

ARIN: Virtual Reality Experience and Writing About VR for a Popular Audience

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ABSTRACT

ARIN is a virtual reality, sci-fi horror experience for the HTC Vive, which incorporates visual and tactile performance elements and staging to increase the viewer's sense of immersion. The first part of this paper covers the design process of the ARIN Virtual Reality Experience from concept to completion including playtesting and critical analysis. This cinematic virtual reality experience exploits the viewer's preconceptions about VR to augment the loss of agency and humanity in the narrative. The second part, individually written by Izzie Schiavone, explores how popular science writing uses the Hero's Journey as a narrative structure that helps communicate scientific knowledge to a popular audience. The findings from studying popular science writing were used to write an article about VR and the development of the ARIN Virtual Reality Experience.

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PART ONE: THE ARIN VIRTUAL REALITY EXPERIENCE

1. INTRODUCTION

The ARIN Virtual Reality Experience (hereon referred to as The ARIN VRE) was developed by four Worcester Polytechnic Institute (WPI) students in Interactive Media and Game Development (IMGD) for the fulfillment of the WPI Major Qualifying Project (MQP) requirements. The ARIN VRE development team, known as Taction, consisted of four art-track students: Graham Held, Izzie Schiavone, Matt Thompson, and David Wang. The ARIN VRE was in development from September 2016 to April 2017.

The ARIN VRE is a narrative, virtual reality (VR) experience for the HTC Vive system. ARIN stands for Automated Reconnaissance Intelligence Network. ARIN is an android that the player embodies in the experience; however, the player is not immediately aware that they are an android. The experience tells the story of the player, as an android, gaining consciousness and sentience before they were supposed to. In response, two technicians fight to shut down the android by physically removing pieces of the android's body which act as representations of the android's humanity. The ARIN VRE emphasizes ARIN's lack of control over the situation by subverting the player's expectation of game-like interaction.

The ARIN VRE also uses external hardware, such as a reclining chair, to ensure congruence between the player's physical body and that of their avatar, ARIN. The congruency between the player's "meatspace" body and their virtual body increases player immersion and decreases outside interference that could disrupt the player's suspension of disbelief.

The main goal of the ARIN VRE was to create a cinematic experience for VR that made VR part of the experience. The development process revealed two additional goals: creating an

experience that suited the sci-fi horror genre and flipped the table on the usual android/human dynamic in media in that genre.

Chapter two discusses the research that went into the development process, including how virtual reality affects the player and the elements of sci-fi horror and short film narratives. Chapter three shows how the team applied the background research to the ARIN VRE and also goes into more depth about the experience itself. Chapter four covers both the team's development methods, including iterative design methods and specific software choices, and the team's playtesting methods. The results of playtesting are covered in chapter five. Chapter six covers avenues for further development of the ARIN VRE based on playtesting results and other potential directions that arose during development but were not able to be explored fully.

2. BACKGROUND

2.1. Virtual Reality

2.1.1. What is Virtual Reality?

Philippe Fuchs and Pascal Guitton (2011), French researchers who focus on theoretical applications of virtual reality (VR), describe VR as a representation in which the audience is offered an additional dimension of interaction by allowing the audience to become an actor in a virtual environment (Introduction to Virtual Reality, p. 3). Fuchs and Guitton (2011) acknowledge that their definition is broader than what the general public would consider virtual reality (Introduction to Virtual Reality, p. 4). The generally accepted definition of virtual reality, in the eyes of Fuchs and Guitton as well as to other researchers, more heavily incorporates the hardware used to create the virtual environment (Fuchs & Guitton, 2011). Specifically, the head-mounted display (HMD) is seen as an integral part of current virtual reality experiences (VREs) (Fuchs & Guitton, 2011; Dixon, 2006; Bhagat, Liou, & Chang, 2016). A general definition of

virtual reality, in its current form, is a fully digital environment in which the audience can become an actor through wearing or holding some kind of hardware.

2.1.2. Virtual Reality Hardware

There are a variety of HMDs designed to facilitate VREs. PC Magazine includes five HMDs at various price points in their ranking of “The Best VR (Virtual Reality) Headsets of 2017” (Greenwald, 2017). The article includes two HMDs that run off of a PC (the Oculus Rift and the HTC Vive), two that use cell phones as the display (Samsung Gear VR and Google Daydream View), and one that is console-based (Sony PlayStation VR) (Greenwald, 2017). While the cost of each of these devices varies anywhere between \$80.00 and \$800.00, the designs of the HMDs are very similar. Each features a rectangular plastic (or plastic covered in fabric, in the case of the Daydream View) front piece that holds the displays in front of the user’s eyes. The HMDs are held against the user’s face with one or two straps that go around the head. Digital Trends magazine, in an article comparing the HTC Vive and the Oculus Rift, describes HMDs with this type of design as “like a wearable brick” (Digital Trends Staff, 2016).

2.1.3. “Serious” Virtual Reality

VREs allow audience to participate in training activities without the overhead cost of creating the appropriate environment and paying live actors to facilitate the training (Bhagat, Liou, & Chang, 2016) (Chang & Weiner, 2016). These trainings also allow for the exact experience to be repeated in an identical manner, which can act as quality assurance for training (Chittaro & Sioni, 2015). VREs have been used to train military personnel to fire weapons, civilians for emergencies, and doctors for pediatric health emergencies (Bhagat, Liou, & Chang, 2016) (Chittaro & Sioni, 2015) (Chang & Weiner, 2016). The VREs allow the trainees to

interact with their training, which increases retention (Bhagat, Liou, & Chang, 2016) (Chittaro & Sioni, 2015).

VREs are also being used as medical tools outside of training. VREs have been used to treat PTSD and dyslexia and diagnose traumatic brain injuries (Rizzo, et al., 2015) (Pedroli, et al., 2017) (Edwards, Vess, Reger, & Cernich, 2014). PTSD VRE treatments use the concept of prolonged exposure therapy (Rizzo, et al., 2015, p. 256). PTSD patients are immersed in a virtual environment that they may find triggering. The patients are able to desensitize themselves to these environments because they know that outside of the VRE, they are in a completely safe environment.

VREs can desensitize patients to triggering content, but it can also be used to foster strong emotional responses in users. A study run at the Stanford University Virtual Human Interaction Lab that suggests that VREs create a stronger empathetic link between the user and their avatar in the VR world (Ahn, Bostick, Nowak, McGillicuddy, & Bailenson, 2016). When combined with other types of sensory input, such as tactile input, users were likely to develop a high level of empathy for their non-human avatars (Ahn, Bostick, Nowak, McGillicuddy, & Bailenson, 2016, p. 5).

2.1.4. Virtual Reality in Entertainment

Virtual Reality has made a splash in the private sector with the release of a collection of HMDs available to the public. In 2014, Facebook bought Oculus, the company that makes the rift, for two billion dollars (Yarrow, 2014). In the first six months of the HTC Vive's release, the company sold 140,000 headsets (Langley, 2016). These sales numbers came in despite the HTC Vive costing nearly eight hundred U.S. dollars and requiring a higher-end PC to run effectively (Greenwald, 2017). The HTC Vive and Oculus Rift, along with the other headsets mentioned in

part two of this section, can be used to watch films, play games, or interact with other kinds of VREs.

2.2. Horror

2.2.1. Social Fears in Horror Films

There are two leading theories as to what makes the subjects of horror films scary. The first theory comes from Robin Wood, who argued that the fear in horror films is derived from a fear of change in social order (Schneider, 2004). Wood claims that the horror is derived from the oppressed or repressed uprising and fighting back against the oppressors (Schneider, 2004). Positive endings in horror films show a return to the original social order. The second theory states that the feared subjects of horror films are derived from cultural anxieties (Kellner, 2003). An example of this can be seen in the resurgence of the zombie as a horror character in the early 2000s. “The Millennial Zombie”, as Nicole Birch-Bayley describes the new zombie, stems from the post-9/11 fears of catastrophic events that could bring entire metropolises to a screeching halt (Birch-Bayley, 2012). Wood published his theory in 1979 and it could be argued that his examples, which were all from the 1970s, reflected fears of social change caused by the real life uprising of the feared groups. Wood specifically mentions women and homosexuals as oppressed groups that are shown breaking social order in horror films (Schneider, 2004). It could be that these actually reflected the cultural anxiety caused by the gay pride and feminist movements of the 1970s.

2.2.2. Millennial Horror

Related to the cultural anxiety theory of horror, there are a few specific markers that cultural critics have identified in modern horror films. We have already mentioned the Birch-Bayley’s “Millennial Zombie” as one of these hallmarks. The other hallmark is a particular kind

of body horror that focuses on lack of control (Reyes, 2014, p. 145). Millennial body horror differs from the body horror found in past decades' horror films because it is precise and calculated as opposed to the bloody mangling found in older films (Reyes, 2014, p. 144). This body horror plays off of fears of surgery and, in Reyes' words, "the post-modern subject's fear of technological advances" (Reyes, 2014, p. 145). Advanced technology as the cause of mankind's downfall can be seen in films like *I Am Legend* (2007), where the zombie outbreak is caused by a bioengineered version of measles designed to cure cancer, and *Ex Machina* (2014), whose story revolves around a terrifyingly human artificial intelligence. Advanced technology is also cropping up in horror television. The British television series, *Black Mirror* (2011-present), features frequent horror based on modern and near-future technology, including several episodes about virtual reality and artificial intelligence.

2.2.3. Artificial Intelligence and Sci-Fi Horror

While advanced technology may be a trait of horror in the new millennium, sci-fi horror is a genre as old as horror films themselves. From 1933's *The Invisible Man* to 1979's *Alien*, science and horror have been intertwined from the start. Artificial intelligence, in particular, has been used to inspire fear in films since at least 1968 with the character H.A.L. 9000 in *2001: A Space Odyssey* (1968). AI also exist as oppressive and violent forces in other films not generally considered part of the horror genre, such as *The Terminator* (1984) and *The Matrix* (1999).

2.3. Short Films

There are four subsections of short film. The subsections correspond to the length of the film, which also determines the basic plot structure. Dan Gurkis calls these four types of film the short-short, the conventional short, the medium short, and the long short (Gurkis, 2006, p. 4). The short-short, as the name suggests, the shortest form of short film. These films feature a

single dramatic action and crisis (Gurkis, 2006, p. 4). One conflict arises and is confronted before being resolved in just one to two major scenes (Gurkis, 2006, p. 4). The second category of short film is the conventional short, which is the most common form in live action film, while short-shorts are more prevalent in animation (Gurkis, 2006, p. 5).

In order for the story to be effectively communicated in a short film, there must be a low limit for the number of characters featured. Gurkis also suggests having the events of a short film occur over the “briefest time period possible” (Gurkis, 2006, p. 6). Gurkis pulls this idea from the ancient Greek concept of classical unities (Gurkis, 2006, p. 6). The three classical unities are unity of time, unity of place, and unity of action (Watt, 1908, p. 531). While these unities are no longer used in theatre or feature films, they act as a helpful guideline for making a short film work (Gurkis, 2006, p. 6). Unity of action says that the film should be held together with one main conflict that carries through from start to finish (Watt, 1908, p. 531). Unity of time dictates that the action be resolved over the time of no more than a single day (Watt, 1908, p. 532). Unity of place suggests that the film or play be set in a limited number of locations (Watt, 1908, p. 532). The classical unities prevent a work from wandering and developing loose ends, plot holes, or confusing narratives.

3. DESIGN

1.1 Experience Goals

When designing the experience, we considered how each design decision would affect the player’s reaction. We leveraged removal of agency to evoke uncertainty and fright in the player when participating in our experience.

Virtual reality provides the player with a greater sense of agency than with traditional videogames because it almost eliminates the constraints imposed by standard input hardware.

The mapping of vision, audio, and hand movements into the virtual world give the player 1 to 1 control over how they observe and interact with their environment. By contradicting the player's expectations of control, we can make them feel uncomfortable. We decided that taking away the player's ability to move both in the game and in real life would result in a sense of unease. The removal of player agency augments the efficacy of the narrative - how the humanity of the player is slowly stripped.

Uncertainty is another reaction we wanted to elicit from the player as they participated in the experience. We based artistic design choices around hiding and revealing elements as the narrative unfolds to keep the player uncertain about how the environment or characters might change. Such examples include the sudden appearance of the medical needles from behind the player or the large industrial arms from their storage bay. Additionally, we wrote dialog to suggest that the technicians know information about the environment and about the player that the player does not know. Ultimately, following removal of agency and uncertainty, we wanted the player to experience fright by including aggressive intrusions into the player's personal space.

3.1. Theme

Virtual Reality is often seen as a marker of dystopia in science fiction. The rapid development of technology also ties into fears of sentient computers, another common dystopian theme. The ARIN VRE wanted to explore feelings that are common in films and books about these topics: themes of distrust and lack of agency. However, to take advantage of VR's ability to create empathy, we decided that working from the android's point of view would be more powerful. We wanted to challenge the fear of artificial intelligence by getting the player to sympathize with the android.

We also chose to draw upon real world robotics and the potential concerns related to its development. With a more plausible experience, the user can use their current knowledge of the world to relate.

In the experience's scenario, the user is put in the place of an advanced android that is being developed to host a sentient neural network. This immediately creates an unstable situation with no clear-cut or pre-existing protocol to explain what should be done in the event sapience is achieved by an artificial intelligence. The user is then stripped of their humanity as the nature of their existence is revealed to them.

3.2. Immersion

3.2.1. Audio

As a VR experience, the ARIN VRE's audio is different from normal films or movies. Instead of simply playing the recorded sound tracks, we wanted the ARIN VRE to have 360 audio for the purpose of immersion. That means the sound of a certain object in the environment will vary depending on the position and direction of the object relative to the camera. For instance, when a character is talking in front of the player avatar, the players will hear slightly louder audio in their left ear if they are looking at the right side, and vice versa.

3.2.2. Visual

The ARIN Project is set seventy years in the future. This near future setting allows us to create a convincing science fiction. The lab relies on a lot of things that are simply very exclusive, advanced technology today being used as if it is everyday technology. Instead of having to invent a large collection of new technological devices, we decided to take the advanced technology of today and simply take it one or two steps further. We added in visual suggestions

of this tech being a more user-friendly version of old tech: they're more ergonomic, lighter weight, and more powerful, but they get the same job done.



Figure 1: Comparison between our design (right) and a real-life counterpart (left). Image source:

http://www.homedepot.com/catalog/productImages/1000/a0/a03dd447-1868-41f7-9303-bd9d4a59dd07_1000.jpg

These visual designs are implemented in a photorealistic fashion. The photorealism adds to the foreboding nature of the environment and narrative. Lower realism and cartoony visuals often present themselves as fun or friendly, which acts against the direction of the experience. From a practicality standpoint, photorealism also allows for the use of high quality photo textures, which alleviates some of the texture painting necessary for the project.

3.2.3. Tactile

External hardware was used to build the tactile environment for the players: a zero gravity chair (see Figure 2) that the player can sit in and relax, a safety belt, and the HTC Vive controllers. We believe that by building this tactile environment, the player can immerse into the VR experience quickly and empathize with ARIN more easily.

The zero gravity chair serves several purposes. First, the chair can be modified to match the exact same shape as chair that ARIN sits on, which improves immersion by lowering the dissimilarity between the player and the avatar. Second, the player can fully relax on the chair so that they will not be distracted by discomfort while sitting. The safety belt was sewed onto the chair so that if the player permitted, the safety belt would be put on and restrict their movements. In the ARIN VRE, the avatar ARIN is unable to move its body and get up from the medical chair. By physically restricting the movement of the player in the tactile environment, it with the restriction of moving ARIN's body in the experience, which potentially leave them vulnerable and insecure to create more empathy with the main character. The HTC Vive controllers were provided as an emergency exit. Whenever the player wants to stop the experience, they can hold down both triggers on the controllers for three seconds and go back to the title screen.



Figure 2: The zero gravity chair used in the performance

3.3. Narrative

3.3.1. Plot

The plot of the ARIN VRE is designed to achieve our experience goals of creating unease, uncertainty, and the feeling of being removed of one's humanity. The plot was also designed to be scalable to the scope of our game. The experience script had a 1-3 minute scene inside a larger, 5-7 minute story that could achieve the goals of our experience either way. The flexible narrative allowed us to test if we were achieving these goals without investing the time and effort into a longer piece that may not be effective.

Although the ARIN VRE is a virtual reality experience, the narrative closely follows the structure of a short-short style short film. The relationship between length and plot in short film is covered briefly in section four of chapter two. To reiterate, short-shorts are the shortest form of short film. Short-shorts are under five minutes long and feature a single point of conflict as the major crisis of the film. The crisis in the ARIN VRE is ARIN gaining consciousness and awareness before it was intended to.

The player starts the experience lying on a table in a room that is designed to look somewhere between a spaceship and a lab. In the experience, the player takes the role of ARIN, an android that uses an advanced artificial intelligence. A woman, Dr. Ada Barrow, is the only other being in the room. She notices that ARIN is awake and tries to communicate with ARIN. When Dr. Barrow realizes that ARIN is responding, she calls in Dr. Escarra. Dr. Escarra rushes into the room and immediately decides that what is happening with ARIN could compromise either the project or the safety of the technicians in the lab. The central crisis reaches the climax when Dr. Barrow and Dr. Escarra decide that the only option they have is to force ARIN to shut down. Medical robots cut open the android's body, revealing its true nature. This breaks the

connection between ARIN and the technicians and makes the divide between them even more obvious. Dr. Barrow removes ARIN's mechanical ribs and pulls out a power source that is placed where ARIN's heart would be if ARIN were human. After ripping ARIN's "heart" out, Barrow shuts ARIN down. ARIN's vision fades out, returning briefly as a last glimmer of hope, before ARIN shuts down completely.

The plot is designed to lead the player into believing that Dr. Barrow cares about ARIN's wellbeing and safety at first. Then the plot takes a slight turn when Dr. Escarra comes in. Suddenly, the two technicians are concerned about ARIN. The technicians' worry should make the player concerned for ARIN's wellbeing. The player's concern builds a greater empathetic connection between the player and ARIN. The plot fosters this connection in order to make the removal of the player's agency and humanity more impactful. The removal of the humanity comes through in the actual removal of the things that make ARIN look human. First, ARIN's gown is removed, revealing eerily spotless skin. The big moment of dehumanization comes when ARIN's chestplate is removed and ARIN's mechanical interior is revealed. The moment of dehumanization is also accompanied by the technicians beginning to speak about ARIN as an "it." Calling ARIN "it" is also a way of removing the sense of humanity because the pronoun is associated with inanimate objects and reducing humans to inanimate objects.

3.3.2. Setting and Environment Design

We looked to scientific and industrial environments for our inspiration, specifically silicon wafer fabrication rooms, factories, server rooms, and even the International Space Station. Not only did we draw visual inspiration from these references, but also aural inspiration when designing our sound effects.

Visual Design

The “clean room” environment, exemplified by the silicon chip production environment as shown in Figure 3, helps us immerse the player by evoking a sense of claustrophobia and unease. This type of environment is almost entirely white and unnaturally sterile, almost acting as sensory deprivation. Only hints of color exist around the space and draw the player’s attention. It helps the characters stand out because their skin hues pop from the otherwise desaturated surroundings.

To create a feeling of claustrophobia, we designed a room far taller than it is wide. The large expanse above gets darker toward the top as the lighting is focused on the bottom third of the room (Figure 5). This makes it impossible for the player to know where the ceiling is and what might be up there. Additionally, the player is presented with areas of unbalanced detail density to make them feel as if the space is closing in upon them. The “clean room” was also modified to look more lived in. The more detailed spaces have evidence of use and grime, which makes the room feel more real and leads the player to question the history of the room.

