered to a computer with the exception of one. The Oculus Quest was recently released as the first fully self-contained wireless VR headset which does not need a computer to operate.

• Asset Creation
For these next things we used a program called Maya by Autodesk for:

- Computer modeling (or computer modeled assets)
- Model texturing and shading
- Lighting
- Computer Animation (if necessary)

• Asset compiling
The assets need to be organized together in some way so that it will combine to create a viewable environment. Game engine software is currently the most accessible way to do this and there are two main software platforms: Unity and Unreal.

- Unity Game Engine (used for this project)

• Programming
Knowledge and ability to program is essential for interacting with VR elements. Most of this is done in a coding software like:

- Microsoft Visual Studio
- The C# programming language
    - Scripting is initiated through Unity often using Microsoft Visual Studio (IDE)

• **Virtual Reality Equipment**

Hardware needed to view the final experience.

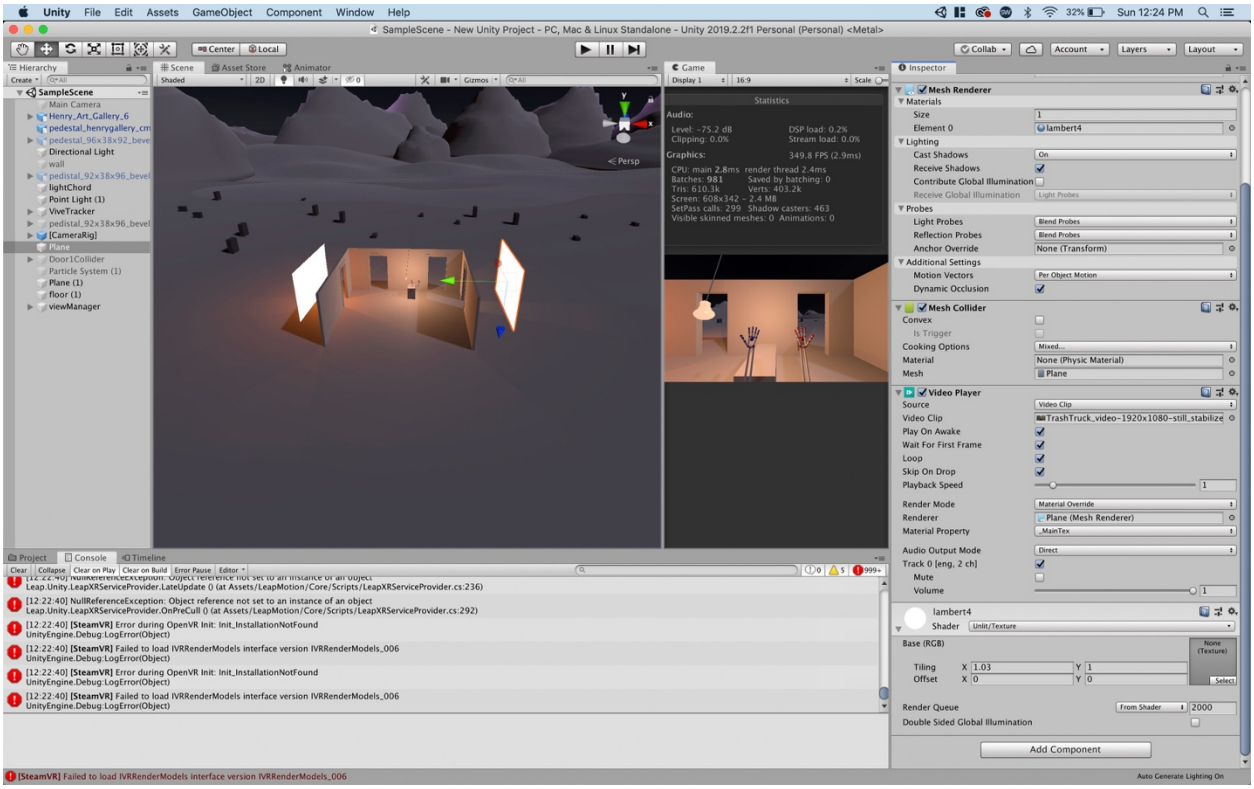
- HTC Vive (used in this project), other VR platforms exist.
- Leap Motion - Hand Tracking Sensor

• **Conceptualization and Testing**

There needs to be an idea for creating an immersive space.

