Living in the Moment: Exploring Aesthetic and Movement Quality Attributes to Create Successful Immersive Gameplay in Therapy

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Abstract

The quality of aesthetic and movement experience can be imperative to a physical therapy patient's recovery. While the experience of moving is often restricted to the physical actions determined for the patient's personal needs, the addition of external motivation such as interactive movement games can support the quality of the recovery experience. We ask the question, 'how can interactive art games support a patient's recovery process by focusing on quality of movement performance, enjoyment and engagement?' The recent rise of virtual and augmented reality in gameplay with high resolution graphics and believable characters is now easily available to the consumer. This provides an opportunity to explore how these platforms of gameplay can be used for the betterment of people who are battling illness and injury. In our research of color psychology, movement quality techniques/observances, and implementation of gaming elements like scoring and entertainment, we hope to find trends as to what succeeds or what fails to make an enjoyable and productive therapy game. Our project will provide data and answer the questions: 1) How the quality of visuals affect the behavior of the patient, 2) How to simulate authentic therapy movements and exercises into real life and gaming situations, and 3) How to provide an experience for the patient that drives them to succeed in their therapy.

Living in the Moment: The Aesthetic and Movement Quality Attributes That are Necessary to Create Successful Immersive Gameplay in Therapy

Introduction

When I was a child, I was involved in a horseback riding accident that shattered the growth plate in my elbow. I had to have emergency surgery to repair the damage. Unfortunately, this surgery left my right arm frozen in a ninety degree angle. Over the next ten years, I went through additional surgeries to try to regain as much as my movement as possible. In addition to these surgeries, I was also required to go through physical therapy. As if the surgeries we not taxing enough, the idea that I would have to do these boring and very painful exercises for months on end left my young self extremely unmotivated. As a result of my lack of motivation, I did not get the results I could have had I tried. I now am faced with even more surgeries in the future as a young adult because of the lack of progress from my childhood rehabilitation. This is a type of future I would like to help others, particularly kids, avoid when they have to go through physical therapy rehabilitation.

Physical Therapy focuses on achieving movement goals through exercises that are targeted to a specific anatomical action. While patients are personally engaged in their recovery process, there is often a lack of external motivation to support their experience. Interactive technologies such as virtual reality have been explored in the domain of physical therapy, however these studies continue to be few and lack exploration in aesthetic experience. We are interested in how a focus on color theory and qualities of whole-body movement can support meaningful engagement in gameplay to encourage physical therapy patient's recovery process.

Virtual reality has once again become popular amongst gamers and has a stronger presence amongst the general public with the release of the Oculus Rift and HTC Vive. This

development has prompted game developers to create exhilarating adventures for a person to experience while never having to leave their city. A player can become one of the Apollo 11 astronauts as they enter the Earth's atmosphere. They are there in the cabin in their suit, looking out the window at Earth through the flames that are covering your capsule. The capsule is shaking violently and they can almost feel it shake all the way through their body even when in the real world, they are just standing still with a headset on. The difference in VR now compared to the last rise of VR is the graphics quality and the ability to impact the virtual world in an embodied way. "The reason why embodied gaming works has such a wow-factor is because it plays into our tendency to perceive the world as something with which to be engaged. Using the controller of a Rift or Vive means becoming that much more immersed in a reality that invites you to act in it (Peeters, 2016)." Peeters' quote indicates that incorporating the body's agency in VR game design will have a much stronger impact on playing in virtual worlds. This level of agency can support the meaningful use of play in many other areas, including physical therapy.

Virtual reality has been labeled as a passing fad nearly every time a new leap in the technology is made. The simple, geometric visuals that players were subjected to in earlier generations caused the fascination for VR to die quickly. Currently graphics have become very close to believable that it is nearly at the point of reality blurring seamlessly into reality. The current state of high resolution graphics should be removing the stigma attached to virtual and augmented reality. This also creates an excellent time to explore the effect of color theory and aesthetics in gameplay. Now more than ever there is a strong argument for developing meaningful play in therapeutic capacities that has the potential to benefit people of all generations.

With the leap in graphics comes an opportunity to add principles of visual art, such as color theory, to create environments that subliminally trigger emotions and mental states to not only make a believable space, but help patients get over mental blocks in their recovery. Small visual cues that artists use to convey emotion are an aspect of meaningful gameplay are often overlooked due to a focus on creating and fine tuning technology. Work by Salevati, et al. explores how color theory can be used in addition to a generative visualization system to effectively bring attention to viewer's emotional experience (2016). Subyen, et al. explored how to use Kandinsky's color theory to map metaphor to qualitative movement information in order to emphasize the perception of movement in a live generative visualization system (2011).