Our environment was initially designed to closely match the clean room depicted in Figure 3, however through the iterative process it gradually became much darker as shown in Figure 4. We felt that the initial full-white concept was not the best expression of our experience goals because it was not uncertain or frightening enough. In order to augment the sense of unease and uncertainty we made the environment much darker, matching that the ISS interior (Figure 6). We introduced unnatural color variations throughout the space above the user and even designed a post-processing shader to artificially darken the room’s extremities. The removal of light and artificial darkening focus the player’s attention on their immediate surroundings.

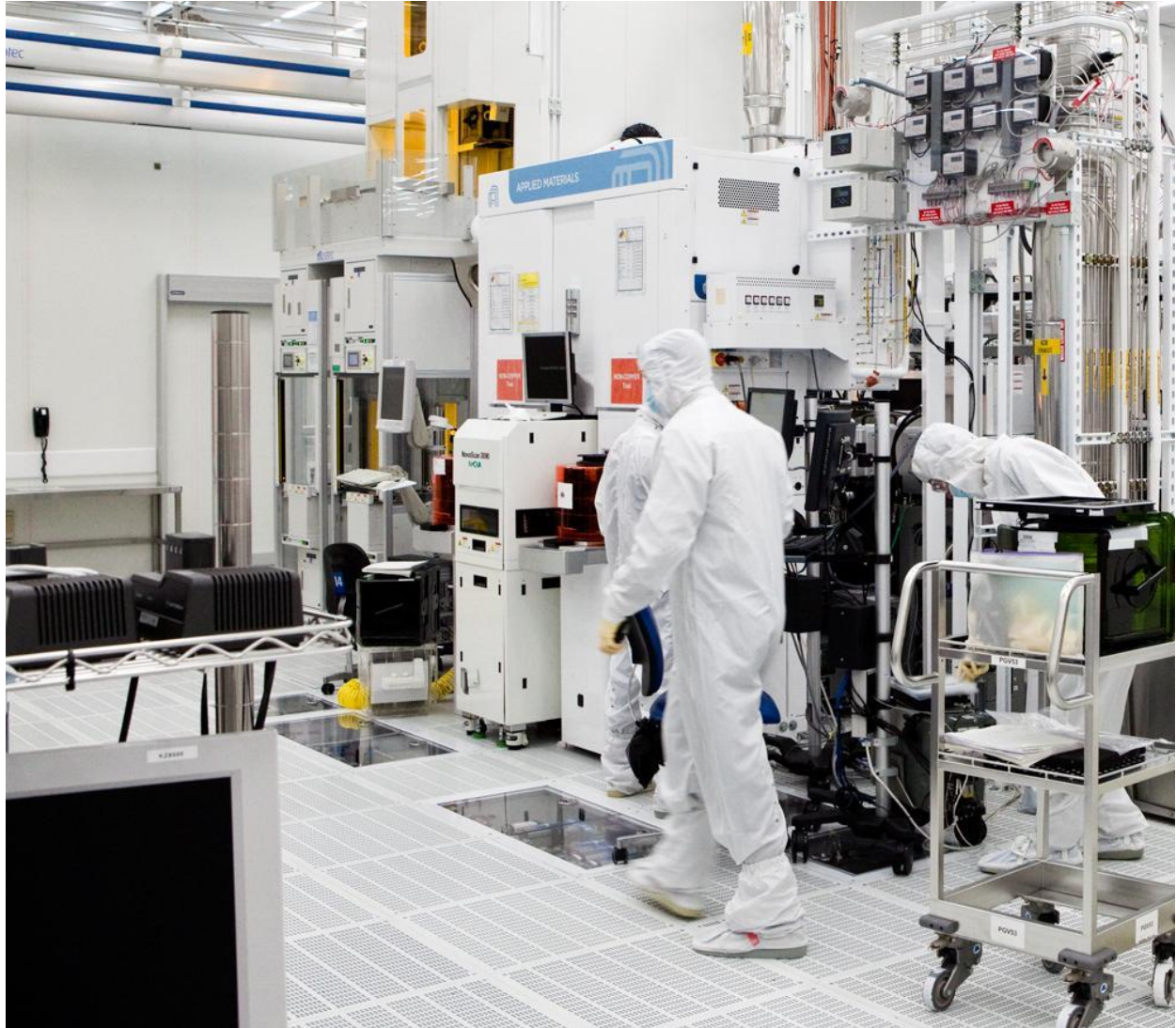


Figure 3: Silicon chip clean room environment. source: https://www.wired.com/images_blogs/gadgetlab/2010/10/mg_6161.jpg

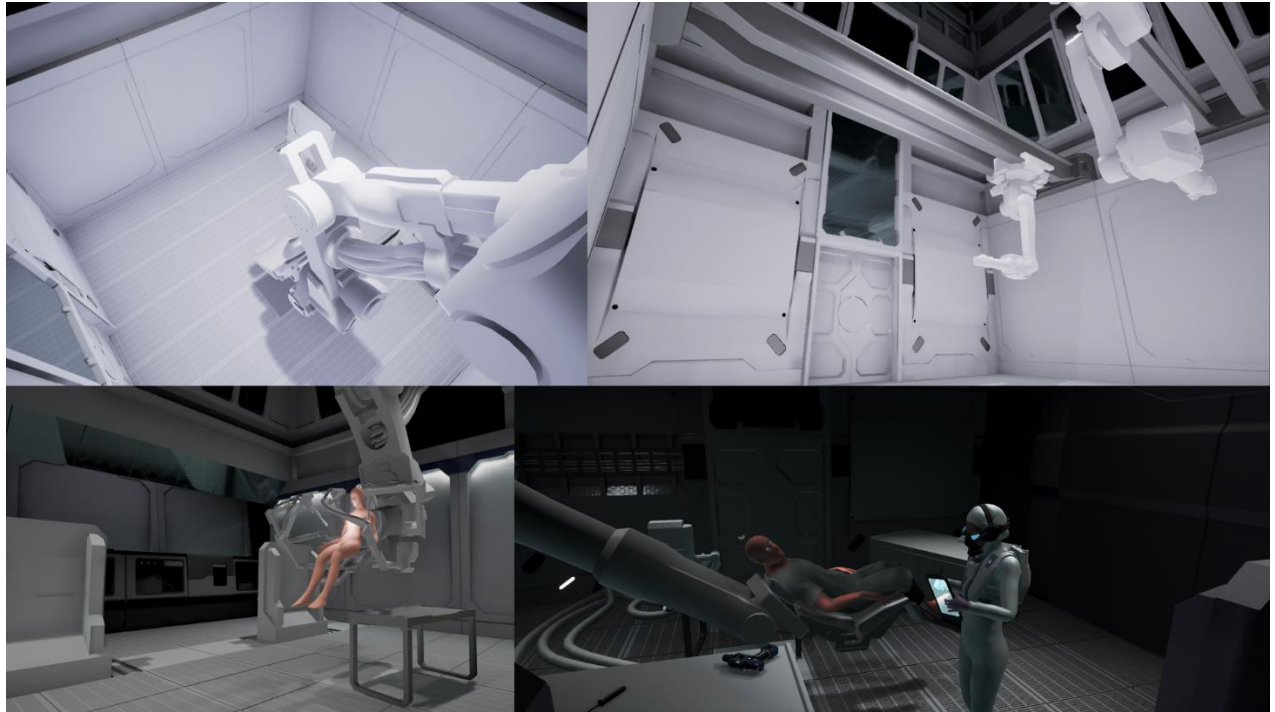


Figure 4: Progression of environment design - upper left represents earliest, lower right represents final

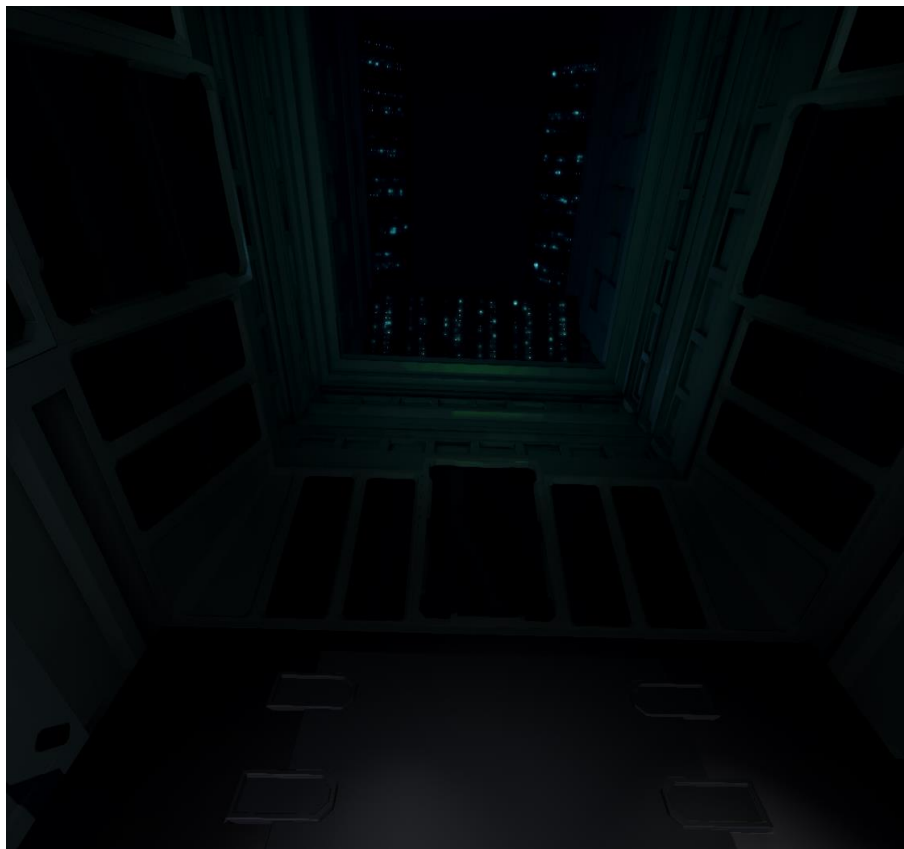


Figure 5: Upward-facing shot of the ARIN VRE environment

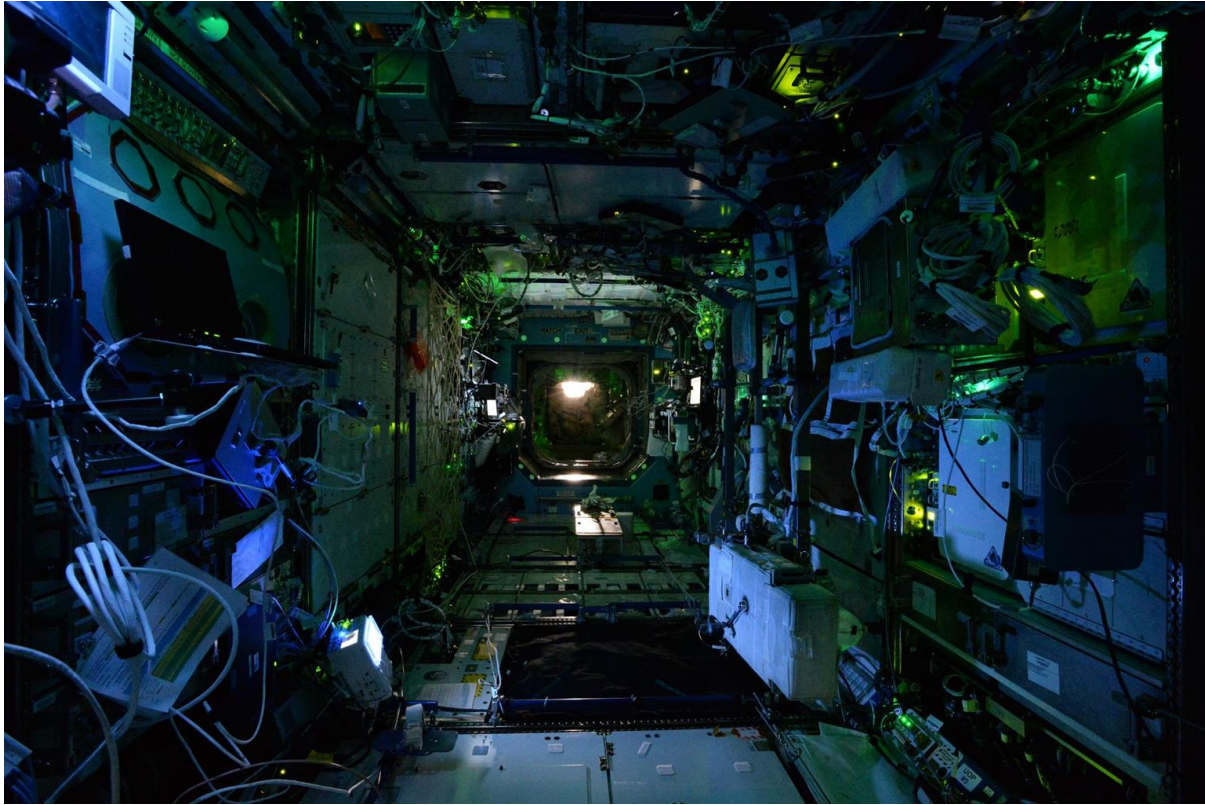


Figure 6: International Space Station internal shot: source: <https://s-media-cache-ak0.pinimg.com/originals/18/79/f4/1879f463421be0f99578dc5769be2277.jpg>



Figure 7: ABB IRB 1600 - real world industrial arm inspiration

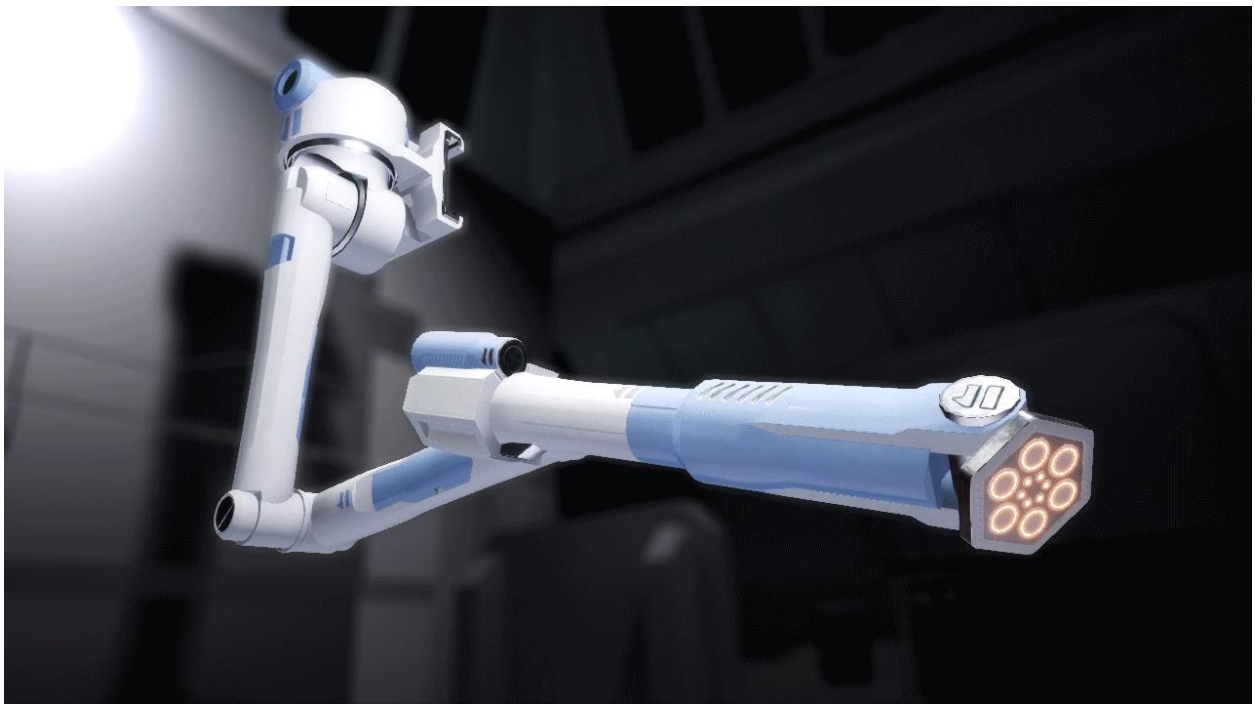


Figure 8: In-engine version of the large armature



Figure 9: The two large armatures

Inspired by clean rooms as used by NASA as well as the sci-fi environment designs of well-known sci-fi horror films, like *Alien*(1979), the environment is meant to displace the player and take them out of their comfort zone. Large machines occupy the space and come out of panels in the walls to give the player the feeling that the room itself is alive.

For example, there are two large armatures (Figure 9) that appear at tense points in the film, which take the room from a somewhat calm environment and transform it to feel like the room itself is attacking the player. In order to design a convincing and realistic armature, we began by looking at a real-world example shown in Figure 7. Not only did we draw from this example for its visual design, but also its specific movement characteristics. This robot, known

as a wrist-partitioned arm, has 6 joints in a specific configuration which give it the ability to move freely inside its reach (Hollerbatch & Sahar, 1984). Our arm was modelled specifically to match this configuration, with an additional redundant joint for extra reach. This means that when rigging our armature with inverse kinematics, it behaves similarly to its real world counterpart. Even if the player does not have experience with industrial robots, they still understand that the armature is a plausible device. Keeping our designs within the realm of “physically plausible” helps to suspend the player’s disbelief in the reality of their environment. We applied this design strategy to all of our models, considering not only how to depict them as visually realistic, but also mechanically realistic.

Inspired by the lighting in films like *Alien*(1979) and *Blade Runner*(1982), we created a largely blue and green lighting scheme (Figure 5). The room is taller than it is wide, so by concentrating the lighting toward the bottom of the room, we were able to create a dark, expansive ceiling that makes the player feel a sense of unease about what might be up there. Especially because there seem to be horrific mechanical devices hidden in every other corner of the room.

Sound Effects

The sound effects for ARIN are based largely from real industrial robots and industrial settings. Even the ambient background noise was composed from a mixture of industrial air conditioning sounds and low-pass filtered industrial machinery. The sound effects are designed to make the environment sound “cold.” At the same time, the sound effects needed to be embellished and futuristic to match with the visuals of the environment. The robots, for example, include the whine of a jet turbofan engine in order to cover the higher frequencies and impose more sonic information upon the player.

All sound effects were processed to include reverb and low-frequency boosts to create the boomy effect of a vast, empty, and artificial space. Hard surfaces such as metal are able to reflect sound efficiently, which produces the reverberation effect often present in large, empty warehouses or hangars. We use this effect to make the environment seem larger than it appears, especially given the vanishing ceiling.

3.3.3. Characters

Technicians: Narrative Roles

Dr. Simon Escarra is a highly regarded and published computer engineer specializing in deep learning and neural networks. He is older and more experienced in the field of artificial intelligence than his co-researcher, Dr. Ada Barrow. He worked on the prototype version of the AI that ARIN is using and is the project lead on the implementation of this AI into a functioning android for military espionage purposes. He does not have a moral conflict with the existence of sapient technology, however, he has concerns over the power that is being given to this technology. As a military android, ARIN is designed to be skilled in deception and manipulation as well as physically powerful. Dr. Escarra is very hesitant to deal with this technology outside of any environment that he does not have complete control over. When ARIN wakes up unexpectedly, he fears the worst: that they could have a dysfunctional AI that cannot be controlled or contained.