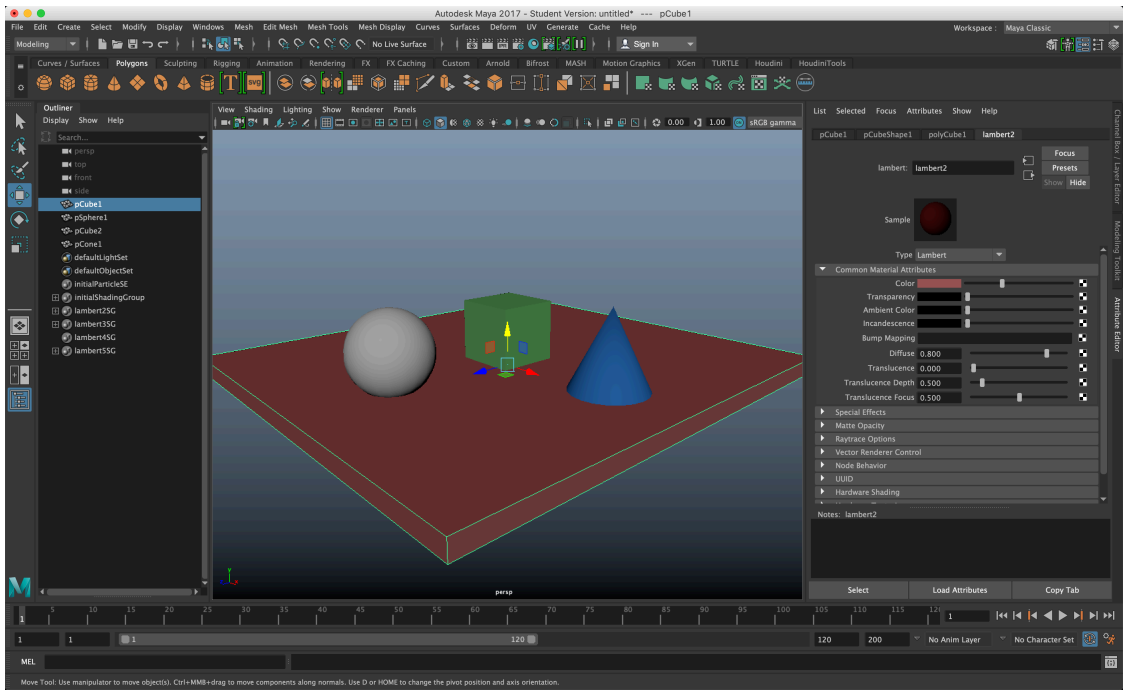
The idea needs to be arranged using all of the previous components to create structure of the environment. Modes of interaction need to be considered in this beginning stage. Some questions to ask in this process are things like: How will someone interact with the environment or object within the VR environment? What cross-over will there be with the VR world and the real world. What consequences will there be when interacting with the VR world while existing in the real world?

Once testing has been completed, a final program build is exported from Unity and run from the headset. The virtual reality can now be experienced at this point.



Unity – Game Engine
version 2019.2

The learning curve for this process is currently very steep. It requires the familiarization of many things at once. 3D modeling and Animation software is difficult to learn although readymade 3D assets can be purchased and inserted for quicker movement down the VR creation pipeline at the expense of specific custom details or 3D assets. The pipelines for Virtual Reality creation are still not totally established with the format being fairly new to open access. This makes for an ever-changing workflow that if often “buggy” and not standardized, which makes learning difficult as reference examples of pipelines become outdated. Any time the needs to be any kind of interaction with virtual objects or control over virtual objects, programming needs to be used in Unity. Programming became a huge hurdle that eventually led to me having to collaborate with someone who was versed in programming to make progress on the project. It took me about 5 months of hard work before I really started to wrap my head around how to begin to make something very simple in VR.