The quality of a physical therapy patient's holistic experience, and particularly their movement experience can be imperative to their recovery. While the experience of moving in traditional therapy is often restricted to the physical actions determined for the patient's personal needs, the addition of external motivation such as interactive movement games can support the quality of the recovery experience. We ask the question, 'how can aesthetic and interactive art games support a patient's recovery process by focusing on quality of color theory, movement performance, enjoyment and engagement?' This project highlights two gaps in current game and health research to support patient experience: 1) there is a lack of tailor-made games that support the patient's experience of moving and 2) there is a lack of qualitative data around patient experience to identify parameters of motivation and engagement. This paper is a survey of research in interactive technology and therapeutic situations and describes our game prototype for upper limb rehabilitation.

Background on the experience of existing systems

While there have been prior projects that explore the use of VR in therapeutic situations, the findings show promise yet have been limited to available technology. Based on research done with stroke victims, burn patients, and children with decreased motor function participating in VR therapeutic exercises (Wille, et al., 2009), there is a research gap over a few key areas. Improved graphics have potentially changed the study's results, and how to implement color theory for the best experience needed to assist in improving the patient's goals. We want to also look at how to best maintain the quality of the movement when it is merged with gaming elements to assure that the patient not only enjoyed themselves, but reached or exceeded their goals in the process. We have compared a variety of games designed for therapeutic uses and describe the systems in more detail in the following paragraphs (See Table 1).

Study/Game	**User**	**Movement/Task Relation**	**Game Objectives**	**Graphics**	**Color Theory Application**	**Technology used**
Merians	3+ years post stroke victims	Move hand to touch, hold, or grasp virtual objects	Improve fine motor movement in hands	Patient hand has life-like representation; Basic object representation	Unknown	CyberGlove w/ interface unit; visuals are on computer screen
Schneider/Hood	Chemotherapy patients	Exploring environments or solving mysteries	Distract from chemotherapy treatment	Unknown representation of real life environments	Unknown	i-Glasses® SVGA Head-Mounted Display, i-O Display Systems
Robillard	People with phobias	Interact with objects or environment corresponding to patient's phobia	Lessen phobia's effect on patient	Unknown representation of real life environments and objects	Unknown	I-Glass® Head Mounted Display, modified versions of video games
Woodland Wiggle (O'Shea)	Children in hospital	Arm movement creates various interactions with images and sound	To ease/soothe children's minds while they are in the hospital	2-D images, simple storybook like images	Bright, non-threatening colors	C++ with openFrameworks and a Xbox Kinect
Gesturetek	Various physical therapy patients	Various outward limb movement interacts with various images	To improve range of motion/ hand-eye coordination/etc.by virtually playing sport themed games	Basic 2-D imagery to simulate real life environments	Color choices tend to make graphics look busy visually and make text hard to read	Unknown programming but uses a sensor similar to Xbox Kinect

Hoffman, et al	Burn victims	Explore and interact with an ice/snow world	Reduce pain caused by severe burns	Unknown representation of an icy environment	Used appropriately to simulate a snow/ice environment	HMD and a fixed joystick; game is *SnowWorld*
Supernova	Physical Therapy Patients	Qualities of motion in arm movements, with spatial location and speed	Provide engagement to support rehabilitation	Realistically generated space imagery	Mixed use of warm and cool colors to affect mood	Microsoft Kinect camera and Java

Table 1. Analysis of Existing Therapy-Oriented Games

The Merians, et al. (2002) study on stroke victims using VR to improve their hand dexterity is a study that deserves further testing. The study used three patients recovering from a stroke they had three to five years before and put them all under a virtual reality based therapy program. Each patient went through approximately 90 minutes of these VR exercises five days a week for two weeks (p. 904). This is a lot of time spent in therapy. Any therapy routine, VR-based or not, would show improvement, but since the patients likely had plateaus in their recovery an intense routine would be needed to show results. If VR therapy showed progress in potentially difficult cases, there is promise that it can show progress for new patients that need a typical clinical therapy routine two to three times a week for 45 minute sessions each as the Merians study described (p. 900).