Ada Barrow is an accomplished robotics engineer and electronic systems designer who was brought on to the ARIN project after the development of the AI. She is in charge of producing ARIN's peripherals and is more interested in that aspect than in the AI design and implementation. She has a "shoot first, ask questions later" mentality which gives her a sense of direction and allows her to accelerate the plot faster than Escarra would have been able to on his

own. Barrow pushes Escarra to make time sensitive decisions more quickly, because she is impatient, but also concerned with keeping the project on schedule. She has gotten antsy as she hasn't been able to truly test a lot of the work that she's put into the project because ARIN hadn't been activated yet. Barrow treats ARIN with more compassion and humanity because she is not as familiar with ARIN's programming. AI is still somewhat of a mystery to her at the detailed level, so she resolved to just treat ARIN as if it is human.

Technicians: Character Design



Figure 10: Dr. Ada Barrow (left) and Dr. Simón Escarra (right)

The setting is inspired by medical facilities and clean rooms, and thus the two technicians are outfitted in sterile uniforms (Figure 10). However, in order to provide a narrative foil for the android's dehumanization, we wanted the other characters to be easily humanized by both their design and actions. In order to do this, the two characters had to be noticeably different. Some of

these design choices are more obvious than others. Barrow is female and Escarra is male, their noticeably different silhouettes make it easy for the player to differentiate the two, despite their identical uniforms.

Other details are less obvious and created to suggest that these characters have a richer background and are not just stock versions of a man and woman who fulfil the single purpose of building this android. Escarra has a larger gut and heavy eye bags that suggest that he spends more time working on this project than taking care of himself. There is a heavy wrinkle between his brows to suggest he spends a lot of time with them furrowed in concentration, which can be seen in Figure 11. Barrow is a little younger than Escarra, which is reflected by her voice and small details in her clothing, such as her more fashionable footwear. Both characters wear the same basic costume, so making sure they had visually different silhouettes was necessary to make sure the players could tell the two characters apart immediately.

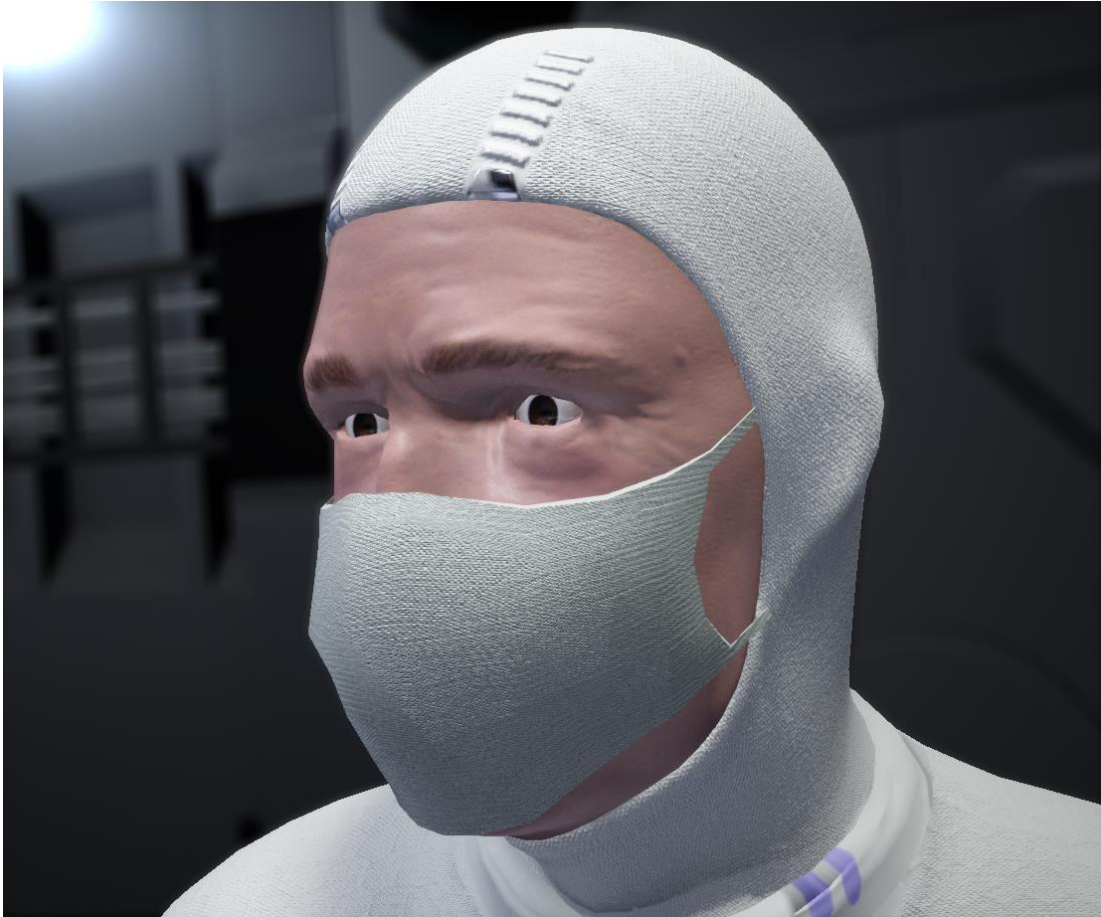


Figure 11 Dr. Escarra. The texturing on his face and his sagging jawline reveal his age and fatigue.

We set out to make these characters more diverse, in terms of gender and age than the traditional sci-fi game characters because we felt that it added an extra layer of believability to the characters. We were also inspired by the way some science fiction works, like the original Star Trek television series, feature a more diverse cast of characters as a way of envisioning a future that has progressed past the civil rights issues of modern time.

The technicians' costumes were also designed to emphasize the theme and setting. The suits were inspired by cleanroom coveralls, but reimagined for how they could evolve in the near future. Inspiration for this evolution was taken from many places, such as the asymmetrical paneling on Star Trek uniforms and "performance enhancing" details from athletic clothing. For instance, they fit closer to the body, which prevents the fabric from easily snagging on

mechanical parts. The head coverings are made of a tight, synthetic material that allows for the technicians to put on and remove high tech, head-mounted, AR gear without removing the hood of the suit. Barrow has an intricate piece of AR headgear that can be flipped up to reveal her eyes, or down to hide them (Figure 12). At the beginning of the experience, the player is able to see her eyes, which creates a sense of trust. As Barrow begins to disassemble the android, she flips the lenses down, obscuring her eyes and making her look less trustworthy. The lights come primarily from above and around the android, so the lenses become more opaque as they reflect the light near the android. The effect of the lighting on Barrow's AR gear can be seen in Figure 13.



Figure 12 Dr. Barrow with AR headset.

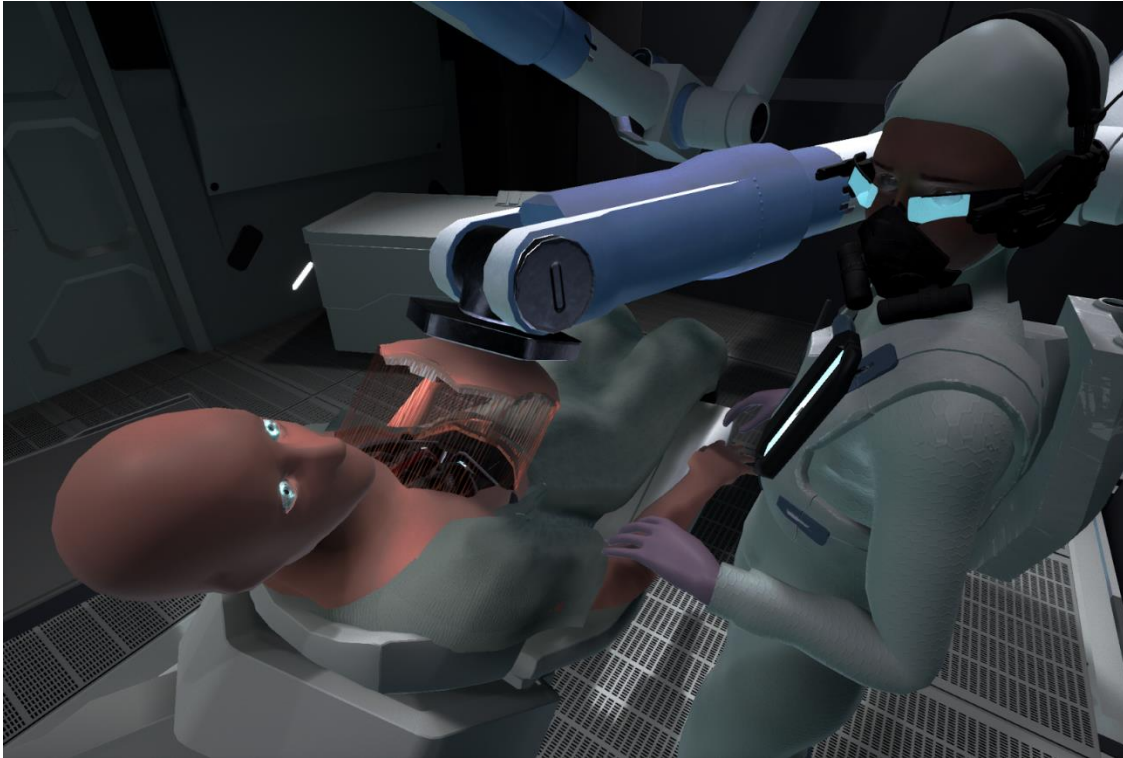


Figure 13 Example of how the lighting interacts with the material on Dr. Barrow's lenses.

Both technicians also wear masks. Barrow's is more heavy-duty than Escarra's, as she works directly on the mechanical elements of the robot and may be close up with strong epoxies and other dangerous substances. Escarra's is less intense, just a cloth cover, as he tends to be further away from the android and in the room for shorter amounts of time. The masks also serve a practical purpose for the animators by removing the need to have perfectly accurate lip sync. Lip sync takes a lot of time. Adding the masks allowed us to spend more time on making the other animations highly polished and believable. The masks also make the technicians scarier because they further obscure their faces.

Certain familiar elements were kept to maintain the illusion at the beginning of the plot that the player is in some sort of medical facility. For example, the purple color on the technician's uniforms is similar to the purple often seen in scrubs and other medical clothing. Both technicians also wear purple nitrile gloves, which are generally associated with medicine.

ARIN: Narrative Role

ARIN stands for Automated Reconnaissance Intelligence Network, which is the artificial intelligence program that ARIN runs and was named for. The project to create ARIN was funded by the military and benefactors who support the military. ARIN was designed to appear human and act as a spy when finalized. This is why ARIN doesn't have an easily accessible external shut off--to prevent those not familiar with ARIN's construction from deactivating the android.

ARIN does not have speech capabilities. This restricts the player's communication to a limited set of gestures that they would be capable of performing while wearing the VR headset and in the chair. Because ARIN can't speak, we didn't have to account for user voice input, something that was way out of the scope of this project. Taking away ARIN's voice limits its influence as a character separate from the player. This "silent protagonist" sense allows the player to project their own emotions onto the character, which makes the player feel more in tune with the actions of the protagonist.

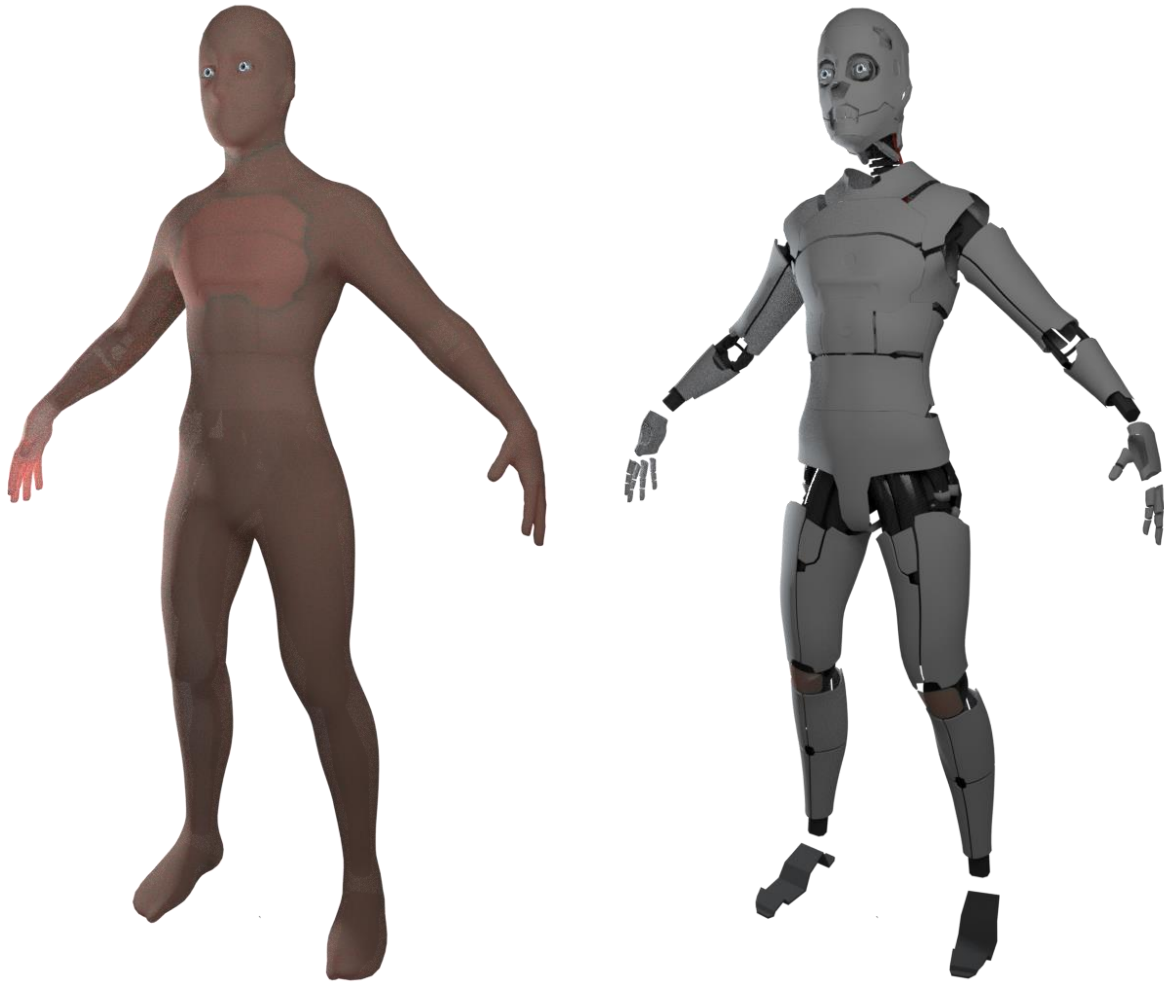
ARIN: Character Design

Figure 14: ARIN's body with skin (left) and without skin (right)

ARIN, the android, is designed to be androgynous - a blend between male and female proportions (Figure 14). We felt that this would prevent discrepancies between the player's body and ARIN's body to make it easier for the player to assume the role of ARIN.

ARIN is covered with an artificial skin weave which acts as a flexible regenerating barrier against the elements. To the player this will resemble normal skin - perhaps a little too smooth. When the technicians have to remove the skin, however, it should look like they are cutting through real skin. The illusion of humanity is only on the surface of the android.

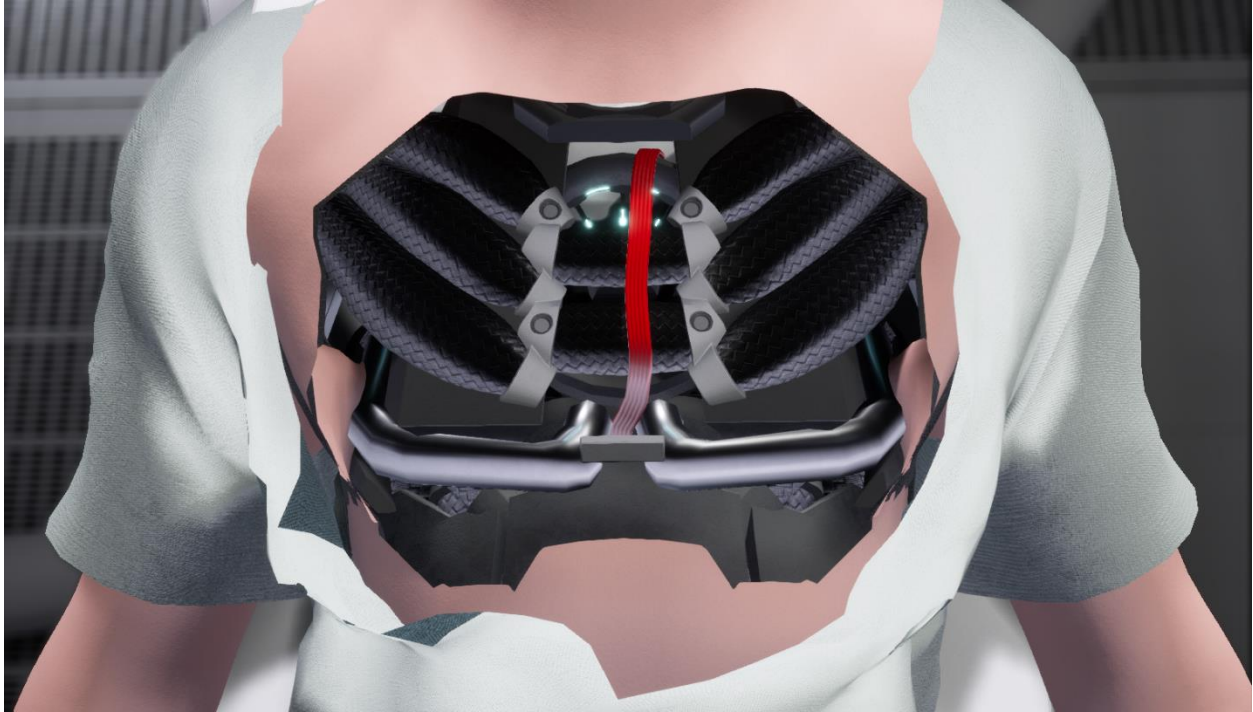


Figure 15: ARIN's internals

ARIN's internal structure (Figure 15) features structural components inspired by human anatomy such as rib plating and synthetic muscles which follow similar contours to real muscles. Mixed in with those components are more standard computer parts, circuit boards, fans, and wires. We looked at Boston Dynamic's big dog prototypes (Figure 16) and computer motherboards for inspiration, as well as Deus Ex (Figure 17) concept work for the more futuristic anatomically-inspired musculature. Notice how the big dog prototype includes exposed and chaotic internals – wiring, fans, pipes etc. – and structural caging. The structural caging was modelled to the contours of the android's figure, but kept relatively square in order to appear industrial. On the other hand, we wanted to convey a futuristic aesthetic by including organic muscles such as those seen in Deus Ex (Figure 17). Deus Ex depicts prosthetics modelled directly after human musculature, as a mixture of organic forms and hard mechanical edges. We wanted to make it seem as if ARIN was a hybrid between mechanical and organic components,

so when the player sees their own internals, they associate the organic components with their own anatomy. The resulting disunity between industrial and organic is unsettling.

