

THESIS

DANCING THE TWO STEP: A PHENOMENOLOGICAL QUALITATIVE STUDY ON
STROKE SURVIVORS' EXPERIENCES USING AN AUGMENTED REALITY SYSTEM

Submitted by

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ABSTRACT

DANCING THE TWO STEP: A PHENOMENOLOGICAL QUALITATIVE STUDY ON STROKE SURVIVORS' EXPERIENCES USING AN AUGMENTED REALITY SYSTEM

Introduction: Having a stroke can be a very debilitating experience causing hemiparesis or hemiplegia. Often, when individuals are discharged home, therapeutic support decreases. This provides rehabilitation specialists with an opportunity to create an at-home, remotely-monitored therapeutic tool. Augmented reality (AR) provides a medium to meet this opportunity. The purpose of this study is to understand stroke survivors' overall experience using AR technology as a remotely-monitored, home-based therapy program, so that rehabilitation professionals can gain a clearer view of its impact and impression on survivors' day-to-day lives. *Methods:* This study incorporated a phenomenological qualitative approach, where two participants were trained on an AR system called Gator Games, and were interviewed three times over a month's time to ascertain their lived experiences using such a system. The interviews were transcribed, coded and analyzed. *Results:* The following themes were identified: (1) No time to be impaired, (2) Perseverance, (3) Hope: Still trying new therapies in hopes of getting better, and (4) Having a Primary Hobby: A way to see me improve and get better. These results were confirmed through triangulating analysts, peer debrief, and member checking. *Discussion:* Due to technological difficulties with Gator Games, the AR system was minimally part of the participants' daily lives, rather than being a large part of their lives. The focus of these individuals was more on their role as a family member, persevering through their symptoms and participating in a passionate hobby. *Conclusion:* There is a potential for this technology to be used as a remotely-monitored, at-home

therapeutic tool, however, for the games to be considered more engaging, they need to be customized according to participant feedback and potentially include more mentally stimulating games versus games that focus on physical capabilities.

ACKNOWLEDGEMENTS

First, I would like to thank the study participants for allowing me into their homes and sharing their lives with me. Second, I would like to thank Dr. Pat Sample for her continued support and guidance as my advisor and mentor. She has prepared me for success and without her, this study would not have come to fruition. Third, I would like to thank Dr. Matthew Malcolm for his ingenuity in providing me with an opportunity to pursue this project. I also would like to express gratitude toward Dr. Sudeep Pasricha and the Colorado State University Computer Science Engineering students assigned to this project for their dedication and hard work on the technological and brainstorming aspects. Finally, I owe immense gratitude to my family and good friend, Samantha Clement, for their unconditional support throughout this process.

DEDICATION

I dedicate this paper to Michael Paul, the Founder and Executive Director of On Target 4 Vets and to Dr. Elizabeth J.K. James, who have taught me what it truly means to overcome injury and who have been instrumental in my desire to continue working in neurorehabilitation.

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INTRODUCTION

Each year, 795,000 Americans experience a new or recurring, cerebral vascular accident (CVA) or stroke, and 137,000 people die as a result (American Heart Association, 2014). Strokes are the fourth leading cause of death in the United States. Having a stroke can be a debilitating experience, with approximately 80 percent of stroke survivors experiencing hemiparesis or hemiplegia (National Stroke Association, 2012). Twelve percent of stroke survivors regain full upper extremity function, however, 30-60% of those with hemiplegia, regain no function in the upper extremity (Kwakkel et al., 2008). Hemiparesis can result in an individual having difficulty in grasping objects, using fine motor coordination, and movement precision, as well increasing the individual's muscle fatigue (National Stroke Association, 2012). These difficulties can negatively impact an individual's ability to function in his or her life.