Schneider and Hood (2007) studied the psychological effects that VR-based environments had on patients going through chemotherapy. The study found that patients who use the VR experienced a perceptively shorter chemotherapy session due to the distraction of being in a different place virtually. Through another study by Robillard, et. al (2003), that also found immersing people with phobias into virtual situations that made them confront their fear without *actually* confronting their fear for logistical reasons was very effective (p. 468). The environment they were immersed in was able to be made for phobias that would be difficult to be exposed to in the real world and completely controlled for the sake of the patient.

Figure 1. Woodland Wiggle

Figure 2. GestureTek

There are two examples of commercial games used in a therapeutic or medical setting. While not a typical example of a therapeutic game, the Woodland Wiggle installation by Chris O'Shea (O'Shea, 2013) located at the Royal London Hospital provides the children in the hospital a fun distraction through the use of motion capture and interactive media. The GestureTek company has created a system similar to the Xbox Kinect setup for patients to play games such as bowling, drumming, or playing a soccer goalie. While the technical setup works brilliantly, the graphics appear dated and seem to take away a certain enjoyable aspect to the game.

These are both considered augmented reality, in that the user is not fully immersed in a virtual environment, but can physically interact with computer generated imagery and sound. Both VR and AR as systems have their own personal potential strengths and weaknesses. As one can see in both these examples, the patients do not have to wear or hold any equipment, they can interact with other users, and it appears to be easy to use. However, if you notice in all the GestureTek exercises, all the games appear to rely on a sensor recognizing a silhouette. This causes quite a few limitations in the exercises this type of setup would be able to allow the user. VR, on the other hand, allows users to move three-dimensionally without any of the same

restriction. The types of exercises the user can participate in and the freedom to move increase. Exercises that involving movement straight forward or backward, like rowing, would be more easily tracked and visually rewarding in virtual reality.

However, as research by Rebenitsch, Owen, and Coburn (2014) stated, motion sickness and disorientation are a common problem in VR, especially when graphics of environments and objects are not accurate. If the program the patient is using does not have environments and interactive objects that their mind can adjust to using correctly and causes them nausea, then the amount of time of their session is decreased dramatically and affects the outcome of their recovery negatively. Disorientation can be a big problem as well. Patients with neurological problems could have potential to have balance issues and falls.

Color theory, specifically color psychology, is the broad study of color relationships and the role they can play in affecting the mind. It is a concept most used by visual artists when creating everything from illustrations, graphic design, photography and many things in between. One of the most easily recognized uses of color theory is the creation of logos. Depending on the company and what they are selling, the graphic designer making the logo will skillfully use colors that trigger an emotion response from the viewer to associate the company with a certain mood or feeling. Looking at the chart we have created using popular color psychology used in logo design that stems from the study of color theory that early twentieth century painter Wassily Kandinsky did (Fig. 3), many companies that involve nature will use mainly green within their logos. Companies that want to build trust with their customers (financial institutions, car manufacturers, computer companies) will use the color blue because it gives the sense of dependability and strength to the consumer. Even when broader concepts like light making

objects bigger/dark objects appearing smaller and cool colors invoking calm/warm colors invoking energy are applied they can have a subconsciously tremendous impact on the mind. Kandinsky recognized these emotions in the early twentieth century and much of what he discovered remains the same today.

While in many games, artists recognize these concepts and apply them brilliantly, they are not applied at all in current therapy gameplay. In therapy, the patient's mindset must be handled just as attentively as their impairment. If the patient is in pain, not motivated, or even a combination of the two, the end result of their therapy will not be as successful. One of the easiest and most impactful ways to trick the patient's mind is through these color theory/color psychology concepts. Exploring what color schemes affect the patient the most and in what way will be important in designing the aesthetics of the game. Questions to be tested include: 1. What color temperature is best for each type of therapy? 2. Do color families (complementary, analogous, monochromatic, etc.) affect the patient's mindset? 3. Does using many vivid colors versus very few colors affect the patient's ability to use immersive technology?