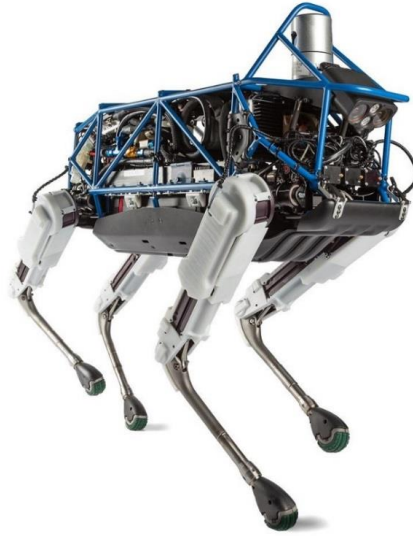


Figure 16: Boston Dynamics' "Spot" version of the "Big Dog" robot. source: <http://www.blog.davidburrell.com/wp-content/uploads/2015/02/spot2.jpg>

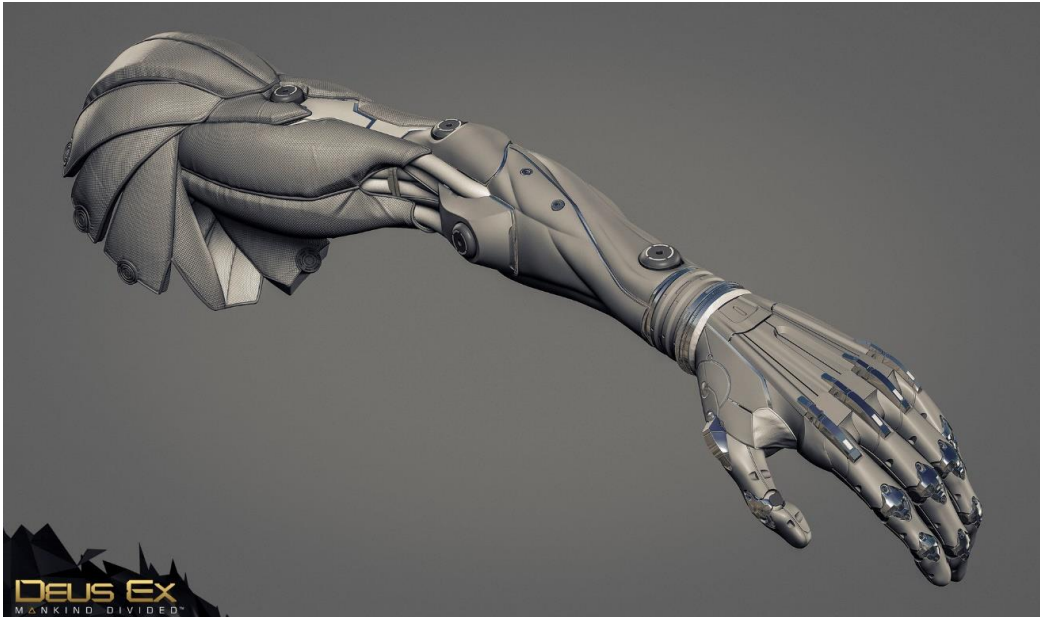


Figure 17: Concept art from Deus Ex showing musculature. source: http://vignette1.wikia.nocookie.net/deusex/images/f/fb/Adam_Jensen_arm_render.jpg/revision/latest?cb=20160920111423&path-prefix=en

3.3.4. Voice Acting

As discussed in the previous section, we limited the number of characters in the experience to avoid confusing the player and to allow for the few characters to be developed more fully within the time restriction. Of the three characters in the experience, only two have speaking roles. We chose to make ARIN a mute character for both storytelling and immersion purposes. By making ARIN mute, we placed another limit on the player's ability to fight back. Removing the player's agency can increase the feelings of stress and anxiety. Mute player characters are easier for the player to relate to because they won't say things that they player might disagree with. In game design, silent protagonists are known to increase the connection between the player and their avatar.

Unlike ARIN, the two other characters are constantly communicating. They are accustomed to documenting their actions as part of their scientific procedures. The back-and-forth dialog also encourages the player to look around in order to follow Barrow and Escarra's voices. In order to keep the immersion, we had to find voice actors who sounded old enough to voice the two middle aged characters and were also able to exaggerate the emotion in their voices. We took advantage of the strong theatre community at Worcester Polytechnic Institute and opened auditions to any interested students. By keeping within the university, we were able to work with voice actors with whom we could easily schedule recordings. Our methods for recording audio, including dialogue, are discussed in section 1.6 of chapter four.

4. METHODS

4.1. Workflow

4.1.1. Agile production

The goal of the ARIN VRE was to create an immersive sensory environment that takes advantage of the storytelling possibilities unique to virtual reality hardware. In order to adapt to sudden changes in narrative based on playtesting or evaluation feedback, we needed to use an iterative production model to constantly refine our assets. We chose to follow an agile approach to designing the ARIN VRE. An agile production model allowed for us to continually assess elements of the experience well before releasing the final product. The agile production model, which is a common production style for video games, encourages testing the game frequently in order to spot changes that need to be made early on. The Agile model allowed us to quickly prototype design alternative, such as how the environment could be rearranged and re-lit to better convey the uncertain atmosphere in the narrative. With the ARIN VRE, our goal was open-ended enough to allow us the freedom to make experimental changes.

Agile production is a general concept of development with a variety of more specific organizational methods that a team may use. We decided to work with the Kanban production model. Kanban refers to a production model developed by Toyota to provide an easy visual indication system to the organization and priority of production tasks. We use a Kanban system, Trello, in order to organize our larger-scale tasks into small-scale tasks. The system makes it possible to visibly gauge the volume of production tasks in a certain category. It is also highly collaborative, allowing us to add tasks as they came up and take on new tasks as we finished them.

4.1.2. Live action script tests

To tell our story in a virtual reality environment, we had to ensure that all parts of the script worked together with the staging to create the immersive experience we were looking for. One of the tools we used for this was a live action script test. In this script test, we had a playtester lie down on a table in the center of a room while two actors performed the parts of technicians Barrow and Escarra. We recorded it from 3 different cameras placed strategically in the room. Two of the cameras were placed in opposite corners of the room, and were pointed at the “operating” table in the center. The third camera was a GoPro that we attached to the playtester’s forehead to record the player’s point of view. We did this with two different playtesters and it gave us a better sense of how the character’s movements needed to be choreographed as well as how the interaction between the player and the experience was effected by the setting.

We learned a number of things from the results of the script test, including which parts of the script that didn’t work or sound natural as well as parts of the blocking that didn’t make sense. The main thing we learned, however, was that lying down on a table wasn’t the most optimal position for the player because in order to see the action they would need to sit up. Based on these conclusions, we changed the experience to use a reclining lawn chair to seat the player instead. We found that this was not only more comfortable for the player, but also that it made it easier for them to view the events unfolding around them.

4.1.3. Static Art Workflow

Zbrush and Marvelous Designer

We chose Zbrush as our primary character modeling software. Zbrush provides very powerful high resolution 3D modeling tools (Pixologic, 2017) that allowed us to create character

models with a high level of detail density, which helped us to reach the photorealistic look for our characters. The clothes of the characters were created and assembled in Marvelous Designer. Marvelous Designer is a great tool for designing realistic clothing and fabric. With the specific tool kit and workflow Marvelous Designer provided, we were able to block in the basic form of the characters outfit quickly and then brought the models into Zbrush for adding details and refining. After UV unwrapped the character models in Autodesk Maya, we were able to export the low resolution model with normal maps quite conveniently.

Blender

We chose to use Blender as our primary modelling and animation platform because it offers our team a number of advantages over commercial software such as Autodesk Maya and 3ds Max. All three software provide industry-standard modelling and animation packages and output in the same general formats. All three software packages have very active communities - Maya and Blender are also continuously updated to stay in line with modern UI conventions. The choice of Blender did not affect the visuals of the final product but its other features significantly sped up our production process.

Blender is a free, open source platform (Blender Foundation, 2017) which means we do not have to accredit any of our work to Autodesk. Even if we were to take our experience to market, we would not have to worry about intellectual property ownership conflicts due to Autodesk's licensing restrictions. It made it simpler for our team to stay up-to-date with the latest versions without significant time overheads.

Blender's open source status also facilitates a large community which regularly contributes to bug fixing and addon creation on a much larger scale than Autodesk could employ. We used a number of third-party add-ons in our process, primarily "rigify," which generates rigs

automatically with animation controls. This add-on, as well as other modelling add-ons saved us a lot of time without introducing any cost. The add-ons themselves are open-source, which means that we may modify them if need be.

Blender also includes a powerful python scripting layer (Blender Foundation 2017), like Maya's pyMEL. The documentation is very clear and thorough, including examples and templates. Maya seems to lack in this area. We used the scripting to help greatly speed up the exportation process of large batches of fbx files, as well as particular repetitive use cases like automatically rigging the physics system for the tubes on the medical arms.

4.1.4. Animation

Storyboard

Traditional storyboarding is focused on framing out specific shots. In cinema, camera angles act as narrative devices, influencing the tone of the scene. With virtual reality, the designers have no control over where the player may be looking and therefore, cannot frame out specific shots. With this in mind, we had to take alternate approaches.

After we completed our first animatic, we wanted to further refine our storytelling elements so we revisited the storyboard concept. We no longer had large portions of the script to change, and were focusing more on small edits and using the scene to our advantage. The top-down storyboard was done to aid in the development of our second animatic, which would then become the skeleton for our final animation. We chose the top-down style because it gave us a better sense of when the characters would be within the player's view (Figure 18). This format also made it easy to overlay the movements of the characters so we could make sure they were taking advantage of the full expanse of the scene (Figure 19). By making sure that the characters

cross the center of the player's field of view, we were able to encourage the player to look around, taking advantage of the player-controlled camera.



Figure 18: A single frame of the top-down storyboard

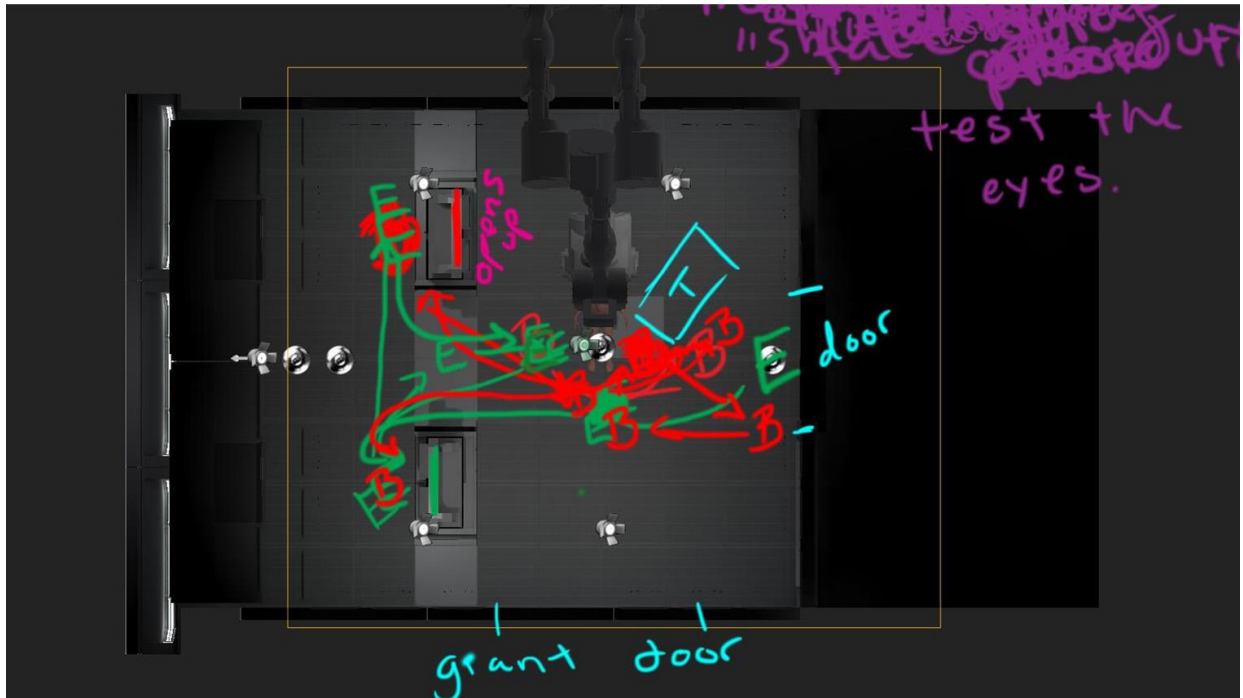


Figure 19: A "heatmap" view of all the overlaid storyboard frames. Shows how often the characters occupy a given space

4.1.5. Audio

Voice Acting

Virtual reality is a primarily audio-visual experience, so voice acting is a key performance element in our project. We held auditions for student voice actors, focusing primarily on whether or not the voice talent sounded old enough. We also considered how well we thought the voice talent would convey the personality of the characters - Escarra's crankiness and Barrow's cynicism. We oversaw the recording process with our voice actors, ensuring that both were present for the sessions in order to add conversational authenticity. Had our voice actors recorded their lines separately, they would not have been able to cue off the other's tone of voice.

There were two recording sessions. The first session was a scratch track—a rough pass through the script so we could have animation timing reference. The scratch recording allowed

us to identify and troubleshoot dialog issues in the script such as awkward word choice and timing-related issues when integrating with the animation. Analyzing the scratch track allowed us to improve our script and implement those improvements in the second recording session.

The actors read through the script multiple times with varying tone, giving us options to choose from. We decided which version of the line worked the best, including swapping out single phrases, and produced final audio stems for Barrow and Escarra separately. Separate tracks allowed us to make use of Unreal 4's positional audio to help aid the sense of immersion.

We post-processed the audio from the voice actors in order to make them sound older. This included pitch shifting both voices down by a semitone and boosting the lower frequencies. Even through the pitch shift down was nuanced, 50 cents of a semitone at most, the characteristic of the voice changes enough for the listener to notice a difference. The low frequency boost helps the voices sound richer.

SFX

The sound effects are designed to juxtapose the environment's medical appearance. We sourced our sound effects from freesound.org and our own recorded audio. As discussed previously, we used sounds inspired by industrial and metallic elements such as industrial air conditioning, electronic whine, and metal-on-metal contact. The reverb effect and low-frequency boosting helps convey a sense of emptiness despite the apparent size of the room.

4.2. Game Engine

Currently, the two primary development platforms for VR games are Unreal 4 and Unity 5. Both engines come with native support for both the Oculus Rift and the HTC Vive and integrate the development process seamlessly. We elected to use Unreal over Unity because it offers more flexible material options and in-depth animation controls. Unreal's rendering

pipeline is also much more flexible and artist-friendly with features like post processing materials using the node editor. Accomplishing something similar in Unity requires intimate technical knowledge of the shading API.

The sequencer tool included in Unreal makes editing cutscenes and cinematics much simpler. Recent updates to Unreal have focused heavily on improving the cinematic capabilities of the engine, including adding cinematic camera controls and post-processing options, sequencing and playback controls, and VR optimizations which increase the quality of rendering on VR hardware.

5. PLAYTESTING

5.1. Methods

5.1.1. General Playtesting Methods

In the late 1980s, Kathleen Gomoll worked as a member of the Advanced Technology Group at Apple to develop guidelines for user testing. We incorporated suggestions from these guidelines into our playtesting procedure where they fit with our objectives. For example, we encouraged players to say things that they noticed about the experience during their playtesting time. We also showed the players all of the equipment they would be interacting with and explained how it worked in order to create a more comfortable environment. Our written disclosure fulfilled most of the other steps that Gomoll suggests for user testing, including informing the player of how their feedback will be used and ensuring them that they would be able to quit at any time. We also made sure to verbally and physically demonstrate how quitting the experience worked with the controllers that the player would be using, as players may not have encountered the type of controllers we were using prior to this experience. We felt it was especially important that our players were able to quit as soon as they felt uneasy as we were

working with surgical themes and trying to create feelings of being trapped, isolated, or otherwise dehumanized.

5.1.2. Open-ended survey

We designed a short, open-ended survey for our playtesters to fill out once they completed the experience. We chose to design our survey using open-ended questions because we specifically wanted detailed, open-ended feedback (Fink, 2013). A close-ended survey would perform better on a larger scale and allow for quantitative statistical evaluation, but we needed to gather more personalized feedback for analysis. We also knew that our playtesting group was not going to be very large, so an open-ended survey would be easier to parse through. The survey was partially designed to gauge how the user reacted to the experience as well as general playtesting feedback related to technical glitches and basic quality control.

The survey contains the informed consent form (see Appendix B) followed by 4 questions randomly selected from a list of 7 (see Appendix C), followed by a closing feedback question. We designed the survey this way in order to allow the user to provide feedback quickly-enough to retain the experience and cite specific elements of it. Additionally, open-ended questions place greater mental load on the user. A large quantity of open-ended questions causes the user to lose interest and the quality of responses diminishes. We made the assumption that we would have enough playtesters so that all of the questions would be answered at least twice.

5.1.3. Procedure

The VR MQP requires the use of human subjects as play testers. Our project is an augmented virtual reality experience, which means that in addition to traditional VR hardware

and software, we include constraints and effects that could potentially introduce unease in the subject.

In order to attract play-testers we made sure to include Virtual Reality as our main selling point. Modern virtual reality platforms are still rare, expensive, and space-consuming, so the average person is unlikely to have used the hardware. We had e-mails sent out with our “elevator pitch.” In order to help incentivize playtesters to give us feedback, we incentivized the task with a raffle item: a \$40 Steam gift card.

In order to schedule sessions, a simple public spreadsheet was created to allow us to organize when we could oversee playtesting and allow our playtesters to sign up for a time slot. At the beginning of each session the playtester was prompted to read our informed consent form and either agree to continue or disagree. If they agreed, they participated in virtual reality portion of the experience.

In the interest of creating the most immersive experience we could, we restrained the player so they could not move beyond a certain controlled extent. These restraints consisted of a single, quick-release strap around the shoulders to minimize limb and upper body movement. These straps created a physical sensation when the player tried to move which correlated visually with restraints in the movie. We hoped to increase the sense of immersion by including tangible elements like these.

In order to separate our players into those willing to undergo the full experience and those who do not, we asked for informed consent beforehand and then split our subjects into groups. We were interested in analyzing the differences between players who had physical restraints and those who did not. We did not include restraints unless we had explicit consent via the informed consent form from the player beforehand. If the player did not wish to be restrained

then we allowed them to participate under the assumption that they will move very little from their initial location.

We then helped the player get situated in the chair. Then they were given the HTC Vive headset and controllers. We explained that if they, at any time, wished to stop the experience, they could hold down the triggers on the controllers to stop the VR playback in the event that they experienced simulator sickness, or felt too uncomfortable to continue the experience. Once the player was ready to start, we ran the VR experience.

Following the experience the player was given a short questionnaire so they could provide us with valuable feedback. We did not collect information on these questionnaires which could be used to identify the subjects.

5.1.4. PAX East

We brought our early beta build to PAX East 2017. PAX East is one of the biggest game festivals in the United State, so we think it's a great way to show off this project and get potential feedbacks from the players there. The informed consent form and online survey were prepared for players who were willing to playtest (see Appendix A for PAX-specific forms).

Unfortunately, because of the space limitation, we were unable to have a separate computer for the survey so the players had to take it on the own time after PAX, which lead to zero response to the survey from PAX. However, the oral feedback from all the players were mostly positive besides suggestions for further animation improvements.