The point of rehabilitation is for an individual to regain as much prior function as possible and return to an independent lifestyle. Though there are numerous intervention options to combat hemiparesis and hemiplegia, a challenge for rehabilitation professionals is to provide remotely-monitored rehabilitative services at home (Loureiro et al., 2011). The need for remotely-monitored, home therapy programs has been established, however, the challenges to these programs include a therapist's availability for assistance when needed, cost-effective measures especially on a long-term basis, maintaining a client's motivation and compliance with the program, the client's ability to work a program, and additionally, having a home program that is therapeutically effective (Timmermans et al., 2009). Not only is motivating an individual to participate in a home therapy program an obstacle for a therapist to overcome, but so is monitoring his or her progress as well as keeping the cost affordable.

Without home programs, stroke survivors may see a decrease in the rate of recovery and ultimately a decrease in daily function because they no longer have the continued support they were receiving during inpatient and outpatient rehabilitation. In focusing on finding remotely-monitored, home-based therapeutic intervention options, virtual reality (VR) has become more commonly used for rehabilitation. For an individual, VR creates a simulated environment to move throughout, focusing on increasing motor function in an affected upper extremity (Alamri, Cha & Saddick, 2010). An alternative to VR is augmented reality (AR), which provides an opportunity for individuals to combine a virtual world with the real-life world (Furht, 2011). While both of these systems provide options for home-based therapy, AR is considered an emerging and promising technological choice over VR because AR is more cost-effective and exercises have the potential to be translated into an individual's daily life (Alamri, Cha & Saddick, 2010).

While new AR programs are being developed consistently for home use, the efficacy of these programs is still in question. The intent of each program is very clear, however, the translation of how these movements and motor function increases can apply to daily life is less clear. Even more, current literature indicates that in regards to these programs, individual perspectives are rarely considered in establishing efficacy. Understanding the individual experiences of stroke survivors using AR as a remotely-monitored, home-therapy method can provide clinicians and researchers with the most direct information about the success of the method. The more information collected about user experiences, the more AR systems can be perfected to achieve maximum efficacy and usage. To demonstrate the importance of this, I first will describe VR programs that have been designed for rehabilitation purpose and then will discuss AR options and their usefulness in post-stroke rehabilitation. I will highlight the purpose

of this study while reviewing existing research literature. Subsequently, I will outline the methods I used in this study as well as the strategies I used to encapsulate post-stroke survivors' experiences using AR technology as a remotely-monitored, home-based therapy program.

Virtual Reality

Virtual Reality (VR) is a computer-based system which is meant to simulate a realistic environment (Alamri et al., 2010). VR has been used for military training, entertainment purposes, medical training, and surgical applications, to increase spatial awareness and to assist with decreasing the impact of phobias (Merians et al., 2006) (see Figure 1). For instance, the military uses VR to simulate situations that may be experienced in reality, such as, flying a jet, putting out fires, or completing safety training (Strickland, n.d). More recently, VR has been used for therapeutic uses to offer an easier, more accessible form of rehabilitation. The need for VR as a rehabilitative tool came about due to the difficulty professionals have had in delivering therapeutic options that provide enough intensity to effect neural reorganization and functional outcomes. Virtual or computerized programs may offer a way to maximize time, which is valued by the client and practitioner. Due, however, to the complexity, necessary multiple technological components, and cost of these rehabilitation methods, some of the programs are offered only in outpatient rehabilitation facilities (Loueiro et al., 2011).

While some VR programs still are conducted in rehabilitation facilities, others have been attempted at home. Bach-y-Rita (2002) developed a home therapy program, named Palanco, for post-stroke individuals, which is designed to assist players to play the game pong, with a mechanized handle that provides feedback of vertical and horizontal movements made. Johnson and colleagues (2007), created a "Robot/Computer-Assisted Motivating Rehabilitation Suite" using a combination of various joysticks, wheels and software for stroke survivors to play

customized games and tasks during therapy sessions. Colombo et al. (2007), created a robotic device for the wrist, shoulder and elbow that allows individuals to complete simple tasks to increase user motivation. A commercial option also is available from *Hometelemed* that permits the opening and closing of the hand with use of a 2-channel cuff that provides feedback through a workstation that delivers tele-monitoring and tele-therapy (Gritsenko et al., 2004, Kowalczewski et al., 2007). Tele-monitoring allows a therapist to remotely monitor an individual's progress. All of these systems provide an option for individuals to continue therapy at home, however, it is still unclear to what degree individuals are able to generalize the benefits of VR therapy into their daily lives.