Figure 3. Color Psychology in Logo Design and Kandinsky Color Emotion Comparison

One of the most notable explorers of color theory was the early 20th century Russian painter, Wassily Kandinsky. Known for his non-representational Bauhaus work, he also studied how colored affected mood. An example of what Kandinsky found was that though black and white both represented nothingness, white gave off a sense of hope whereas black felt as though this nothingness was final, like death. Where black or white was silent emptiness, warm colors like red and orange gave off the sense of tumultuous or energetic movement. On the opposite end of the color wheel, cool colors like blue and green were associated with peacefulness and calm. In a recent study on movement quality visualization, participants observed that the visual representations of different movement types based of on the Kandinsky color characteristic scale were accurate to the emotion or quality the movement was making (Subyen et al., 2011).

These studies, from a VR technology standpoint, were performed nearly a decade ago when the technology was in a less advanced place. Now that technology and graphics have gotten to the point where movement tracking and visuals have become so lifelike, we would like to take these studies even further to see what can be done to make them successful. We want to make therapy into something fun and enjoyable, rather than miserably hard work many patients tend to view it as. We want to make the overall experience more satisfactory than the 75th percentile (Monnin & Perneger p. 686) to the 90th percentile.

Movement Interaction. Whole-body movement interaction in games is not a new concept, and is often geared towards immersive engagement and fitness. The use of computer vision options for tracking movement wirelessly is found in the Microsoft Kinect, the Playstation Eye, and the Wii as a few examples. The movement objectives from using these methods of tracking are often spatial. The wii remote's location in space and change in speed (using a

gyroscope and accelerometer) is mapped to its graphic on a screen and triggers an event when there is a collision between the wii and the graphic. How these tools are used determines their effectiveness in gameplay or meaning to generate engagement.

Whole body movement has been found to support quality of player engagement, pressing them to achieve goals or to relax (Pasch et al., 2009). This has been found in studies on the design of game controllers that use natural interfaces such as the Wii or guitar for Guitar Hero, which affect social interaction (Lindley et al., 2008). When these controllers are designed for more natural, embodied actions players seem to be more immersed, found by analyzing the use of speech and utterances during gameplay (more vocal use indicating more engagement socially). Another novel method of controlling a game through movement is gaze. While controlling a game by using gaze is challenging, it has been found to be novel and immersive by engaging the player through using a new form of body action (Nacke et al., 2009). The kinetic camera is used in Tweetris, where two players compete to quickly create tetris shapes with their bodies to play a whole-body form of tetris. These explorations of various whole-body methods of gameplay illustrate new forms of engagement that are possible to be designed for.

Work that explores the use of movement quality has yet to be included in game design, but has been developed for performative and visualization use. Subyen et. al's paper on using movement qualities in aesthetic visualization uses a single accelerometer system to capture and analyze movement data for qualitative information. This qualitative information is mapped to a movement framework called Laban Movement Analysis, which categorizes movement into categories of Weight, Space and Time that can combine to create 'Basic Efforts'. 'Basic Efforts' reflect general gestures that anyone can perform including Punch, Press, Wring, Flick, Float,

Dab, Slash and Glide. This work maps Kandinsky's color characteristics (which have a metaphoric mapping) to 'Basic Efforts' while using an L-System to generate visualizations. The user wears a glove with the accelerometer built in, and when moving the glove detects the 'Basic Efforts' in the movement and projects accompanying visualizations of various types of lines and colors that are mapped to the qualities of movement. This system is the underlying inspiration for implementing movement qualities into a rehabilitative experience for physical therapy patients.

Another work that explores the use of a kinect camera used for whole-body drawing in Art Therapy. This system focuses on the use of expressive movement as metaphor to support patient's experience of shift or change. This study found that the drawing tool was supportive for populations that could not easily hold a pen or manage the concentration or fine motor control often needed in drawing. It also found that it was useful to many populations because 'body movement stimulates motivation' (pg. 84) and that it supported the control of impulse and behaviour. The interaction between mind and body was found to be very revealing to participants about their behaviour while the ability to work qualitatively, with rhythm and flow, supported expression. This simple yet engaging system was a safe place for participants to play (it is touchless), it is easy configurable (all parameters can be manipulated on the fly) and highly portable for use in commercial situations.

These various perspectives to whole-body interaction and the opportunities presented by qualitative movement information, alongside its application in a therapeutic environment, suggest that our explorations in game design could be highly useful to rehabilitate physical therapy patients. The following section describes our design process and goals in the creation of our game 'Supernova'.