5.2. Results

Based on feedback from playtesters (see Appendix C) we assume that we successfully communicated the narrative of the experience. From the four responses we received, three correctly identified either the literal components of the narrative such as “some kind of internal

work on myself,” or the symbolic components of the narrative such as “shutting ARIN down because she woke up too soon.” It is interesting to note the discrepancy between these two examples: one refers to the avatar as “myself,” perhaps feeling a stronger connection to it than the second playtester who refers to the avatar in the third person.

Our playtesters were unanimously in agreement that the experience did not induce any motion sickness, despite some of the technical glitches and artifacts related to Vive hardware issues. Other general feedback included visual errors in the animations: “finish the animations, y’all[sic],” Unreal 4 player setup: “positioning the head a little bit better would have made me feel like [the avatar] was my body more[sic],” or feature requests such as making use of the Vive controllers to actually move the hands of the avatar.

Playtesters felt the “most uncomfortable” when their “personal space” was invaded by either the technician or the other mechanical implements. Only one player explicitly reported discomfort, the other players felt either uncertain or even thrilled. One playtester described how experience the removal of the chest plate was “cool because [they] felt like [they] could almost feel” it. Other playtesters who experienced the version with the medical needle had visibly adverse reactions. According to one player the needle “was very scary,” which is an indication that our goal of creating a horror experience was somewhat successful.

5.3. Conclusions

Playtesting feedback allowed us to identify a rather intriguing phenomenon regarding how the playtesters felt they “interacted” with the experience. We did not expect to be able to direct the player’s attention as effectively as the playtesting data show. From our observations we noted that none of the playtesters ever looked at the door Escarra walks through, which was

never animated. We assume that the lack of a sound cue made this possible because Escarra's entrance makes no noticeable sound.

Our survey asks the playtester to describe whether or not they felt as if they could interact with the characters—the majority of our responses indicated that the players felt compelled to follow the instructions and then incredulous about whether or not their interaction had actually made a difference. One playtester, for example, realized “after following the ... instructions that [they] could have tried ignoring them.” Another playtester wondered about what would have been different if they had ignored the instructions. Yet another playtester confidently stated that Barrow “responded to the nod.” In reality, the player's actions have no bearing on how the narrative unfolds. These data show how the player's expectations of agency in VR informs how they experience it.

PART TWO: THE MONOMYTH IN POPULAR SCIENCE WRITING

By Izzie Schiavone

ABSTRACT

This project looks at narrative structure in popular science writing. Popular science writing makes use of narrative structure in order to communicate science to a non-specialist audience. Schrempf (2012) argues that popular science writing has become the modern myth because it is now the main way that the general public comes to understand the existence of the world around them. Joseph Campbell (1971) theorized that all myths follow a similar narrative structure. The narrative structure of myths is known as the hero's journey or the monomyth. Through fantasy-theme analysis of five pieces of popular science writing, this project suggests that popular science articles may follow the monomyth structure. The narrative structure trends found through the fantasy-theme analysis were then applied to the writing of a popular science article about virtual reality (VR).

6. INTRODUCTION

Popular science writing is a way for professional research to be made accessible to a non-specialized audience (Russell, 2009, p. xii). Popular science writing has a profound influence over the public understanding of science (Yearly, 2000, p. 105). The public understanding of science is foundational to what a culture believes to be true about science (Camus, 2009; Giles & Sides, 2008; Harmon, 1985). The public understanding of science also has a profound influence on which problems, discoveries, and advancements are featured in the public eye and seen as important (Kueffer & Larson, 2014). The perceived importance of scientific endeavors influences the direction of scientific advancement by affecting government policies and funding (Kueffer & Larson, 2014).

The way popular science writing uses narrative has been explored through analysis of the genre and its use of metaphors (Broks, 2007; Burnham, 1987; Fahnestock, 1998; Giles & Sides, 2008; Harmon, 1985; Hilgartner, 1990; Mellor, 2003; Russell, 2009; Shinn & Whitley, 1985; Yearly, 2000). The popular science genre has also been looked at for the role it serves in modern culture (Schrempp, 2012). Although popular science is a genre that has gained a lot of attention due to its impact on societal progression in the age of technology, little has been written about how the narratives in popular science writing are constructed.

I sought to explore how narrative is structured in popular science writing in order to develop a more concrete understanding of how to create an effective popular science narrative. A more well-defined structure could help professional researchers communicate directly with a non-specialized audience without their research needing to be interpreted by a third party author.

George Schrempp (2012), a mythology scholar, claims that popular science writing has filled the role of myth in modern American society because it presents narratives through which the public comes to understand the function of the world around them. Schrempp's (2012) book suggested to me that popular science may not only share societal roles with mythology; it may also share narrative structure. Joseph Campbell (1971) presented the concept of the monomyth, a unified narrative structure shared by all myths, in his book "The Hero with a Thousand Faces" in 1949. In this paper, I use fantasy-theme analysis on five popular science articles to see how they may make use of this monomyth structure.

In chapter two, I cover past research that establishes the goals and genre traits of popular science writing. I also look at how narrative has been examined in popular science writing and in mythology in order to later draw parallels between the two. Chapter three covers how I went about analyzing popular science articles and how those articles were selected. The results of the

fantasy-theme analysis are presented in chapter four. From the results of the fantasy-theme analysis, I wrote a short popular science article about virtual reality game development. The article and my writing process can be found in chapter five.

7. LITERATURE REVIEW

7.1. Introduction

Popular science writing is a way that professionals communicate their research and findings to a non-specialized public audience (Russell, 2009, p. xii). In order to communicate the research clearly, popular science writers do more than just translate professional jargon into more simplistic language (Camus, 2009, p. 466). Popular science writers must also provide a new context that allows the reader to interpret the ways that the science interacts with their life or interests (Camus, 2009; Giles & Sides, 2008; Harmon, 1985). Yearly (2000) acknowledges that popular science writing, for the most part, increases the public understanding of science (p. 105). The public understanding of science then influences where and how much funding for scientific research is allotted (Kueffer & Larson, 2014).

The connection between popular science writing and public opinion makes popular science writing a necessity in generating funding for scientific research (Camus, 2009; Kueffer & Larson, 2014). Thus, understanding how to create successful and well-targeted popular science writing is essential to continuing research.

The popular science writer's need to explain complex systems to a non-specialist audience is the reason for the use of metaphor, narrative, heroes, and morality in popular science writing. These literary devices guide the audience's engagement with the text and understanding of the science behind the text. Through explaining complex systems and how those systems relate to the audience's existence within that greater context, popular science writing acts as a

modern analog to traditional mythology. Traditional mythology tends to follow a specific structure that Joseph Campbell identified and named as the hero's journey. The hero's journey uses the hero as an audience proxy so that the audience may learn the hero's complex world alongside him. The hero's journey, as another literary device that allows the author to explain a complex system, might also be employed by popular science writers.

7.2. The genre of popular science

According to Nicholas Russell (2009), Professor of Science Communication at Imperial College London, popular science encompasses many facets of the relationship between professionals and the general public (p. xii). In the book *Understanding Popular Science*, Peter Broks(2007) notes that popular science may refer to the public understanding of science as well as the methods by which science and scientific "fact" is communicated to the general, non-professional public.

Both agree, along with many others, genre of popular science is a method through which science is made accessible to the non-professional public (Broks, 2007; Burnham, 1987; Fahnestock, 1998; Hilgartner, 1990; Mellor, 2003; Russell, 2009; Shinn & Whitley, 1985; Yearly, 2000). In the largest sense, popular science is any communication between the professionals and the public. However, many scholars have pointed out the flaws in the breadth of that definition, as it relies on a binary division between "professional" and "public" (Fahnestock, 1998; Hilgartner, 1990; Mellor, 2003). As a way of addressing this, Stephen Hilgartner (1990), professor of science and technology studies at Cornell University, came up with the concept of a spectrum of scientific communication (p. 524). Hilgartner's delineation of science communication has been used by many in the study of science communication since he articulated the concept in 1990 (Adams, 2011; Fahnestock, 1998; Mellor, 2003).

In this paper, I am examining trends in mass media popular science found in books, magazines, and newspapers. Mass media popular science falls on the extreme right, or “downstream,” of Hilgartner’s (1990) spectrum of science communication (p. 528). Additionally, it should be noted that I will not differentiate between the so-called “hard” and “soft” sciences. For the sake of this analysis, there is no need to exclude or differentiate between the professions, as I am looking at broad narrative decisions, rather than more specific stylistic choices. Another benefit of this definition is that it allows me to examine how those in the less-scientific professions communicate with the public, including economists, sociologists, and even video game developers.

Hilgartner (1990) places popular science books and mass media publications “downstream” on his spectrum because they are written for an audience that is not intimately familiar with the field of study and thus have a lower level of complexity (p. 527-528). Hilgartner (1990) also places textbooks on the downstream end of the spectrum (p. 528). However, Fahnestock (1998) designates textbooks closer in style to scientific papers. Fahnestock (1998) looked at science writing from an Aristotelian perspective, noting that scientific papers and textbooks are heavily based in forensics. Forensics is one of three types of rhetoric defined by Aristotle (350 BCE); it is most well known as the rhetoric of legal proceedings. Forensics, according to Fahnestock (1998), is also found in scientific papers, as they are concerned with procedure. Popular science, unlike scientific papers and textbooks, is mostly epideictic, according to Fahnestock (1998). Epideictic rhetoric, to Aristotle (350 BCE), is the rhetoric used in celebration and memorials. Popular science writing is a way of celebrating scientific progress (Fahnestock, 1998).

Fahnestock (1998) and Burnham (1987) split the celebration of popular science into two categories. Fahnestock (1998) calls these categories “the wonder” and “the application;” Burnham (1987) calls them “GeeWhiz!” and “interesting” (p.5-6). Terms aside, the reason for the division is the same. Some popular science writing is meant for the reader to take the knowledge and incorporate it into their life; this is the “interesting” or “application” popular science writing. The other kind of popular science writing presents knowledge that excites the audience, but does not encourage the audience to change their views or lifestyle because of it. In both cases, popular science is not intended to provide its audience with a complex and procedural understanding of the underlying science (Broks, 2007; Burnham, 1987; Fahnestock, 1998; Hilgartner, 1990).

Popular science writing assumes a nonspecialized audience; however, that does not mean that works of popular science writing aren't read by professionals in that field. Broks (2007) notes that several popular science authors have openly acknowledged in interviews that they keep in mind that professionals in the field they are writing about, or in adjacent fields, may be reading their work. The assumption of a nonspecialized audience keeps popular science accessible to an audience that does not have a background, or even much knowledge at all, about the subject. Felicity Mellor (2003) explains how the restrictions created by writing for a non-specialized audience influence popular science writers to present the knowledge and scientific content of their writing in ways that have already been proved effective (p. 517-518).

7.3. Metaphor in popular science

Rhetorically, metaphors were once viewed as an embellishment used in communication that had an aesthetic value but no influence on rhetorical function (Foss, 2009, p. 267). Metaphors are now considered to have significant rhetorical influence because of their ability to

act as a lens for interpreting situations (Foss, 2009, p. 268). Metaphors relate two terms that are considered part of separate contexts. In creating a metaphor, the connotations of the terms' contexts are not completely wiped out (Foss, 2009, p. 269). The connotations of one of the terms can, if the metaphor is used repeatedly, become associated with the other term in the metaphor (Foss, 2009, p. 269). The rhetorical function of metaphors is part of the reason that there is opposition to the use of metaphors in professional science writing.

In popular science, metaphor is used to relate the abstract to the familiar in a way that makes the scientific concept easier for the general public to understand (Giles & Sides, 2008; Harmon, 1985). These metaphors often personify the science being explained. For example, apoptosis, a cellular process that ensures that cells do not divide after their DNA starts to deteriorate, is often called "cell suicide" or referred to as the cells "killing themselves" (Camus, 2009). In Julia T. Williams Camus' (2009) study of 37 articles on cancer by UK newspaper, The Guardian, seventeen of those articles included metaphors that gave cancer cells a human comparison (p. 47).

In professional science, metaphor is often used in the same way (Giles & Sides, 2008, pg. 2), but its use in a professional context is controversial. Giles & Sides (2008) point out that some scholars challenge the use of metaphor for obstructing the "truth" of the science (5-6). To counter the opposition to metaphors, Giles & Sides (2008) recall the theory of light as a particle and as a wave as metaphors that aid both the public and the scientific community in making further discoveries and inventions (p. 5).

Metaphors in professional science are more likely to be isolated. A scientist may refer to the "rules" that a cell follows, but the metaphor is unlikely to be extended to describe an entire narrative around the creation of those rules. In popular science, cancer cells go to war, they do

battle, and they are wounded (Camus, 2009, p. 47). The metaphor is extended to create a richer narrative. Through metaphor, narrative becomes another component of popular science writing.

7.4. Narrative in popular science

Muurlink and McAllister's (2015) study of trends in popular science reveals that narrative writing, both fictional and non-fictional, makes up the majority of writing for entertainment (p. 4). While narrative fiction dominates, nonfiction genres, such as biography and popular science, are also presented in a narrative style (Muurlink & McAllister, 2015, p. 5). It is only natural that a genre intended for entertainment as well as education would employ this technique to engage readers. Mellor (2003) observes that the popularity of popular science books that use narrative as a structure for the underlying science has created a "formula for success" ...which encourages other popular science writers to adopt similar approaches to their subject matter" (p. 517-18).

However, narrative may serve a more practical purpose in popular science writing than simply attracting readers. Narrative provides an organizational structure that emphasizes logic and aids in memory retention (Adams, 2011, p. 170). The logical nature and factual accuracy of a claim or series of claims made by a piece of popular science writing is aided by the narrative by showing the reader the procedure (Adams, 2011, p. 170 & 178). This evidence of procedure satisfies the need for proof more than unrelated facts because it gets the reader to "see" the logic.

The connection to the potential for memory retention as an impetus for the use of narrative in popular science was put forth by Jon Adams (2011) based on the use of narrative as a mnemonic tool (p. 170). He bases this argument on Miller's work in understanding the limits of human short term memory, citing Miller's publication "Magic Number Seven, plus or Minus Two" (Adams, 2011, p. 170). Miller (1994) suggests that there is a finite limit to the number of

things a person can store in their memory, but by “chunking” sections of things that are to be remembered, these new “chunks” become the units that are limited by the brain (p. 351). Miller (1994) also suggests that connecting the “chunks” into sequences with logical order (such as a story), the number of chunks remembered can be increased (p. 351). This theory of memory implies that a reader will remember more scientific facts if they are arranged into a narrative format.

7.5. Heroes in popular science

In his essay “Real Facts with Fictional Cases,” Adams (2011) mentions two types of heroes in popular science writing: the subject and the scientist (p. 171-173; p. 176-177). The choice of who is cast as the hero in a work of popular science is a rhetorical decision on the part of the popular science writer. Adams (2011) notes that personifying the subject and allowing that subject to take the role of the hero leaves less room for the reader to question the accuracy of the author’s claims (p. 176-177). However, personifying the scientist lends more validity to the actions which lead to those claims and increases the chances of the reader viewing those claims as “logical” (Adams, 2010, p. 176). This may account for what Muurlink and McAllister (2015) call “the biographizing trend in popular science writing,” (p. 1).

Like Adams (2010), Muurlink and McAllister (2015) present the subject and the scientist as two possible heroes in popular science writing (p. 2). Muurlink and McAllister (2015) focus on how this effects the popular half of popular science. The authors’ research into book sales and popular writing shows that narrative writing outpaces all other forms of writing in number of bestsellers (Muurlink & McAllister, 2015, p. 4-5). Narrative writing, in terms of sales, is leaps and bounds more popular when compared to expository writing that is not connected through a narrative (Muurlink & McAllister, 2015, p. 4). Science writing that is not narrative is likely

expository (Broks, 2007; Muurlink & McAlister, 2015). Expository writing relies on the facts being presented to be the main reason for the reader to engage with the writing. Narrative and heroes give the reader characters that they can become attached to, meaning that the actual facts behind the story can be duller and far less sensationalized. The power of character driven narrative to make uninteresting facts into an attractive piece of writing may be part of the key to success that Mellor (2003) observed popular science writers trying to emulate (p. 517-518).

7.6. Moralization through narrative

Arranging facts and information into narrative is not a rhetorically neutral act. The placement of events, characterization of those involved, and the decisions made to include or omit facts all hold rhetorical value. According to Ron Curtis' analysis of how the Baconian model affects popular science writing, narrative has the power to cast neutral acts in positive or negative lights (Curtis, 1994). By casting real people and events as characters in a story, the writer can influence their audience's response to the ideas, theories, and actions of those characters. Just as fictional narratives have heroes and villains, so does popular science writing. Popular science writing has the power to turn scientific fact into a question of morality: a characteristic pointed out by Curtis (1994), Broks (2007), and Adams (2011). Science, like a myth, becomes something that one chooses to believe in.

7.7. Popular science as myth

The myth is a cultural story, the likes of which are found across the globe and throughout history. The narratives of myths were used to explain scientific and social phenomena (Myth, n.d.). Schrempp (2012) describes how the term myth is now often used in popular science writing to suggest falsehood (p. 3). The change in the definition of myth stems from myths' now

known to be incorrect explanation of natural events. By redefining the word myth as a synonym for falsehood, science has opposed itself against the mythic (Schrempp, 2012, p.4).

Schrempp (2012) argues that popular science writing has become the modern myth. By ascribing narrative to series of events and characters to real people, popular science writers have created cultural stories that explain scientific and social phenomena.

In *Ancient Mythology of Modern Science: A Mythologist Looks (Seriously) at Popular Science Writing*, Schrempp (2012) analyses several well-known works of popular science writing and compares them to attributes of specific myths and highlights the use of myths as metaphors in that writing.

Schrempp (2012) concludes his examination of popular science by claiming that through the writing of popular science, humanity has preserved the tradition of the myth while also placing it under great scrutiny (p. 222-232).

7.8. The monomyth

So far, I have discussed traits that popular science writing shares with narrative writing and storytelling. I have also examined the way that popular science writing can fill a cultural gap created in the absence of traditional mythology. Although I looked briefly at structure when talking about the use of narrative in popular science writing, I have not yet clearly defined what kind of structure popular science writing follows.

Most narrative structures can be broken down into simple plot diagrams that feature a rising action, climax, and falling action. While plot diagrams illustrate the creation of dramatic tension, they contain no specifics about the type of dramatic tension or the emotions, perspectives, and events of the narrative. More specific ways of breaking down narrative structures often fall along genre lines—tragedy and comedy, for example. The structure of

storytelling that I'm most interested in discussing is the Hero's Journey. The Hero's Journey is a way of breaking down narrative into key actors and actions. These actors and actions are tropes that can be found in fantasy and mythology both globally and throughout time.

In *The Hero with A Thousand Faces*, Joseph Campbell (1971) presented a transformative argument: all myths, regardless of culture of origin, follow the same basic structure. In his book, Campbell (1971) identifies two basic structures around which all myths are developed. The first is the "Adventure of the Hero," also known as the hero's journey; the second is the "Cosmogonic Cycle" (Campbell, 1971). According to Campbell (1971), the hero's journey exists within the cosmogonic cycle (p. 260). The hero's journey is the narrative through which a mythological hero's story is told. It follows a basic cycle, though some elements may hold greater significance based on the story in question (Campbell, 1971, p. 245-251). The cosmogonic cycle is larger than the hero's story and is ascribed to myths of creation (Campbell, 1971, p. 255-260). As such, the hero of a myth may never encounter the stages of the cosmogonic cycle; however, its framework provides a structure to how cultural myths are often built upon a foundational myth of creation (Campbell, 1971, p. 260).