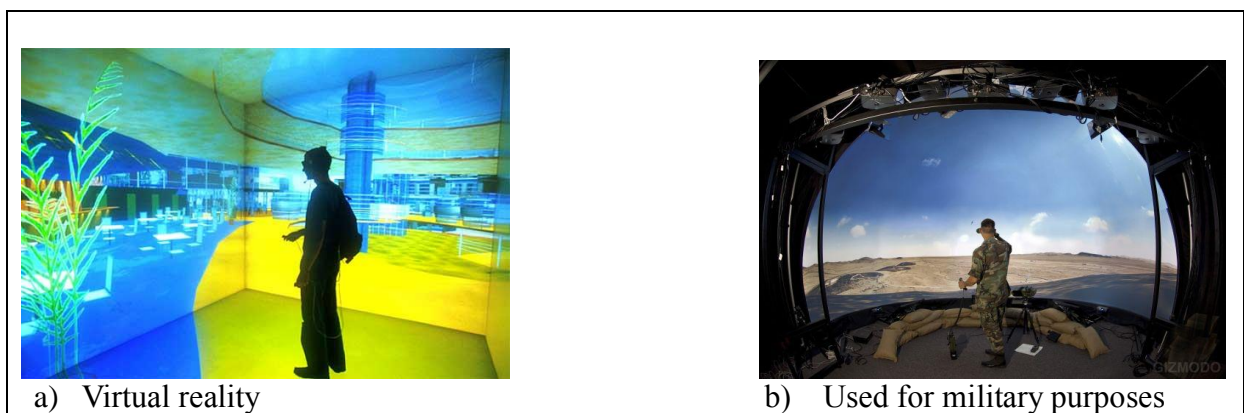


Figure 1. Virtual reality and its uses

Augmented Reality

In addition to virtual reality (VR) programs, augmented reality (AR) is emerging as an option for home therapy programs. AR combines a realistic physical environment with computer-generated technology or a computer-generated environment with real-life objects, creating a blended reality (Alamri et al., 2010, Furht, 2011). It is intended to increase an individual's interaction and ideas about the real world because the person can be using real-life objects to navigate a simulated world. AR also is intended to simplify an individual's experience,

by bringing the therapeutic information directly to him or her, and to the immediate environment. By doing so, the individual's experience becomes more applicable to daily life.

AR was originally developed in the 1950s by Morton Heilig who used these ideas to create a well-rounded sensory experience in a movie theatre (Furht, 2011). This meant that individuals could watch a film in a theatre with surround sound, while smelling certain fragrances, being tilted in their chairs, and thus be fully immersed in the experience. This initial use of AR encapsulated the goal of AR in blending a virtual world with a real-life. Though still an emerging area in rehabilitation, AR has been used in a variety of ways including for aircraft assembly, outdoor mobile games and video games. For example, AR glasses have been used to assist engineers in providing instructions for building fighter jets (George, 2015). The glasses provide a visualization of each part put together in real time to indicate that they are properly assembled. Additionally, AR has emerged as a therapeutic tool, specifically to assist an individual in motor function, and even to augment an individual's senses. For instance, if an individual experiences marked vision loss, AR technology can assist with increasing vision as a compensatory method by using a head mounted display (HMD) to provide larger images or labels for the images at which the individual is looking (Furht, 2011).