Design Process and Goals

Motivation. Drawing from existing research and professional backgrounds in art theory and movement interaction, we are implementing a physical therapy game prototype in collaboration with a professional physical therapist. We are motivated by personal experience in injury and physical therapy, and an interest in creating more enchanting play during recovery (McCarthy et al., 2006). Enchantment in gameplay is defied by McCarthy et al. to mean pleasurable disorientation, where perception and attention are heightened (McCarthy et al., 2006). It states that a sense of wonder is tied to being present in the moment, without relying on our rational memory of something. Yet it also requires 'Flow' (Csikszentmihalyi, 1997), needing just the right amount of continual challenge to maintain engagement without becoming overwhelming.

To design for enchantment in a physical therapy game, we have explored options for full-body engagement while performing exercises. We have designed a 2D space environment in which to explore color theory and movement that can provide many opportunities for level development. Our game, titled 'Supernova', focuses on the player's *quality* of movement to complete their exercises rather than simply measuring range of motion. The focus on quality of motion enables a focus on the player's experience of play, bringing external motivation to their rehabilitation.

Technical Setup. Our current setup uses a single Microsoft Kinect to capture the player's arm movements. The player needs to stand within the predetermined record space. The 2D space world is projected on the wall in front of the player and reflects the impact of their actions on the environment. Currently the system is designed in Java (specifically Processing). This setup is

portable and easy to implement in a therapist's office. The next iteration setup will utilize the Perception Neuron inertia-based motion capture system and the Oculus Rift with the space environment in a 3D platform.

Movement Tracking. Currently we are tracking the spatial location of player's arms with a Kinect camera but are working on tracking qualities of motion. The current gameplay reflects whether the player 'touches' a graphic component, however using movement qualities will make the game much more dynamic. 'Flick' gestures are quick, light and indirect, which we track by calculating whether the movement is fast and changes direction frequently. 'Float' gestures are sustained, light and indirect, which we track by calculating whether the movement is slow and changes direction frequently. 'Press' gestures are sustained, strong and direct, which we track by calculating whether the movement is slow and does not change direction frequently. The calculations are made by windowing the movement data in short durations of .25 seconds and comparing the similarity between data over each second.

Space Environment. In the photos of nebulas taken by telescopic satellites, colorful gas clouds form striking shapes that spark the imagination to associate them to objects like butterflies and horses. Because these clouds are invisible in reality, scientists assign colors to each element found in the clouds. Since they are initially a blank slate, assigning specific color palettes to artist created nebula clouds can give the image its own emotion and personality. We use Photoshop brushes based on forms found in photographs taken of space to create our own nebula images with varying emotional qualities. We used aspects of Kandinsky's color scale to design our own peaceful (Fig. 4) and energetic (Fig. 5) versions of space environments. Two dimensional images were created with many layers, which are extracted and made transparent. These images are

staged spatially within the game world so the player can 'fly' through the layers, simulating an experience of moving through the galaxy. Additional graphic elements can move through the space, creating the tasks for the player to achieve.