The first edition of Campbell's *The Hero with A Thousand Faces* was published in 1949 and uses ancient texts and mythology as the foundation of Campbell's argument for the existence of the hero's journey. While Campbell bases his argument on ancient mythology, examples of the hero's journey have also been found in modern works of the 20th and 21st centuries. The Harry Potter series by J.K. Rowling (1997-2007) and Star Wars (Lucas, 1977) have both been used as modern examples of the hero's journey (Mackey-Kallis, 2010, p. 207-227). These stories, and ancient myths, use this narrative structure because it places the hero in a position where they are being introduced to a new world, Harry Potter to the world of wizards, Luke

Skywalker to the world of Jedi, and Odysseus to the world of war (Homer, 1990). The hero then learns about the new world that they are in along with the audience. The hero in the hero's journey then acts as a filter through which the audience can understand the hero's world and the complex interactions within it. In this way, the hero's journey acts as another way for an author to explain a complex system to an audience that is not yet familiar with it.

7.9. Fantasy Theme Analysis

Fantasy-theme analysis, also known as fantasy-theme criticism, is a method of rhetorical analysis based on Ernest Bormann's fantasy-theme theory (Foss, 2009; Golden, Berquist, Coleman, & Bormann, 1983). Bormann's fantasy-theme theory describes instances in which groups create shared meaning and understanding based on a group fantasy (Golden, Berquist, Coleman, & Bormann, 1983). "Fantasy," in the case of fantasy-theme analysis, does not refer to something that is necessarily magical or out of reality in some way; rather, fantasy here refers to events that are imagined by the group as they create a narrative about the past or the present (Golden, Berquist, Coleman, & Bormann, 1983). Fantasy-themes, according to Bormann, become a shared vision for the group and a lens through which that group interprets certain events and creates meaning from symbols (Golden, Berquist, Coleman, & Bormann, 1983). Myths are used by social and cultural groups to create meaning and explain or put into perspective the world in which the group exists. This makes myths an example of a larger-scale fantasy-theme, which Bormann points out in his piece in the 23rd chapter of *The Rhetoric of Western Thought*, "Rhetoric as a Way of Knowing: Ernest Bormann and Fantasy Theme Analysis" (Golden, Berquist, Coleman, & Bormann, 1983).

As I have previously discussed, popular science writing is a vehicle for recontextualizing science so that it may be understood by a non-specialist audience (Camus, 2009; Giles & Sides,

2008; Harmon, 1985). The non-specialist audience is then able use the narrative presented by the popular science writing as a lens through which they interpret certain aspects of their lives. In this way, popular science writing fulfills a similar societal role to myths. The similarities between popular science writing and myths are not the only signs that popular science writing is involved in the creation of fantasy themes. Popular science writing also uses narrative fantasy to create rhetorical visions in the same way that orators, the main focus of Bormann's analysis, do.

8. METHODS

Popular science writing, by creating dramatic stories with narrative structures, heroes, villains, and metaphors is a fantasy theme for the readers. Through fantasy theme analysis, I will look for specific trends in popular science writing that suggest the existence of a fantasy type. In Ernest Borman's words, a fantasy type is "a stock scenario repeated again and again by the same characters or similar characters" (Golden, Berquist, Coleman, & Bormann, 1983, p. 434). In addition to looking for general characteristics of the popular science fantasy type, I will also be comparing the traits of that fantasy type to the traits of the myth fantasy type—the hero's journey.

In order to analyze popular science fantasy-themes, I followed the methods for fantasy-theme analysis presented in Sonja K. Foss's book, *Rhetorical Criticism: Exploration and Practice* (p. 97-136). I chose five popular science articles. All of the articles had different topics, authors, and publishers to separate rhetorical devices that were common in popular science writing as a whole from rhetorical devices that were derived from the subject, author's writing style, or publication's preferred content. To examine the fantasy theme of each article, I read through and pulled out character, setting, and action themes. I then coded and connected the characters to the actions, describing who acted and who or what was acted upon and the setting

in which these actions took place. These coded themes are the fantasy themes of the article. I compiled and arranged the fantasy themes in typed documents, included in the appendices, for reference and ease of comparison.

Once all five articles were encoded and organized, I compared the fantasy themes and rhetorical vision of each article with those in the other articles to find similarities. Similarities in the fantasy themes and rhetorical visions of the articles would suggest a shared fantasy type. I also looked at these fantasy themes through the lens of the hero's journey to see similarities between the fantasy type of popular science writing and the fantasy type described by the hero's journey.

9. RESULTS

I chose five popular science articles to analyze. The articles were "Battle of the Ash Borer" by Matthew Miller (2014), "David Deutsch's Dream Machine" by Rivka Galchen (2011), "Neanderthals Were People, Too" by Jon Mooallem (2017), "Where the World's Only Grass-Eating Monkeys Thrive" by Craig Welch (2017), and "Accidental Therapists: For Insect Detectives, the Trickiest Cases Involve the Bugs that aren't there" by Eric Boodman (2017). "Battle of the Ash Borer" by Matthew Miller (2014) covers the discovery and attempts at eradication of the invasive Emerald Ash Borer beetle in Michigan, USA. "David Deutsch's Dream Machine" by Rivka Galchen (2011) describes the field of quantum computing through an interview with David Deutsch, a prominent figure and founding researcher in the field. "Neanderthals Were People, Too" by Jon Mooallem (2017) narrates the author going to an archeological dig of a Neanderthal site in Gibraltar. "Where the World's Only Grass-Eating Monkeys Thrive" is a National Geographic article that talks about the Geladas, or Bleeding Heart Monkeys, that live in Guassa in Ethiopia (Welch, 2017). The final article, "Accidental

Therapists” by Eric Boodman (2017) tells the story of a Connecticut entomologist and the cases of hallucinated insects that she’s seen. The articles were published in *The Lansing State Journal*, *The New Yorker*, *The New York Times*, *National Geographic*, and *Scientific American*, respectively (Boodman, 2017; Galchen, 2011; Miller, 2014; Moallem, 2017; Welch, 2017). The articles by Miller (2014), Galchen (2011), and Mooallem (2017) have a strong narrative structure that resembles *The Hero’s Journey*; the articles by Welch (2017) and Boodman (2017) have a weaker narrative structure that does not share the same traits. The articles with stronger narrative structures encourage the audience to incorporate the knowledge provided by the article into their lives or aim to provide useful knowledge, while the other two articles are written to entertain the audience. The three articles with stronger narratives featured many steps from the Hero’s journey; however, they end before the “return” in most cases. The end before the return could represent the idea the science is a constant cycle of discovery rather than a linear path to an end.

9.1. The Application vs. The Wonder

The articles by Miller (2014), Galchen (2011), and Mooallem (2017) fit into the popular science writing category that Fahnestock (1998) refers to as “the application” and Burnham (1987) calls “interesting” (p. 5-6). The purpose of these three articles is to not only make the audience aware of the science but to also provide them with a deeper understanding. The articles by Welch and Boodman fall within Fahnestock’s (1998) definition of a popular science article written for “the wonder.” These articles would be “GeeWhiz!” in Burnham’s (1987) taxonomy. These two articles concern more obscure aspects of science—Welch (2017) tells the story of a species of monkey that only lives in a remote area of Ethiopia and Boodman (2017) describes entomologists’ encounters with a psychological illness that is considered relatively rare. Welch

(2017) and Boodman (2017) focus their articles on discussing the “what” more than the “why” because their audiences are less likely to come in with any notion of the subject.

It is also interesting to note that Welch (2017) and Boodman’s (2017) articles contain significantly more images than the other three articles. “Where the World’s Only Grass-Eating Monkeys Thrive” was written for National Geographic and contains fourteen high resolution photographs (Welch, 2017). “Accidental Therapists,” originally published in Stat News and then republished in Scientific American, has eleven photographs (Boodman, 2017). In contrast to these highly visual articles, the “application” article with the most images had only six, one of which was a graph of U.S. government spending (Miller, 2014). The amount of images suggests that the written content of the article is not necessarily the “selling point” that encourages the audience to continue reading the article. Instead, the visuals serve to draw the audience in the way a narrative does in other popular science articles.

9.2. Character Archetypes

The hero’s journey has eight character archetypes: heroes, shadows, mentors, heralds, threshold guardians, shapeshifters, tricksters, and allies (Campbell, 1968, p. 245-246). These roles do not have to all be filled in order for the narrative to be a hero’s journey and characters can fill multiple roles. In the case of popular science writing, the articles suggest that the hero role can be passed between characters or applied to a collection of characters. The strongest example of a collective role is the role of the hero in “Battle of the Ash Borer” (Miller, 2014). The hero role is traded between various entomologists, arborists, and government officials. The scientific process described in the article features many small progressions toward a larger, unified, goal. In order to create a cohesive narrative, the author, Matthew Miller, switches between heroes. Scientific discoveries and advancements are rarely the work of a single scientist;

therefore, the author of a popular science article may choose to have the hero role shared by several characters in order to make the narrative more cohesive. Additionally, some of these character archetypes can be fulfilled by a non-entity, like a belief or an action. The “application” articles have characters that fill these roles, but the “wonder” articles lack any well-defined character roles.

9.2.1. Battle of the Ash Borer

Four character archetypes show up in “The Battle of the Ash Borer” (Miller, 2014). In this article, entomologists act collectively as heroes in the fight against the shadow, or villain. The shadow in this article is the Emerald Ash Borer. The use of a multi-character hero works to reinforce the military metaphors in this article. At the end of first chapter of the article the author writes “they [scientists] have lost most every battle. They may yet win the war”, which places scientists in a similar role to an army. By gathering the scientists into a collective army at the beginning of the article, whichever scientist take the lead in a chapter of the article becomes part of the collective hero. The other two character archetypes that are prominent in “The Battle of the Ash Borer” are the mentor and the herald. The mentor is a Chinese scientist, Chenming Yu, whose writing provides guidance to the scientists in beginning their fight against the emerald ash borers. The herald, of course, is when the ash trees in Michigan start dying en masse. The death of the ash trees is what causes scientists to look into the cause and discover that there is some unknown insect causing the destruction.

9.2.2. David Deutsch’s Dream Machine

“David Deutsch’s Dream Machine” focuses mainly on the titular scientist and his study of quantum mechanics and quantum computing (Glachen, 2011). Much of the descriptive paragraphs in the article describe Deutsch’s appearance and his home. His actions and his

interview provide the framework for the article. He is the hero in the article with other quantum physicists acting as allies. The herald for this story of quantum computing is the discovery of quantum mechanics. There are also threshold guardians in this article. Threshold guardians act to prevent the hero from crossing the threshold. In “David Deutsch’s Dream Machine” the threshold guardians are familiar names in the world of physics—Albert Einstein and Niels Bohr. Both scientists wrote papers on why quantum mechanics should not be studied. Galchen writes the paragraph about Einstein and Bohr’s refutations of quantum mechanics and follows it up with a quote from a paper by Deutsch that calls out Bohr’s claims as against the true goal of scientific research.

9.2.3. Neanderthals Were People, Too

“Neanderthals Were People, Too” frames the realization that Neanderthals were more like humans than was originally thought through the story of the author, Jon Mooallem (2017), learning the same thing. Jon, the character, works well as a hero despite not being one of the scientists because he is the outsider. He comes in with the perspective that the audience of the article has, including the incorrect perception of Neanderthals as inferior to humans. Jon is clearly the main character as he is the central figure; he is present in all modern day portions of the story, with the portions that happened in the past acting as background but not narrative. The perception of Neanderthals as inferior and human supremacists, as Mooallem calls them, are the shadow characters in this article. The mentor, Clive Finlayson, invites Jon to come to an archeological excavation of a cave in Gibraltar, and during the excavation, Finlayson provides Jon with a lot of background on what is known about Neanderthals. The background that Finlayson gives Jon allows Jon to draw conclusions about the connections between humans and Neanderthals.

“Neanderthals Were People, Too” is the only of the three articles to also have a trickster character, or in this case, characters. Tricksters, through their unconventional outlook and wild nature, encourage change within the hero. In the article, twin artists known as Kennis and Kennis, work to create sculptures and paintings of Neanderthals by studying human diversity and the way different cultures develop styles and trends. Their wild jokes, including pretending to bowl with modeled Neanderthal heads, strike Jon as bizarre. The Kennis brothers’ depictions of Neanderthals in human ways helps Jon see them as more human, which changes his perspective. A photograph of their sculpture of a woman and child Neanderthal is the most prominently featured photograph in the article, which allows the audience to make the same visual connection with the brothers’ work that Jon does in the article.

9.3. Hero’s Journey

The hero’s journey is a cycle that can be divided into three parts based on the three act structure. Act one establishes the hero, the major conflict, and the setting. In act two, the major conflict becomes higher stakes and the crisis moment occurs. The final act shows the hero leaving that crisis moment with a resolution. This structure can be mapped on to the hero’s journey by separating the twelve steps into three parts. “The Ordinary World,” “The Call to Adventure,” “The Refusal of the Call,” and “The Meeting with the Mentor” become act one because these steps establish the conflict, introduce the hero, and create the setting. Act two consists of “Crossing the Threshold,” “Tests, Allies, and Enemies,” and “The Ordeal.” “The Ordeal” is analogous to the crisis in the three act structure. Finally, act three concludes the myth with “The Reward,” “The Road Back,” “The Resurrection,” and “The Return with the Elixir.” The separation of the cycle into three acts as well as the stages that are present in the three monomythic articles can be seen below.

Table 1 Stages of the monomyth found in three of the popular science articles that were analyzed.

	Battle of the Ash Borer	David Deutsch's Dream Machine	Neanderthals Were People, Too
The Ordinary World	●	●	●
The Call to Adventure	●	●	●
Refusal of the Call		●	●
Meeting With the Mentor	●		●
Crossing the Threshold	●	●	●
Tests, Allies, and Enemies	●	●	●
Approach	●	●	●
The Ordeal	●		●
The Reward	●		●
The Road Back			●
The Resurrection			●
Return with the Elixir			●

The popular science articles tended to omit much of the “return” part of the hero’s journey. The return part includes steps such as “the road back”, the “resurrection”, and “the return with the elixir”. These steps are when the hero takes what they have learned or gained and brings it back to the ordinary world. In the case of “Battle of the Ash Borer” and “David Deutsch’s Dream Machine” the final scientific truth is not yet known, so it cannot be brought back to the ordinary world. Instead, the arborists and entomologists in “Battle of the Ash Borer” are still trying to save the ash trees and the quantum physicists in “David Deutsch’s Dream Machine” have not made a quantum computer powerful enough to run algorithms that would prove the many worlds theory. In “Neanderthals Were People, Too” there is a full discovery and the narrative includes steps up to “the resurrection”, where the hero faces a final test. The article does not feature a “return with the elixir”. It could be argued that the article, as it is how the author—who is the hero in the story—shares what he learns, is the return with the elixir.

9.3.1. Act One: The Ordinary World, Call to Adventure, Refusal of the Call, and Meeting the Mentor

In mythology, act one of the monomyth establishes the hero's home world and the myth's central conflict. The world the hero comes from is in some way relatable to the audience, through setting or scenario. The hero comes from a world that is somehow familiar to the audience, which allows the unknown world in act two to be discovered by the hero and the audience simultaneously. The call to adventure establishes the conflict and the refusal can be used to show the hero's hesitation about their ability to address the conflict. Finally, at the end of the act, the hero may meet a mentor figure who provides the assistance that the hero needs to move into the unknown.

In popular science writing, act one puts the audience in a familiar setting through the ordinary world. The ordinary world also tends to include some scientific background. The background and setting provide a solid foundation for the audience to challenge their beliefs or accept new information. For example, "Dream Machine" establishes Oxford as a more typical university setting and David Deutsch as an eccentric genius figure before going into any significant discussion of quantum computing. The setting and characters have tropes that the audience is likely to have encountered before, which gives them a comfortable frame of reference for interpreting the rest of the story. The eccentric genius metaphor in "Dream Machine" is carried throughout the article with references to Sherlock Holmes and House, a TV show based on the Sherlock Holmes character. The initial archetypes and tropes provide a stable reference point for the audience and can be brought back to remind the audience of the ordinary world. In "Dream Machine", after the audience is introduced to Deutsch's eccentric apartment,

the author reminds the audience of the familiar by inserting a dialogue with Deutsch about the TV show, *House*.

Act one also creates a familiar setting in “Battle of the Ash Borer,” where the author describes one of the characters driving through the town past “the blue-and-electric-purple walls of the skatin’ station” and a “warehouse that used to be a Kmart.” The descriptions evoke a well-known picture of Middle America. The reader is then introduced to “the invasion”, another military metaphor for the destruction of the ash tree population. “The invasion” is the conflict in the narrative that needs a resolution.

The third article, “Neanderthals Were People, Too,” establishes a different kind of ordinary world. In the case of “Neanderthals Were People, Too” the ordinary world is a commonly held belief and the scientific foundations for that belief. The article begins by providing the audience with the context of past beliefs about Neanderthals. Although the audience may not be familiar with the specifics of the discoveries that led to their idea of what Neanderthals were like, the descriptions would be familiar. Establishing incorrect beliefs as the ordinary world sets up opportunities for refutation later in the article. An ordinary world of incorrect or misinformed beliefs can also be an opportunity to make the audience more receptive to changing their opinions because the author has acknowledge the existence of the audience’s background.

The Call to Adventure and Meeting with the Mentor are primarily plot-advancing steps in the monomyth. Both steps allow the hero to cross the threshold into the unknown world, where the majority of the hero’s transformation takes place. Similarly, the Call to Adventure and the Meeting with the Mentor primarily exist to advance the plot in a sensible way. The Call to Adventure tells the audience why the hero chose to cross the threshold; the Meeting with the

Mentor, should it be present, tells the audience how the hero crossed the threshold. In “Dream Machine” the Call to Adventure—Deutsch’s discussion with a colleague about the possibility of a universal computer—let the audience have a concrete answer for why Deutsch chose to study quantum computing. The mentor in this situation would be Deutsch’s colleague, who suggests physics as the universal computer. The Call to Adventure and the Meeting with the Mentor in “Neanderthals Were People, Too” happen quickly through the course of a phone call that the hero, Jon, makes to the leader of an archeological dig in Gibraltar. In this case, Jon meets Clive Finlayson, the researcher and mentor figure, through the phone call before he gets the call to adventure. The Call to Adventure is Finlayson, the mentor, inviting Jon to join the dig in Gibraltar. In “Neanderthals Were People, Too” the steps happen within the same sentence and serve little function other than moving the plot along. “Battle of the Ash Borer” uses the discovery of beetles in the ash trees as an obvious call to adventure and features Chinese entomologist, Chenming Yu, as the mentor. In “Battle of the Ash Borer,” the mentor is met only through his words, by way of a description that he wrote. Although the other two articles feature living and present mentors, the way “Battle of the Ash Borer” uses the mentorship allows for a narrative situation in popular science writing for the heroes to gain valuable knowledge from past research.

The Refusal of the Call, which usually comes between the Call to Adventure and the Meeting with the Mentor, is not given by the hero in any of these articles. In “Neanderthals Were People, Too,” the hero, Jon, expresses the thought that getting to Gibraltar might be difficult, but he never refuses to go. In “Dream Machine,” the refusal comes from an outside source: Bohr and Einstein’s warnings against studying quantum mechanics. Finally, “Battle of the Ash Borer” has no refusal of the call or warning of difficulty. The researchers in the article have no hesitation to

crossing the threshold and attempting to eradicate the emerald ash borers. The lack of a traditional refusal seems to hint at the idea that scientists are innately driven to research and discover. The heroes do not refuse to attempt to answer questions and solve problems because they are scientists and it is in their nature.