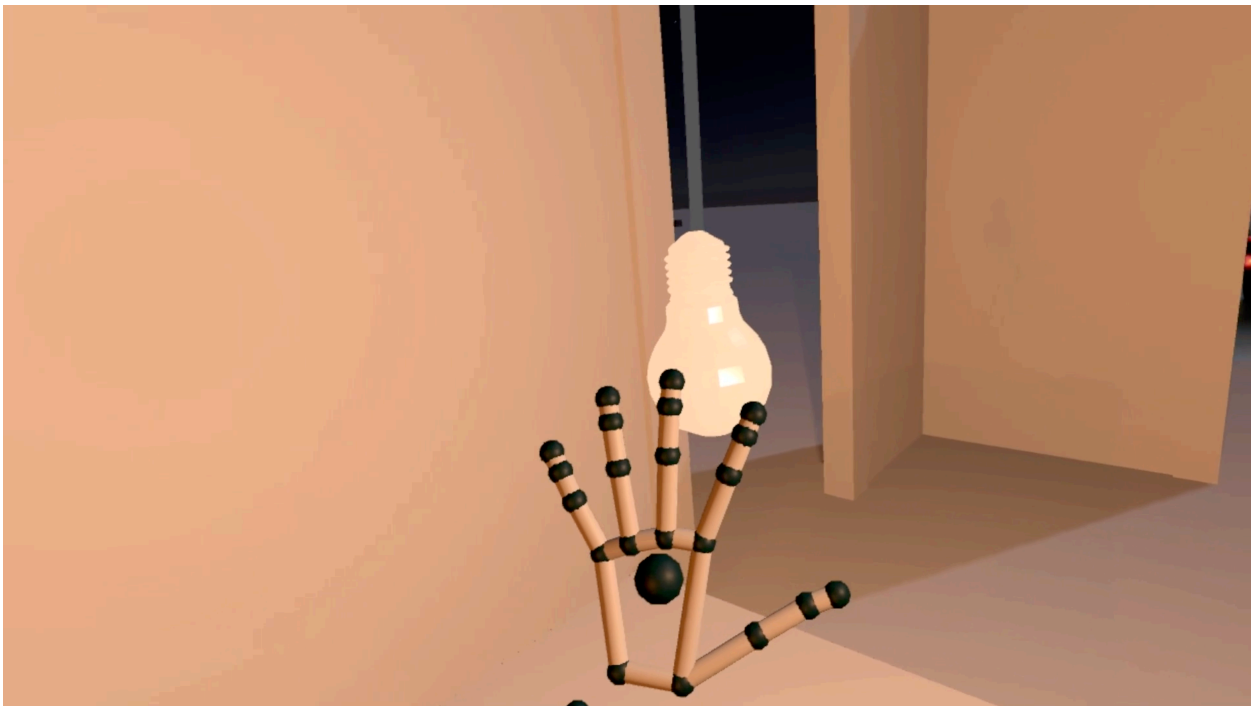


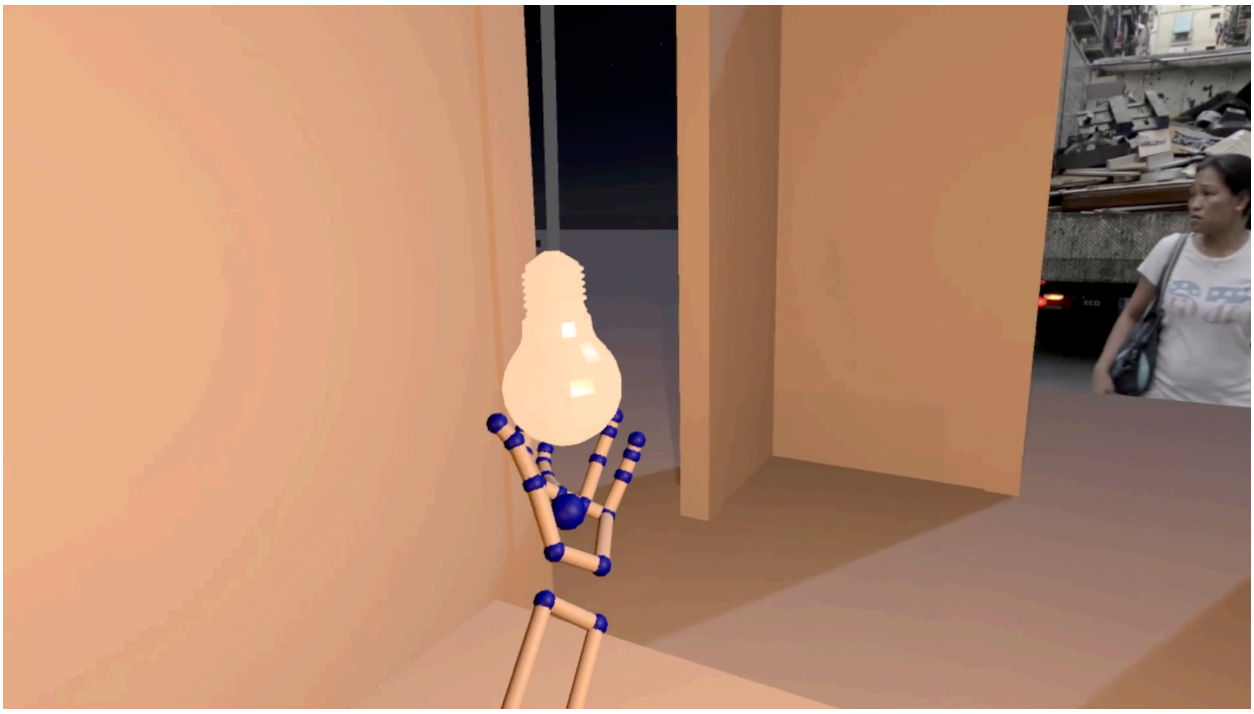
Autodesk Maya (3D modelling and animation software)