AR systems generally include a display mechanism, tracking device, computer and input mechanism (Furht, 2011). The displays can be used as headsets, handheld devices or can be spatial. When a headset is worn, an image is displayed in the individual's actual environment, giving the individual a see-through capability, and allowing the individual to move throughout his or her environment with full visual capacity. The handheld device takes video footage of an individual's actual environment allowing for graphic alterations to be made to the actual footage seen. Lastly, the spatial display allows for an image to be displayed into a real-life environment

without requiring a participant to wear a headset or use a handheld device. An example of this is use of a hologram. All of these mechanisms still can blend an aspect of a virtual component with an individual's real environment or a real object with a virtual environment.

Tracking devices allow for the tasks completed to be followed as well as provide alternative ways to track individuals using the device (Furht, 2011). For instance, GPS could log when and where an individual is using an AR system, if the system is meant to be used in multiple locations. Input mechanisms actually track what the individual is doing with the AR system. For instance, if the system uses a cyberglove™ or a wristband, these items are input devices that provide information specifically regarding how the individual is using the item. The final component to an AR system is having a computer available, either to compile all the information provided or actually to be used as a platform to provide the virtual aspect of the AR system.

AR systems may use similar components to VR systems, such as headsets or gloves, however, it is possible to use an AR system that is more affordable and the intent behind each method is different. Again, VR focuses on all interactions being of a simulated nature, whereas AR actually overlays a virtual object or component onto a real-life environment in real time or a real object onto a virtual environment (Alamri et al., 2010, Furht, 2011). These significant differences make AR a more useful tool to use because the therapy provided can be used within and throughout an individual's daily life. In the example of increasing visual cues due to vision loss, the individual is interacting with his or her actual environment, and thereby the AR system is being translated to daily life.

Most people have experienced or even used AR without necessarily realizing it. For instance, when watching a professional football game on the television, the "first down" yellow

marker is an example of something virtual being applied to a real-life environment. Using Google Maps to get directions, whether on a computer or on a mobile phone, provides a real map with a virtual route to follow (Corpuz, 2014). Scan bars have become more popular, where an individual can scan a code with his or her phone to bring up information about that particular product. New cars are designed with cameras in the back to assist with backing up or parking. The picture on the screen that the driver sees has a grid of yellow or green lines to indicate when the car is straight. If the car is near another object, the car beeps and the lines turn red to avoid collision. Newer cars also provide information of distances to other vehicles and can even track a driver's speed in relation to the posted speed limit of that road (see Figure 2).

These examples indicate how prevalent AR is becoming. To incorporate AR for therapeutic uses, Burke, McNeill, Charles, Morrow, Crosbie & McDonough (2010) describe three important aspects needed in any game design in order to optimize the user's experience, especially those who have survived a stroke. These include meaningful play, challenge and a way to handle failure. Meaningful play is important to ensure that the stroke survivor playing the game is conscious of his or her short-term and long-term goals, what is needed to reach those goals and whether or not he or she is meeting them. Providing a positive approach to an individual's failure also is essential to decrease that person's discouragement when playing, especially if the person does not perform as well as he or she desired. This is answered through maintaining encouragement and a reward system for all who participate in the system. Lastly, changing the level of challenge in the game is necessary to ensure a just right fit for the individual to match his or her current skill level and to also grade the challenge with the individual's changing skill. These strategies are intended to ensure a successful, positive and meaningful experience for the user.



a) First down line for a football game



b) Establishments in a specific area



c) Guiding lines for a vehicle reversing

Figure 2. Examples of augmented reality

PURPOSE

The purpose of this study was for me to understand stroke survivors' overall experience using augmented reality (AR) technology as a remotely-monitored, home-based therapy program, so that through my findings rehabilitation professionals can gain a clearer view of its impact and impression on survivors' day-to-day lives.