9.3.2. Act Two: Crossing the Threshold, Trials, Approach, and the Ordeal

In the monomyth, the second act is where the hero leaves the ordinary world and enters the unknown. Act two is where the hero becomes a hero and transforms physically or emotionally in order to face and overcome the major conflict. Along the way, the hero faces what Campbell calls “The Road of Trials,” a series of smaller conflicts and difficulties that facilitate the hero’s transformation. During the road of trials, the hero may meet ally and enemy characters that serve to advance or hinder the hero’s journey. After overcoming these trials, the hero prepares to face the major conflict. The hero’s preparation happens in the Approach stage. The final stage of act two is the Ordeal, where the hero finally confronts the major conflict.

In popular science articles, Crossing the Threshold is where the science of the article starts to take a more prominent role. In “Neanderthals Were People, Too” the threshold is represented by Jon entering the cave where the dig site is. Immediately, the article begins to cover archeological terms, the history of the cave, and recent discoveries about Neanderthals. The other two articles have the hero cross the threshold through actions without any change in setting. In “Battle of the Ash Borer,” the threshold is crossed with the first attempt to eradicate the beetles. After the threshold is crossed, the information that the scientists learn about the beetles is presented in a more upfront way. Only after the threshold is crossed does the author provide a description of the emerald ash borer. Similarly, in “Dream Machine,” what a quantum

computer does is not explained until the threshold is crossed through the author telling the audience that Deutsch published a paper on quantum computing.

In popular science writing, the trials stage chronicles the work that leads up to a breakthrough. “Battle of the Ash Borer” covers the many attempts at understanding, preventing, and eliminating infestations of emerald ash borers. In “Dream Machine,” the author describes advancements in quantum computing that suggest a build up to creating a quantum computer powerful enough to prove the Many World’s Theory, a theory that Deutsch strongly believes in. The trials in “Neanderthals Were People, Too” are a blend of Jon’s trials and trials faced by anthropologists, geneticists, and biologists who study Neanderthals. In “Neanderthals Were People, Too,” the trials are not only trials for the hero because Jon’s discoveries do not hold the weight of a scientific discovery because he is a journalist. Through including the trials of scientists, “Neanderthals Were People, Too,” is able to discuss the scientific background for these discoveries and the eventual breakthrough at a deeper level.

The last stage that all three articles reach is the Approach. In popular science writing, the approach is when the hero gets that last bit of knowledge that allows them to, possibly, confront the ordeal. In “Dream Machine” the Approach is the last stage in the narrative. The crisis of the article is the Many Worlds Theory, which can only be addressed by being proven or disproven. Quantum computers are not at the point where they can run a sufficiently complicated algorithm that would prove the theory. The constraints of reality mean that there is no way for the narrative to complete the cycle, so it ends with the Approach. The Approach in the article is the creation of a quantum computer that can solve a complex algorithm in fewer steps than a regular computer, which suggests that it may one day be possible to face the ordeal. The Approach is the second to last stage in “Battle of the Ash Borer.” In the “Battle of the Ash Borer” approach, the city of

Milwaukee prepares for the inevitable invasion of emerald ash borers by cataloguing all the ash trees in the city. The catalogue of ash trees allows for the city to quickly take action during the ordeal. The approach happens in “Neanderthals Were People, Too” when Jon meets the trickster figures, Kennis and Kennis. The Kennis brothers’ art shows Jon the humanity in the Neanderthals first-hand. With his new frame of reference, Jon is able to be open to changing his attitude and beliefs during the ordeal. The descriptions of the Kennis’ work also has this effect on the audience, encouraging them to look at Neanderthals as more human.

The last stage of the second part of the monomyth is the ordeal. “Neanderthals Were People, Too” and “Battle of the Ash Borer” include ordeals in their narratives. In “Neanderthals Were People, Too” the ordeal happens when Jon finally feels a personal connection with the Neanderthals who once stayed in the cave and realizes that humans weren’t inherently superior to Neanderthals. “Battle of the Ash Borer” describes the first major success in attempting to control the emerald ash borer invasion. Milwaukee, the city that catalogued all of the ash trees in the article’s approach, inoculates all of the trees with a chemical that protects against ash borer attacks. In “Neanderthals Were People, Too” the ordeal has the hero make the change in his beliefs that the author is trying to get the audience to make. “Battle of the Ash Borer” uses the ordeal as a way to show the tables have turned on the “battle” and ends on an idea of hope for future success.

“Battle of the Ash Borer” ends on the ordeal. There is a hint of a reward: the trees in Milwaukee survive. The reward isn’t a true reward in terms of acting as a stage in the narrative because the author then presents the audience with stories that show how the Milwaukee solution would not work in other areas. The author points out the difficulty of inoculating trees and the effect it has on the wood (it can no longer be used in traditional Native American basket

making). Whether or not the reward is a true reward, the narrative ends before the heroes are able to return to the ordinary world.

9.3.3. Act Three: The Reward, Road Back, Resurrection, and Return with the Elixir

In part three of the cycle, the monomythic hero is rewarded for their success in the ordeal and they are able to take that reward back to the ordinary world. On the way back to the ordinary world, the hero may face tests that they are able to overcome now that they have the reward. Campbell refers to the reward as the elixir. The elixir does not have to be a physical thing, although it sometimes is. The elixir can also be a change in the hero that enables them to overcome challenges they wouldn't have been able to overcome before. At the end of the myth, the hero is able to rejoin the ordinary world and share what they have gained during their journey.

Popular science articles tend to leave the reward, road back, and return out of the narrative. The Monomyth cycle below shows that "Dream Machine" and "Battle of the Ash Borer" do not follow the final steps. "Dream Machine" stops at "the approach" and "Battle of the Ash Borer" ends on "the reward." "Neanderthals are People, Too" completes the cycle, unlike the other two articles.

Not completing the cycle acts like an analogy for the never-ending course of discovery in scientific fields. "Neanderthals are People, Too" completes the cycle because the hero is not a member of the scientific community. He is able to return from a place of scientific exploration to share his knowledge, but even he leaves behind the scientists to continue their journey. Through leaving the cycle incomplete, popular science articles acknowledge that scientific progress never

reaches a finite end. The perpetual journey repeats as science continues to cross thresholds indefinitely.

The reward in “Neanderthals Were People, Too” comes in two parts. The first is a feeling of “continuity” and connection with the Neanderthals. The second Jon does not realize until his return. In the return stage, Jon hurries to fly home after the Brexit vote, which could threaten Gibraltar’s existence. His “road back” is dangerous. Jon thought he might be risking getting stuck in a conflict between Spain and Gibraltar now that the United Kingdom had decided to leave the European Union.

In the “resurrection” step of the hero’s journey, the hero confronts the conflict for a final time. The article ends with a description of a British actress’ comments on Brexit. The actress, Elizabeth Hurley, criticizes those opposed to Brexit for treating those in favor of Brexit as “ill-educated Neanderthals.” Jon reacts initially with superiority based on his new knowledge of Neanderthals; however, he then realizes that he, in becoming emboldened by his superiority, has increased the already existing divide between the two. Jon’s realization shows that he has learned to question what he thinks he knows and his feelings of superiority over those who don’t. What Jon has learned is the elixir of the story. Jon returns with the elixir by writing the article as a way of sharing his knowledge with the ordinary world that he came from.

Although Jon is able to return from the unknown, even he leaves behind the scientists to continue their cycle. The archeologists, including Jon’s mentor, Clive Finlayson, remain in Gibraltar. Jon is able to leave because scientific progress is not his burden.

9.3.4. The Hero’s Journey in “The Wonder” Articles

The two articles that fall under “the wonder” category, “Accidental Therapists: For Insect Detectives, the Trickiest Cases Involve the Bugs that Aren’t Really There” by Eric Boodman and

“Where the World’s Only Grass-Eating Monkeys Thrive” by Craig Welch, do not have character development. There are quotes, conversations, and scenes in each of these articles that make the style resemble a narrative. The narratives in these articles do not resemble the narrative structure of the Hero’s Journey.

The central figure of Boodman’s article, Gale Ridge, does not have any internal conflicts. Gale’s external conflict, which is the topic of the article, is that there are people who seek her out for her entomological opinion on infestations that exist only in their minds. Gale struggles to get these people to seek the proper help that they need, but in the article she does not make progress in making this process easier. For Gale Ridge, there is no resolution in sight.

Welch’s article also lacks any sense of resolution or progress toward resolution. The central character in the article is Admassu Getaneh, who protects the grass that the titular monkeys use as their only food source. Admassu’s conflict is against poachers who destroy or steal the grass outside of the harvest season. The destruction threatens the wellbeing of the geladas, the monkeys who live on the grass. The article has stories of Admassu’s encounters with poachers, but there is no motion toward resolution. The article ends on a scene that describes man-made development butting up against Guassa, the last place where the monkeys and the grass aren’t yet endangered. The author predicts that more hard times, caused by climate change, are ahead.

10. ARTICLE

I applied my observations of how popular science articles construct narratives through the monomyth to writing an article about my experience creating a virtual reality (VR) experience. I used the steps of the hero’s journey to create a basic narrative structure for the article that was intercut with longer descriptions of the more technical aspects of VR development. The technical

descriptions were explained through analogies and metaphors that tie back into the VR project that I worked on by including references to science fiction, writing, and art. The article only includes the first two acts of the hero's journey in its narrative. I use this narrative construction, as did two of the articles that are analyzed in chapter four, in order to emphasize that research and creative endeavors in VR are ongoing. By acknowledging that virtual reality is still being explored by others, I allow myself, as a character, to leave that world behind while still encouraging the audience to look deeper into VR.

What do Pixels Feel Like?

I am approaching the end of my time as an Interactive Media and Game Development undergraduate student at Worcester Polytechnic Institute, so I am working on my year-long senior project. I spend most days getting my senior project ready for the looming deadline of graduation. For this project, as a reflection of what I have learned in four years at school, I am telling a story.

It's not in a book or on stage or even in film. To tell stories, I go to the computer science building, past the tall glass windows, and down three flights to the sub-basement. The door at the bottom of the stairwell leads to a hallway where the sketch comedy group on campus has filmed more than one horror film parody. If you hang a left you'll find a door labeled "sprinkler room" that you need card access to enter.

I tap my card against the reader and go inside. There's no sprinkler control. There's tables, a few computers and a ten foot by ten foot green screen stage. The constant white noise from the HVAC, occasionally broken by the whirr of the elevator control room down the hall, makes you feel like you're on a spaceship.

If this room is a spaceship, the green screen stage is our holodeck. One of the graduate students is pacing in circles in the middle of the stage. He has a virtual reality headset strapped to his face. The headset looks like the square, plastic offspring of a face-hugger from *Alien* and a pair of ski goggles. Wires lead out the back of the headset and across the floor like a leash tethering him to the computer in the corner.

He hasn't heard me come in. He's in an entirely different reality.

Virtual reality, or VR, is the new "it" thing in the consumer tech industry. With VR, you can put on a headset and experience the feeling of being inside a fully digitally-created world. Two screens inside the headset work in tandem, displaying the virtual environment at slightly different angles. The variation in angles mimics the way our eyes actually work, creating the illusion of depth. 3D glasses do the same thing, the red side makes your eye see one angle and the blue side makes you see the other. When combined, pictures can pop out of the screen and into the movie theatre.

Monsters leaping out of the silver screen in 3D movies works like a virtual reality headset, but it is really more like another kind of digitally altered reality: augmented reality. In a 3D movie, you can see the movie, but if you look around you can still see the theatre. In augmented reality (AR), the headset is transparent and behind the digital display, you can still see the physical world.

VR and AR both have a variety of applications, from medicine to military to gaming. VR has unique traits that make it great for storytelling. It can transport the user to an entirely new setting. VR says forget reality; be here instead.

VR gives the designer complete control over the environment more easily than AR. AR experiences that rely on specific environments must have whole rooms or buildings designed around that experience. The HTC Vive just needs room for the position tracking equipment and the Oculus Rift just needs the player to put on the headset.

Understanding the difference is important because VR and AR feel incredibly different to use. VR is like wearing a blindfold with pictures on the back, the real world around you feels like it's there but you can't see it or hear it. AR lets you see the real world and its virtual augmentations, which can make the experience more comfortable because there isn't that feeling of being blindfolded. However, with AR, the experience designer loses the control over the visual environment that they have in VR. Complete control over the setting lets the VR designer create any experience they want to—from swimming with whales to flying on a Pegasus.

You can immediately tell how long someone has been working with VR by the way they walk around. At first, it's like walking around with a blindfold on—you hold your arms out in front of you like bumpers to keep yourself from hitting the walls. The Vive puts up a blue grid to tell you where the walls are whenever you get close to the edge of the motion tracking box, but even when you know that's going to happen, it's hard to trust the machine.

The grad student is walking around at a normal speed without the slow, timid footsteps of a new VR user. He stops in the middle of the room and holds out the two black Vive controllers in front of him. The computer's monitor is facing me and I watch the game's window collapse as the Steam VR setup pops back into view.

Taking off a Vive headset is like trying to put on your coat while carrying a coffee cup. The grad student pulls out his earbuds by yanking on the cords with his pinkies while still

holding the two controllers. Then, he squats down and tries to gently place the two controllers on the ground. He overestimates how close he was to the floor and both of us wince as the controllers drop a few inches and clatter to the ground. Finally, he can take the headset off. I walk onto the green stage and help him carry all the Vive equipment back over to the computer table.

While he shuts down what he was working on, I take the microfiber glasses wipe and clean off the Vive lenses. Once he's left, I log into my account and open up my senior project.

Back in September I started working with three other game development seniors on our senior project. Before summer break, the game development faculty pitched a selection of project options to the junior class. One of those pitches was for a virtual reality short film. Some of my project partners jumped on the chance immediately. I was more hesitant: I had tried for and lost three other project opportunities before this project. I liked 3D art and I've written a lot of sketch comedy but I had no interest in VR.

We brainstormed a few ideas for the film and fell into the sci-fi genre almost immediately. I think it was because the idea of strapping a computer to your face to enter an elaborate digital illusion already feels like science fiction.

Eventually we landed on the story of an android, embodied by the player in the virtual reality experience, that gains sentience earlier than the technicians expect. The android, named ARIN, wants to stay awake but the technicians are determined to shut it down.

The first month or two that we worked on the project, I never really thought of it as a virtual reality experience. To me, it was just a film with some weird constraints: you can't control where the player was looking, so you can't frame shots and your viewer is a character so

you have to either figure out how to program the other characters to respond or explain why the other characters don't react to the player's actions. The process felt like trying to write a sitcom where the live television audience sat on the couch in the middle of the living room set. I thought the audience was still just there to observe. The only difference was that the audience was not just there to observe but also to be a complete nuisance to work around.

The effect VR has on the experience is pretty much all I talk about these days. At this point, I'm doing it to "sell" the projects so that others think that what I did was worthwhile. Mostly, I talk about how we made it more immersive by adding this big, cumbersome, red lawnchair to the already long list of hardware it takes to run the experience. The chair puts the player into the same position as their virtual body is in the experience. When your virtual body looks like it's in the same position as your actual body, it is easier to sink into the experience. When done correctly, you might even start to "feel" things that happen to your virtual body. This phenomena is known as the Rubber Hand Illusion.

The basic idea of the Rubber Hand Illusion is that you can show a person a rubber arm that is in the same position as their arm. When the person sees the rubber arm touched, the person feels like their arm is being touched. Like any illusion, if the person experiencing it knows the magician's secret, the illusion is broken. Every member of the team knows the illusion, so we can't test it on ourselves. Instead, we had to find other people to test our illusion. We needed to find players.



Figure 20 Playtester sitting in the reclining chair with HTC Vive headset.

When you make a game or virtual reality experience, you need to have players test them. These players are uncreatively titled playtesters and what they do is commonly called playtesting. Playtesting is an important part of developing any sort of game or virtual experience. Developers and designers quickly reach a point where they are too familiar with the thing they're making to spot things that are confusing, difficult to use, or hard to understand. Playtesting is like having somebody else edit your essay--they'll almost always notice an error you've overlooked.

I drag the bright red lawn chair into the center of the lime green room. The chair is the kind that is marketed on TV as being able to make you feel weightless. The chair is lightweight

and uses a thin plastic mesh to support the person sitting in it. While it certainly doesn't remove the effects of gravity, it does disperse your weight in a way that makes the chair less noticeable.

There's nothing intrinsically wrong with the chair, but after dragging it along with all the other VR equipment to various exhibitions and showcases, I've grown to hate it. The chair doesn't lock shut, so if you pick it up from the wrong side when it's folded up, it unfolds and smacks you in the shins. At only 5'2", I'm too short to carry the chair under my arm so I tend to drag it behind me when I go to set it up.

The Oculus Rift and HTC Vive were released to the public within a week of each other in spring of 2016. From there, VR has ballooned to a multimillion dollar industry in a single year, despite the two VR headsets costing two to three times as much as a regular game console. Still, the \$600 to \$1000 price tag is far cheaper than that of the VR equipment of the 1990s, which ran upwards of \$94,000 and could require up to a dozen computers to run virtual environments with less visual detail than the original Tomb Raider game¹.

The experiences made back in the 1990s were able to be emotionally powerful in their day, but today audiences expect more from computer graphics. A wonky animation or a blocky looking character throws the player completely out of the experience. They're playing games with incredibly realistic graphics and animation and expect the same from their VR experiences. This is a challenge for the VR developers, not only in terms of the time and labor it takes to produce models and animations that are up to par but also in making the animations render correctly in the headset.

¹ <https://www.vrs.org.uk/virtual-reality/history.html>

When a video game or other interactive 3D environment is displayed by a computer, it has to go through a rendering process. The computer uses all of the data about where everything is in the game and calculates where all the shadows, highlights, and values go to create an image, called a frame. The computer has to create a new frame at least sixty times per second to create a convincing video game scene. The number of images the computer is able to make per second is called a frame rate.

In order to create a convincing VR environment, the headsets have two displays that show the setting from two slightly different angles. Because the displays are not identical, the computer running the VR experience needs to render two entirely different images for every frame of the experience. The maximum number of frames per second that an HTC Vive can display is 90. With two separate images needed to create a VR frame, the computer could be rendering up to one hundred and eighty frames in a single second. If there is too much data for the computer to process, it is forced to drop frames, or skip rendering certain frames to keep up with the demand.



Figure 21 Parallax screens displaying a frame from the Oculus VR's Tuscany VR

To counter this, artists have to make sure that the models (the 3D objects in the VR experience) and animations balance looking real with using as little computing power as possible to render. Detailed animations and models mean the computer has to do more work to render each frame. If the computer runs out of time before it needs to render the next frame, it'll skip the next one to make up for lost time. For example, if the artist pushes for too much realism, the experience can have a lower framerate. Lower framerates make the experience look choppy, which can be another cause of simulator sickness. On the other hand, an experience that isn't realistic enough risks losing the viewer's suspension of disbelief.

Back in the lab, I finish setting up the HTC Vive. There are two sensors at opposite corners of the stage, facing each other. If the headset is in the area between them, they can sense where it is and figure out where to put the user in the virtual environment. The sensors must be angled in just the right way in order to be able to "see" each other and the headset.