participants and onlookers

Hand Tracking was made possible through the use of an infrared camera called a leap motion camera mounted on the front of the VR headset. This tracking system allowed the movements of participants’’ hands to become an intuitive control input for virtual hands in the VR environment. It is likely that hand-tracking technology will continue evolve.

Leap Motion hand-tracking camera





Internal views from the VR headset during use.
Interactions with hands and VR/real world lightbulb as well as video playing beyond doorways.

A sensor was used to locate the position of the real lightbulb for syncing it with the VR lightbulb. This allowed the VR lightbulb to move in response to the movement of the real-world lightbulb. This sensor was the HTC “VIVE Tracker” shown below. It is meant to work with the HTC Vive system. The Vive Tracker was mounted on the light cord about 12 inches above the actual lightbulb. Since the Vive Tracker receives infrared light from the Vive Base-Stations, the Leap Motion camera infrared light would interfere with the sensor’s positioning calculations. This is why the Vive Tracker was placed slightly above the actual lightbulb, remaining out of the eyeline and thus the Leap Motion camera’s view, which emits the infrared interference.

Vive Tracker – motion tracking system

A custom pedestal was made to house the computer needed to run the VR software, Unity as well as the Vive software. The pedestal was made with a cooling fan and a removable top to provide access to the computer for making adjustments to the system if needed. The pedestal is shown in the image below with the top removed, revealing the computer inside. During the exhibition and normal use, the pedestal's top covered the computer effectively hiding it. This took participant focus away from a computer that would have been visible and potentially a distraction and directed it toward the visible elements, the lightbulb and the VR headset.

Primary Research

On several occasions I observed the exhibit at the Henry Art Gallery and talked to people about their experiences. I was able to observe people participating in the experience at varying levels of engagement or interest which provided the foundation for my primary research. I also conducted onsite interviews directly following various participants' time within the experience. I did my best to not interfere or influence their use and reactions.

At one point I entered the gallery and discovered a couple using the VR, taking turns. They looked to be in their late sixties and seemed to be life partners. The man was standing behind the woman holding the VR headset up to her head. It looked a little like they were slow dancing. I spoke with them briefly following their experience in VR, taking turns.

Participant 1: "A lot of things out there are just for entertainment. You're simply overwhelmed, and you're entertained, and it's a marvelous special effects thing, and you go ooh wow!!, but you're not really thinking.
Participant 2: But you're not in it.
Participant 1: They strive to have you in it and your shooting people and you're doing whatever it is but the whole point is to just take you away and not think and make you not think at all. And this really makes you think. It's really overwhelming."