LITERATURE REVIEW

To date, research on post-stroke survivors' experience using technology as a remotely-monitored, home-based program, has tended to focus more on measuring improvements in motor function using virtual reality (VR) technology in a clinical setting, and less so on understanding the individual's experience. Without understanding the experience of participants, the therapeutic intervention's success has relied on scores and measurements. For professionals to understand how the techniques and outcomes of therapeutic intervention are perceived by individuals, it is recognized that professionals need to learn about the personally lived experiences of those who are participating in the intervention. If intervention specialists determine that an intervention "works," based simply on changes in the quantitative outcome measurements used, without understanding the users' experience with the intervention, there is likelihood that the individuals may not use the intervention on a long-term basis. Rehabilitation professionals need to determine whether clients perceive changes in their life as a result of the intervention and need to thoroughly understand what introducing such interventions into their clients' lives can mean to them (Creswell, 2013).

Celinder and Peoples (2012) monitored progress of stroke survivors using Wii Sports® as a therapeutic intervention to increase motor function in the participants' affected arm. The researchers conducted semi-structured interviews in a hospital setting to capture the participants' experience using the Wii as a therapeutic tool. The results indicated that overall, participants enjoyed using the Wii for therapeutic uses. Participants were engaged in the games they were playing, had conversations with others about their enjoyment using the Wii, and though some participants did express frustration with needing to quickly react during the games, this did not

prevent them from continuing to use the program. While there were positive results, the Wii therapy was conducted in a hospital setting and the interviews were conducted in an undisturbed room in the hospital, decreasing the ecological validity and value of the personal experience because the therapy was not provided in a natural environment.

Previously, Merians, Poizner, Boian, Burdea, and Adamovich (2006) hypothesized that VR as a therapeutic tool can provide a challenging, interactive and encouraging environment for a client to practice tasks continually and repetitively as well as provide feedback that is not only rewarding but also guiding in nature. While physical measurements were still logged through VR measures and the Jebsen Test of Hand Function (Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969), this study focused more on the perception of the participants. Pretest and post-test questionnaires were used to assess the individual's perception of current hand function, expectations of therapy and the perceptions and satisfaction in the therapeutic results. Overall, participants showed physical improvements in hand function and movement. Participants' scores tended to be positive overall, though they reported increased fatigue with the therapy. In spite of the fatigue issues, all participants continued with the system and felt encouraged with their physical improvements. The therapy was conducted in a clinical setting and while the questionnaires assessed perceptions of the participants, they did not provide any opportunity for the participants to expand on their written perceptions and estimation of satisfaction.

Crosbie, Lennon, McGoldrick, McNeill, and McDonough (2012) conducted a randomized, controlled pilot study to compare the effectiveness of VR therapy to conventional physical therapy for post-stroke arm rehabilitation, with the goal of increasing motor function. The therapy included a desktop computer, a head-mounted display unit, a motion tracking system and sensors. An exit questionnaire also was used to evaluate participant perceptions of and

satisfaction with the intervention methods provided. Though there was no significant difference between the two groups compared, both groups did show an increase via the Motricity Index (Collin & Wade, 1990). Questionnaires indicated that participants felt they could complete tasks they had not been able to prior to their increased motor abilities. In essence, the study found that using VR as a therapeutic tool in this manner, though unable to produce statistically significant improvements, is feasible and the exit questionnaires indicated that participants perceived improvements in their upper extremity motor function. Though the Crosbie et al. (2012) study attempted to look at both the measurements of improved motor function and the perceptions of those participating, the exit questionnaire did not provide an opportunity for participants to write down their personal opinions and perspectives about the intervention, and was the only non-psychometric data gathered in this study.