However, for our experience, we don't want the player to be able to walk around. We want them to feel trapped, just like the character they're embodying. When the playtester arrives, I have her sit down at a computer and read our Institutional Review Board-approved waiver (getting IRB approval to strap someone into a 360 degree horror film was, surprisingly, not as hard as it sounds). After that, I walk with her over to the chair. I show her the controllers, including the buttons on the back that we programmed so the player can press them and stop the experience if they need to. Once she had the headset on and adjusted correctly, which takes a few minutes, she takes a seat in the chair. I hand her the controllers, which is a process I have gotten used to narrating loudly.

“I’m handing you the left controller.” I say and then I gently tap her left hand with the end of the controller so she can find it. After repeating for the right, I continue with instructions: “You’re going to see two green circles. Line them up by moving your head to start.”

The experience is designed so that it artificially limits where the player is allowed to move to, but if the player did stand up, their view would change wildly. Not only would this change the experience, but it also causes pretty nasty simulator sickness. I tried walking around in the experience once. It made me so nauseous that I had to stop it early and I spent the rest of the day with a nagging headache.

That’s the other problem with VR, it just doesn’t feel good for some people. Even with high framerates and resolution, some people can still feel trapped behind the screens. We have this tool that affords us the ability to tell stories in a way that was never possible before, but right now, not everyone can use it.

Currently, the way we render VR experiences causes simulator sickness more often in women than men. VR uses a combination of parallax vision, the two different angles your eyes see from, and shape-from-shading. Shape-from-shading mimics the way that shadows on objects change slightly as you look at them from different angles. In people with higher levels of testosterone, including transgender men on HRT (hormone replacement therapy), parallax vision is more important in constructing a realistic recreation of vision². In people with higher levels of estrogen, including transgender women on HRT, shape-from-shading plays a more significant

² boyd, d. (2014, Mar 28). Is the oculus rift sexist? Retrieved from <https://qz.com/192874/is-the-oculus-rift-designed-to-be-sexist/>

role³. Right now, we know a lot more about creating effective parallax than creating effective shape-from-shading.

We know more about parallax because most of the people who design VR hardware are men. However, there are women who are making great strides in researching ways to solve this problem.

danah boyd is a principal researcher at Microsoft, a professor at NYU, and the founder of Data & Society, an organization that studies how technology and society interact. Before she honed her focus on social media, she studied computer science at Brown University, where she worked with the university's CAVE VR system. The experience of being in this late-nineties VR environment made danah so physically uncomfortable, to the point of becoming sick, that she only ever used it once. However, this experience led her to dig into why this happened to her. Through researching the connection between gender and simulator sickness, she was able to suggest its connection to hormones early on in 2001.

Nonny de la Peña, who many call the godmother of VR, is a pioneer in what she has named interactive journalism. Her first interactive journalism piece, "Hunger," used real audio that was taken while she was interviewing people for a traditional article about the hunger problem in Los Angeles. She felt that a VR experience was the best way to share this story in a way that was emotionally impactful enough to drive people to action. The experience uses real audio and a digital recreation for the visuals to depict the moment when a man standing in line for food succumbs to diabetic shock and collapses. The experience was first shown with a prototype version of the Oculus Rift because the creator, Palmer Luckey, was working as de la Peña's intern at the time. Luckey has been accused, among many other things, of not taking into

³ boyd, d. (2000). Depth Cues in Virtual Reality and Real World. 1-25.

account women's experiences when designing his VR headset. De la Peña has made no comment on the issues Luckey or the Rift and the two have long since parted ways as collaborators; however, she has been working on developing a VR device for phones that is not only lightweight and portable, but also reduces simulator sickness in women⁴.

Of course, some research shows that simulator sickness goes away after repeated exposure. But who wants to put up with headaches, nausea, and eye strain every time you do something until you've done it enough that it goes away?

When the experience ends, the playtester pulls off the headset. I rush over to take the equipment from her (we've had a few incidents where people have just dropped the controllers on the floor when they're done). She heads back over to the computer where she read the form and fills out the survey.

She's our last playtester of the year. On April 27th, the project will officially be over. We're allowed to continue working on them after graduation, but no one on the team has enough money to put down for the equipment, and our access to the lab shuts down on May 14th—the day of our graduation.

This project has brought me out of the digital side of game development and taught me to think about the hardware and how it feels, and makes us feel, when we play games. I feel like I'm on the cusp of a new type of media, but I'm taking a step back for now.

Although I studied game development, I plan on becoming a teacher after I graduate. When I am a teacher, I am not just going to let game design and VR rest as cool remnants of my undergraduate experience. VR development has taught me to see storytelling and communication

⁴ Volpe, J. (2015, Jan 24). The godmother of virtual reality: Nonny de la peña. Engadget,

in a new light. I want to help my future students learn to think about how the media they choose to communicate with fundamentally affects the message that they are sending. I want to teach them to think about their implicit biases and the importance of accessibility and inclusion when designing for communication and storytelling.

11. POST MORTEM AND FUTURE RECOMMENDATIONS

11.1. What Went Well

We felt that our ability to present an effective, entertaining, and horrifying experience to the user was our greatest success. From our survey data we have shown how users were able to understand the narrative and feel discomfort or even fright at pivotal narrative events. The players were also involved in the experience, despite being immobilized. We could convey an illusion of interactive programming, even when the narrative was completely fixed. We were also able to guide the player's attention towards our characters and centerpiece objects, such as the arms, rather than losing the player's attention to environmental details.

Scope was also handled gracefully. We had initially set out to animate a much longer script, around seven minutes, and even had dialog ready to go. However, when we determined that the animation process required more time than we thought, we were still able to cut the script down without losing the narrative intrigue. It allowed us to devote extra time to polishing the animations and visuals to a more complete state. We made this scoping choice early-enough to allow for the necessary animation adjustments – in other words, our choice to cut the scope did not surprise us late in the process, causing a scramble to complete assets.

11.2. What Went Poorly

Scope, as stated previously, both went “well” and “poorly.” Scoping down our project was an unfortunate requirement of a shorter, more polished result. We had overestimated the

time required to animate but still expected to complete the entire body of animation before our final deadline. The start of our animation process began later than we would have liked because we were refining our character and environment art for a long period of time. It might have been possible to complete the animations had we started sooner. As a result of cutting our scope, we were unable to incorporate other features and stretch goals we were excited to include.

11.3. Out of Scope Goals

We reduced our scope in order to complete the first third of the planned narrative for this version of the experience. Our experience ends when Barrow takes the emergency shut-off button out of ARIN's chest and attempts to power it down. In the full version of the narrative, this would be unsuccessful and as a result Barrow and Escarra would attempt other methods such as removing ARIN's faceplate to reroute the oculars and eventually regain control. They would also try to convince the player that shutting themselves down would actually be the best thing to do, increasing the player's involvement and introducing a more emotional aspect of the experience. In our version, however, the emergency shut-off button is successful and the experience is ended there.

In reducing our scope, we also decided to leave some environment models without textures and focused on texturing certain models that we thought were more important. The models that we didn't texture were mainly walls and doors. Because we were modeling our environment after a clean room, we felt like these untextured elements still fit with the sterile feel of the experience. In future work, however, these models should all be textured.

11.4. Future Recommendations

11.4.1. Adjustable Body Types

One of our experience goals was to create a strong empathetic connection between the player and the player's avatar, ARIN. Virtual reality experiences create empathetic connections easily, but those connections and the sense of immersion require to create them can be enhanced by a visual similarity between the player's body and the avatar's body. The rubber hand illusion (RHI), which is the name of the psychological phenomena wherein a person's arm is touched while they look at a rubber arm that is also being touched in the same way and the person feels as if the rubber arm is their own arm (Perez-Marcos, Sanches-Vives & Slater, 2012, p.295). Unlike the RHI, the ARIN VRE does not have any sort of sequenced haptic feedback implemented. However, we know the RHI is stronger when the rubber hand looks like the subject's own arm in terms of color and texture (Perez-Marcos, Sanches-Vives & Slater, 2012, p.295). This suggests that the connection between the player and ARIN may be stronger if ARIN's skin tone and body type reflected that of the player. Exploring the potential effects of reflecting the player's real body in the VR space could also provide useful information for the development of other virtual reality experiences.

11.4.2. Additional Immersive Hardware

As well as the adjustable body types, in order to create a strong empathetic connection between the player and the player's avatar, we think it would be a good idea for the player to put on a hospital gown before putting on the VIVE. By wearing the same clothing as ARIN, the player will feel more immersed and in character of ARIN as they share the same outfit and body type. It can also trick the player so that it's easier for them to think that they are in a futuristic medical facility at the beginning of the experience.

We have also considered testing haptic vests in the future. A haptic vest is a vest that uses vibration to simulate feeling (mostly touching) for the wearer. It would allow us to simulate the feeling when the mechanical armatures are pressing down on ARIN's chest to further improve the immersion. However, with the vest on player but no vest on ARIN, we artificially created another difference between the player and the avatar. Therefore the effectiveness of the vest is still to be tested.

11.4.3. Improved Voice Acting

Our voice talent was very decent given our constraints. For future considerations, a larger audition pool might have given us more options and a wider range of talents to choose from. The most significant discrepancy between the voice talent and the technicians in the ARIN VRE is the age difference we wished to represent. Our voice talent was limited by age - the age discrepancy is noticeable, especially in voice, because humans are attuned to the nuances in voice. Our voice talent was also limited by total experience in the field.

Other issues were related to recording hardware and location, both of which were difficult to optimize. In both recordings audio glitches from the microphone and external sounds are audible during important lines of dialog. Editing around these errors or removing them is extremely difficult. We had intended to record a third time with our voice talent, but our efforts were directed elsewhere in order to polish the animations, visual elements, and other sounds.

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APPENDIX A: PAX EAST HANDOUTS

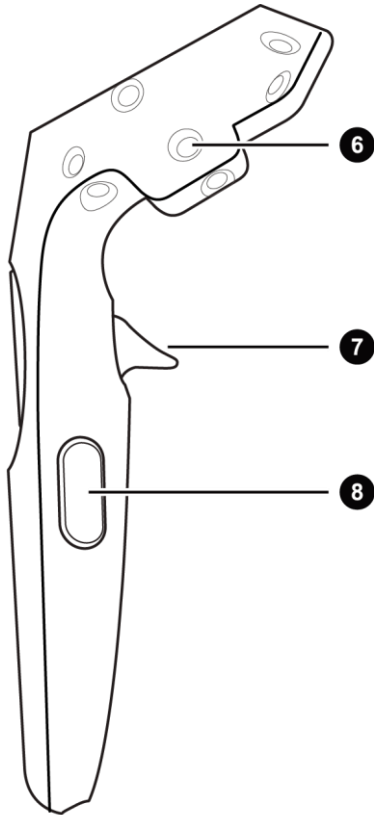
APPENDIX A: PAX EAST HANDOUTS

What is *ARIN: A VR Experience*?

ARIN is a virtual reality experience that uses the player's perception of virtual reality to enhance their emotional immersion. Worcester Polytechnic Institute seniors—Graham Held, Izzie Schiavone, Matt Thompson, and Dongjie Wang—are currently working on the project as their IMGD senior project at Worcester Polytechnic Institute.

What should I know about *ARIN* before I start this experience?

ARIN is a sci-fi horror experience. There are no jumpscares, but the experience contains depictions of surgical themes, which some users may find disturbing. You can stop the experience at any time by holding down the triggers on the HTC Vive controllers (#7 in the picture) for three seconds. Or just let one of the people running the booth know and they'll stop it for you.



What should I know about VR before I start this experience?

While virtual reality headsets have come a long way in the last few years, they can still cause some mild motion sickness. If you experience motion sickness, or any other discomfort while participating in *ARIN*, you can hold down the triggers on the HTC Vive controllers (#7 in the picture) to stop the experience. Or just let one of the people running the booth know and they'll stop it for you.

If you want to be an official playtester, please read this!

(we're sorry it's so long!)

INTRODUCTION

ARIN is a virtual reality, sci-fi horror, short film for the HTC Vive, which incorporates physical performance elements to create a more immersive experience. This project is designed to investigate how people react to unorthodox virtual reality experiences.

PROCEDURE

As a participant you will be asked to wear an HTC Vive headset. You may be asked to wear a restraining strap around your chest and shoulders before beginning the experience.

The investigators may stop the study or take you out of the study at any time they judge it is in your best interest. They may also remove you from the study for various other reasons. They can do this without your consent.

You can stop participating at any time by releasing the strap, asking us to stop the demonstration, or holding down both triggers on the HTC Vive controllers.

RISKS

As with all VR hardware, the HTC Vive may cause simulator sickness, motion sickness, or nausea. If you are very susceptible to motion sickness or may be pregnant (which can increase the chances of simulator sickness), we advise that you do not take part in this experience.

The experience contains depictions of surgical themes, which some users may find disturbing. There may also be other risks that we cannot predict.

BENEFITS

Playtesting data from this experience will help VR developers better understand how to incorporate unorthodox performance elements and narrative styles into their own VR experiences.

We can't guarantee that you will personally experience benefits from participating in this study. Others may benefit in the future from the information we find in this study.

CONFIDENTIALITY

Any information gathered from the playtesting survey for analysis and discussion will be kept anonymous.

APPENDIX B: INFORMED CONSENT FORM

A.R.I.N.

INTRODUCTION

ARIN is a virtual reality, sci-fi horror, short film for the HTC Vive, which incorporates physical performance elements to create a more immersive experience. This project is designed to investigate how people react to unorthodox virtual reality experiences.

PROCEDURE

As a participant you will be asked to wear an HTC Vive headset and a hospital gown over your clothes. You may be asked to wear a restraining strap around your chest and shoulders before beginning the experience.

The investigators may stop the study or take you out of the study at any time they judge it is in your best interest. They may also remove you from the study for various other reasons. They can do this without your consent.

You can stop participating at any time by releasing the strap, asking us to stop the demonstration, or using the designated combination of buttons on the Vive controllers. If you or the investigators choose to stop the study prematurely, you will still be eligible for the study incentives.

RISKS

As with all VR hardware, the HTC Vive may cause simulator sickness, motion sickness, or nausea. If you are very susceptible to motion sickness or may be pregnant (which can increase the chances of simulator sickness), we advise that you do not take part in this experience.

The experience contains depictions of surgical themes, which some users may find disturbing. There may also be other risks that we cannot predict.

If you choose to not take part in this experience due to the risks, you will still be eligible for the study incentives.

BENEFITS

Playtesting data from this experience will help VR developers better understand how to incorporate unorthodox performance elements and narrative styles into their own VR experiences.

We can't guarantee that you will personally experience benefits from participating in this study. Others may benefit in the future from the information we find in this study.

CONFIDENTIALITY

With your consent, we will collect your name for use in the credits of our final production. Any information gathered from the playtesting survey for analysis and discussion will be kept anonymous.

INCENTIVES

At the end of our project, we will randomly select one participant to receive a \$40 Steam gift card.

By signing here you acknowledge that you've read and agree to participate in this study

Signature: _____

APPENDIX C: SURVEY QUESTIONS

- What were the technicians trying to accomplish?
- Describe how your capacity to interact with the experience made you feel. Did it seem forced or natural?
- Describe your role in the story. Did you feel as if your ability to interact made any difference to the course of the plot?
- Describe the moment at which you felt the most uncomfortable.
- Describe any moments, if any, in which you experienced motion sickness or nausea.
- Were there any clear mistakes that you feel we need to address?
- What did you feel we did particularly well in this experience?
- If you have any additional suggestions, commentary, or reactions, please describe them below.

APPENDIX D: RAW SURVEY RESPONSE DATA**What were the technicians trying to accomplish?**

- Trying to diagnose me I think... as to why I was conscious.
- Shutting ARIN down because she woke up too soon.
- I think they were trying to make an AI that was "living".
- Some kind of internal work on myself, by which I mean the cyborg.

Describe how your capacity to interact with the experience made you feel.

- I'm not sure forced or natural would describe it. It felt like an interactive experience, even though I know it wasn't (through conversations with the team). I guess the tests upon waking felt pretty natural
- Definitely seemed natural.
- It seemed relatively natural - when I "woke up" the character noticed and it seemed pretty natural in terms of timing. I thought it was cool that when she asked me to nod and I did, she responded to the nod.

Did you feel as if your ability to interact made any difference to the course of the plot?

- I am an android who has somehow gained consciousness. Only my head was able to move and the rest of my body didn't. Felt as if the rest of my body was like a ghost. The chair restrained my movement and made me feel a little trapped but more immersed.
- I was some sort of patient or subject, seemingly an android. I'm not sure if my ability to interact had any impact; I realized after following the doctor's instructions that I could have tried ignoring them.
- Having the doctor shine the light in my eyes and make me follow the pen made me feel like I could interact, but I did not really feel like I could change the course of the plot.
- I don't know if my interaction made much of a difference. I followed the orders of the technicians, but I don't know what would have happened if I didn't follow them.

Describe the moment at which you felt the most uncomfortable.

- When the ribcage thing got pulled out of my chest. Made me feel deeply uncomfortable.
- When the surgical arm came to rest on my chest, I was the most uncertain of what would happen next; once it removed the front plate revealing an artificial interior, I felt more comfortable again.
- I did not feel uncomfortable at all during this.
- I didn't really feel uncomfortable but the part when she was poking around inside the chest cavity was cool because I felt like I could almost feel her poking around.
- When the robot arms or doctors got really close to the camera.

Describe any moments, if any, in which you experienced motion sickness or nausea.

- When I was looking down on my body, there were moments where I felt the camera shaking/trying to readjust itself. When the person was taking apart my chest plate, her arm was very close to my face and my eyes weren't able to focus. It ended up being a bit blurry.
- I didn't experience any motion sickness, but I did notice that when I turned my head, I shifted slightly left and right, which broke immersion somewhat.

- I didn't feel any motion sickness or nausea.
- none
- I did not experience motion sickness or nausea.

Were there any clear mistakes that you feel we need to address?

- I don't think so...?
- The lady scientist's eyes are messed up. Her hands have no animations. Some polys on the body of ARIN were missing? Like on the chest region there was a tiny triangular hole.
- Having the controllers in my hands, I felt as though I could at least move my avatar's hands, but could not. I don't know if this is intentional or not, but it did make me feel a little less present in the world.
- my head was not where it should have been in the game. one of the doctors appeared and then disappeared at one point.

What did you feel we did particularly well in this experience?

- I think the story was interesting and the environment was really cool.
- Setting looked nice. Got the feeling of hospital/testing room. Not too much to distract.

If you have any additional suggestions, commentary, or reactions, please describe them below.

- The experience felt pretty real! If I was strapped down more the experience might have felt more real. I love the giant robotic arms descending upon me. The needle was very scary and I got goosebumps.
- Finish the animations, y'all.
- I felt like the game expected my head to be slightly lower at times; this was really only noticeable when the doctor shone a flashlight at me. Minor note: there was one point in which the doctor's eyes seemed to vanish; I believe this was around the time that she was using the flashlight.
- Just the ability to move the avatar's hands.
- I think getting rid of any stutter would significantly improve the experience, because that was a bit disorienting at times. Also positioning the head a little bit better would have made me feel like that was my body more.
- none
- There was a part where a drill (I think) was being used - I think sound effects would enhance that part of the experience
- The animations are quite unreal (pun intended). They absolutely need work. The voice acting could also use some work.

APPENDIX E: ARIN SCRIPT

Due to the length and formatting of the script, it was included in the submission of this MQP as a separate file and is available in the Worcester Polytechnic Institute digital MQP collection alongside the .pdf of this paper.