The man then said it made him really question his own reality because it seemed so real and everything was so closely tied to actual reality. He noted that everything in the experience is enough like how it appeared in the real world that it makes for quite a profound reaction. Things that you've seen in the real world room are there in the VR room in the same places but

they look different and there are the extra things like the stars and the landscapes that are different. It connects the two experiences in a profound way. It really makes you question what is real in the world in general. He talked about how it could be interesting to try this in other countries to see what their reaction might be because in America we're so invested in discerning what is real and not real in everyday life that we might have a different reaction to this that someone in culture that is not so constantly concerned with what is truly real on a day to day level. I found their comments interesting in providing insight about how VR in the right context can inspire thought and insight about subjects beyond the immediacy of virtual reality.

Another insightful reaction came from a couple of guys who looked to be in their late twenties or early thirties. I had just walked in the gallery just as one of them had put the headset down after having tried the experience. Both of their names happened to be Alex and they seemed to be fairly tech savvy. I asked what their thoughts were. "It's great. It's seemed almost subliminally scripted in the way that it played out. I put on the headset, looked at the lightbulb, tried to touch the lightbulb and it was awesome that it responded to my touch. The tactility was really great." These guys were almost too perfect as I found them at a time of literally writing this thesis document and they were discussing references to other experiences I had sighted in my research without my bringing them up. One important VR example I had taken note of was a VR company called The Void making VR experiences which implemented tracking and tactility within architectural spaces. Unprompted, Alex said that he had tried something like this at Disney World in a Star Wars experience. He said he thought it was called the Abyss, but I made the assumption that he might be talking about The Void, and he confirmed that he was. He eluded to this being a more engaging experience than the one he experienced in The Void, which I was surprised to hear him bring up. As a follow-up to his statement I asked him, if this one was more engaging, where did this experience pick up where The Void left off? "Just being able to reach and touch the lightbulb, feel it, and then be able to swing the lightbulb was really satisfying. It's hard to describe but it definitely had this little bit of magic that something like the Void didn't have. This was a more exploratory experience and felt less like it was trying to get me to do something or complete some task. It felt more open and natural but had some kind of magic to it with the free exploration and the response from the lightbulb."

Conclusion

In thinking about the reaction from participants and how this project informs the potential future considerations for VR, people seemed to be profoundly affected by the immersion of VR and this profound reaction was heightened by the addition of tactile elements mixed with the presence of hand tracking which provided control of the graphical VR hands. The appearance and control of virtual hands that match their own seemed by far the most engaging aspect of this project. Being able to touch the lightbulb provided an unexpected aspect that made the experience even more immersive. Participants were also in communication with their friends or partners if they weren't in the gallery alone by talking or by touching them to help navigate or somehow attempt to share in the experience, eluding to a desire to share the experience with others. This seems to highlight the desire from people to want to share in VR experiences and reinforce the need to create and develop collaborative platforms and opportunities for VR. The tactility of the experience extended beyond the lightbulb as people explored the walls and doorways freely, using the podium and lightbulb as a positioning landmark for the real world and VR world. Having objects overlap in the space to provide tactile feedback seemed to provide an increased level of *trust in the virtual* space which influences the emotion of the person. This allowed people to walk around freely to navigate both realities at the same time.

Participants would often reach out to confirm the positioning of architectural elements like the door frames and pedestal. This seemed to reassure their confidence in the accuracy of the two alignments, the VR and the real. This trust in the environment provided greater freedom for exploration of the space and of the objects. People were emotionally affected by seeing the hands which they accepted as avatars for their own hands. This let them calibrate their movement within the two aligned worlds by touching the solid objects while seeing the in the same positions in their VR view. The comment was made that the experience made them enter a playful exploratory mindset like they were a child just figuring things out for the first time and having fun. People seemed to respond to this kind of active exploration in terms of interest by sustained engagement more so than a task driven experience might have attempted to sustain them. When not restricted by having to completing tasks to advance the experience, people seemed to be more inspired to think in their own ways and make believe in the experience in a different way than a task driven bombardment of gates to get through. I would imagine this would let people possess their own reactions better, inspired by their own contexts which they mentally bring to the experience. They can own their exploration in the way they might explore a new experience in the real world. This is a much different approach to engagement in comparison to experiences which seem too guided or might be based on unlocking exploration one task at a time, or inducing engagement by being inclined to defend yourself from projectiles playing off our innate reflex of self-preservation.

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