In this sample of research articles there are three main issues not addressed which require further study. The first is the lack of interventions that use a home-based therapeutic intervention approach. These VR interventions have been offered only in clinical settings. Second, subjective “tools” typically included questionnaires, which also yielded descriptive statistics and demographic information. These types of scales seldom provide an opportunity for participants to expand on their opinions and give a well-rounded perspective on their experiences and their overall satisfaction with the interventions. Third, most of these intervention studies have focused on VR as the intervention rather than looking at augmented reality (AR). AR provides an opportunity to combine a virtual environment with real-world objects or virtual objects in a real-world environment (Alamri et al., 2010). Because these issues have not been addressed in current research literature, there came an opportunity for me to study *with* participants, who were learning and using a remotely-monitored, home-based therapy, AR system. By conducting a

series of in-home interviews, I obtained an understanding of the participants' lived experiences and perceptions, thereby obtaining information about what may be most important to, and most preferred by individuals when professionals design an AR-based, remotely-monitored, at-home therapeutic system for them.

METHODS

Study Approach

This study's approach was phenomenological in its intent. This approach was chosen because the goal of my research was to come to understand the participants' lived experience of a particular phenomenon (Creswell, 2013), (in this case, survivors of stroke who were learning and using an augmented reality (AR) system for in-home, remotely-monitored rehabilitation. To date, AR in-home rehabilitation systems have not been studied using this particular qualitative research approach.

Positioning

I chose to study the experience of individuals who were post-stroke, and were using a remotely-monitored home-based AR technology therapeutic intervention for two main reasons: (1) I was intrigued by the implications of having a low-cost, remotely-monitored, home-based therapy option for individuals with an affected upper extremity; and (2) I thought it was essential to understand an individual's experience when co-establishing occupational therapy outcomes. A therapeutic intervention may be considered successful statistically using chosen measurement tools. If, however, the participants did not consider the intervention to be successful and/or if they had negative impressions of the intervention, then overall, the intervention truly cannot be considered successful. The voice and perceptions of the actual users of this intervention needed to be heard.

I was able to participate in the protocol planning, design, implementation and improvement meetings of Gator Games for the purpose of creating the best possible AR system. The potential for this type of system and seeing how it was incorporated into the participants'

daily lives were what piqued my interest most. As my research continued, I found that the intervention played a minimal role in the participants' daily lives contrary to my initial expectation of it playing a larger part. Though my initial expectation was not met, I was surprised and excited by the wealth of information I did uncover in my interviews.

Participants

Inclusion Criteria

Participants were included if they met the following criteria: (1) must be more than 18 years of age; (2) must be more than one month post-stroke; (3) must have a decrease in motor ability in one upper extremity; (4) must be able voluntarily to move the affected upper extremity onto a table and slide the arm on a mat to perform the required movements for the AR system; (5) must have a Mini-Mental Status Exam (Folstein, Folstein & McHugh, 1975) score of more than 24; and (6) must be able to tolerate two 30 minute sessions of therapy each day for five days.

Exclusion Criteria

Participants were excluded if any of the following concerns were present: (1) they were experiencing an additional neurological disease or injury; (2) they had a musculoskeletal injury or disease affecting the mobility of the affected upper extremity; and (3) they had a visual impairment preventing clear sight of objects, as well as the computer screen being used in this intervention.

Sample

A convenience sample of participants was recruited using an established list of individuals who participated in previous post-stroke rehabilitation studies conducted at Colorado State University (CSU). A flyer was posted on the website of the CSU Integrative Rehabilitation

Laboratory (IRL) website. The goal was to recruit a minimum of 20 potential participants, with the hope of succeeding in enrolling five individuals, including both women and men, who would meet the inclusion criteria and be able to participate in using the AR system as a remotely-monitored, home-based, therapeutic intervention approach. Due, however, to unforeseen and continued technical difficulties with the AR system, the overall project which included several other substudies, changed venue from the participants' homes to the CSU IRL. These technological difficulties included the games not loading properly, games starting and stopping in the middle of a session, inversion of the playing so a movement to the right was a movement to the left on the screen, and delayed game play due to the Leap Motion Controller© not recognizing the participant's arm. The outcome for my study was that only two male participants were able to participate prior to relocation of the AR intervention from people's home to the CSU IRL. Continuing with the system at the CSU IRL, would have challenged the ecological validity of this particular portion of the study because using the system in a laboratory would not provide similar circumstances to what the participants would be experiencing at home. Therefore, it would have become almost impossible for me to study how the experiences using Gator Games could be translated to the daily lives of the participants, if at all. Since, the AR system was still to be used in the home for the first two of the participants, I decided to restrict my data collection to those two men. Both men had survived a stroke, experienced decreased motor ability in an upper extremity, and were in the chronic stage of recovery.