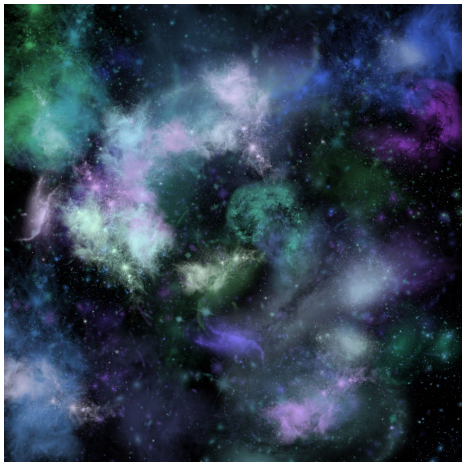

Fig. 4. Peaceful Galaxy

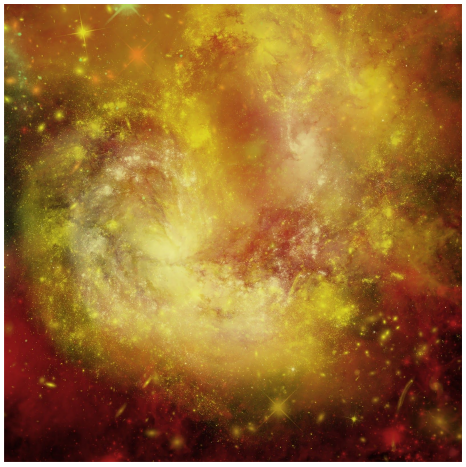

Fig. 5. Energetic Galaxy

Gameplay. *Supernova* challenges players to use the correct quality of movement as they complete specific tasks in space. Players are required to gather atmospheric energy from stars by using quick, light and indirect 'flick' gestures as they are flying through space. Sustained, light and indirect 'float' gestures are used to guide asteroids away. Sustained, strong and direct 'press' gestures are used to create Supernovas. Players navigate by moving their arms in particular spatial quadrants. Raised right arm moves forward and turns right, while a lowered left arm moves backward and turns right. To move forward the player extends arms away from the body. Future developments ideas include user scenarios such as popping bubbles, swinging on vines and bowling (see Figure 6). This experience of attending to movement quality in an interactive

game challenges patients to think differently about the way they move, and the level of control and responsibility they have to their own bodies in recovery.

Discussion and Conclusion

This paper has focused on illustrating the design challenges present when designing aesthetic and movement based games for physical therapy patients, and has presented our preliminary design for addressing these issues. While this is early stage work, we believe that an emphasis on color theory, high quality visual aesthetics and a quality of movement aesthetic will support an engaging participant experience. This preliminary presentation of research, design goals and prototype explorations provides a foundation to further work in the design and deployment of a game to support rehabilitation.

One of the goals we hope to accomplish is to make an engaging and entertaining immersive therapy experience in both a 2D and 3D virtual reality setting. This contribution will support research in patient's rehabilitation experiences and can further our understanding of what creates enchanting experiences. While we are at the beginning stages of this project we feel it is important to emphasize the challenges present in the domain of physical therapy games and movement practices.

Through our future research, we anticipate discovering that certain types of therapy could only work with one type of immersion. For instance, virtual reality might only work for pain relief or phobia treatment because patients with physical balance issues dealing with a complete immersive experience using a headset and hand equipment. In the same vein, an AR experience may not be successful for phobia and pain treatment because it not immersive enough. These

theoretical situations are only preliminary examples of problems we may face when making our environments.

For both of these experiences, the main objective is to implement gaming elements in an effort to make the exercises not only fun, but to illicit a competitive response from the user to do as best as possible during their current session and to strive to do better their next session. This would involve using a scoring system that rates the user's movements in real time comparing it to a perfect example of the exercise then adding their scores to the user's own personal scoreboard/hall of fame. Another gaming element that we will test is the addition of a non-playable character that can show the user how to do the exercise and compete along side of the user in both a coaching role and a competitive role. The preliminary results from a study done by Feltz, et al. (2014) showed a difference in the motivation of players using a virtual partner while working out in an exercise game, the difference might also transfer to the realm of therapy.

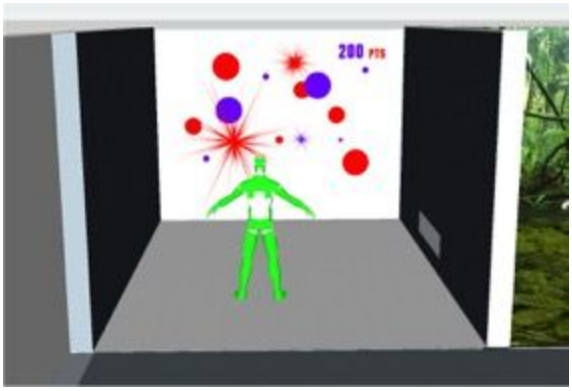

Figure 7. Simple Aesthetic Scenario

Figure 8. Complex aesthetic Example

We will also test the best aesthetic experiences for both types of reality in a therapy situation. Would it be best to use simple, but sophisticated graphics or complex,

multidimensional graphics for a particular therapy? Would just interacting with simple colors and shapes (fig.7) invoke less enthusiasm than interacting with detailed environments like a nebula (fig.8)? Would the more complex aesthetic be too overwhelming when compared to the simpler visuals? What part does color psychology play? Research done by Hoffman, Doctor, Patterson, Carrougher, and Furness (2000) on adolescent burn patients immersed in a virtual reality ice world showed that the subjects' pain levels decreased very significantly. We would like to know if concepts like using cool colors induce a sense of calm in the user or if warm colors make the user more energized are also true in an immersive environment.

This work will contribute new understandings of the impact of various aesthetic qualities on engagement and gameplay experiences. Future work includes expansion on the game design visuals and collaboration with a physical therapist to target specific movement exercises that will provide more detailed design goals.

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