The participants provided written consent to be interviewed about their experiences using the AR system. A copy of the signed consent form was provided to them. The men also filled out a Health History Questionnaire (see Appendix A), and provided physician information. Project staff informed each participant's physician of his participation in this type of study.

Institutional Review Board Statement

This study was approved by the Human Research Committee of Colorado State University, and all potential participants were informed fully about the research study, including all content necessary for potential participants to consider before giving informed consent (see Appendix B). Following the individuals' time to study the informed consent form, and following an opportunity for the individuals to have their questions answered by the researchers, we obtained written consent, in preparation for the intervention and data collection with the two study participants.

Procedures

Home Set-up

Each participant needed access to the internet and was provided a laptop (computer), Leap Motion Controller© (input and tracker) and stand, and mat (spatial display) to monitor movements of the affected arm (see Figure 3) (Furht, 2011). The mat provided ease of movement for the affected arm and the Leap Motion Controller© tracked the arm movements to record progress. Prior to the system being set up in each participant's homes, they first were trained on the system at the CSU IRL. Participants needed to demonstrate competency in using the system before it was set up in the home. The two men first were verbally instructed by me and another researcher on how to set up the laptop and Leap Motion Controller©, while I was available by phone or email for additional questions and concerns. Then they were verbally instructed on setting up a login and password to access Gator Games. After they successfully logged into the program, the men were "talked" through each game, ensuring that they were accessing all the games and were able to ask me questions, if needed. Due to technical difficulties with the system, one participant was unable to fully be oriented to the system at the CSU IRL. Therefore,

he was provided the same instructions and completed the orientation in his home, with my assistance and guidance.



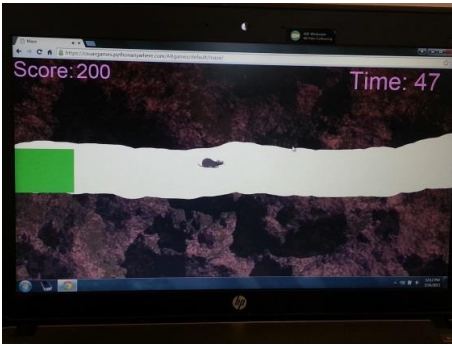
Figure 3. Gator Games setup

Each system was set up in the individual's home for use. One participant set up the system in his office and the other on a counter in his kitchen. I was available and present with one of the participants when he was setting up the system. I let him initiate the set up and was available if he had any questions, which he did not. The second participant had support from another researcher when setting up the system in his home. The other researcher played the same role as I did in being available for any questions, while the participant independently set up the system. After the system was set up, each participant accessed the games, and then began independent playing. Each of the six games included in Gator Games was to be played for one

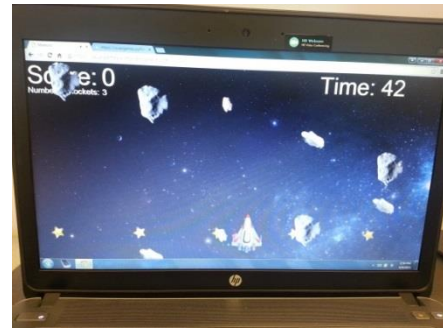
minute intervals, five times each, totaling thirty minutes of play time in each session. The participants were to participate in the games twice a day for thirty minutes each, for five consecutive days. Both participants were provided a tracking sheet for each day he had the system, with each game listed and the amount of time each game was to be played (see Appendix C).

Augmented Reality System

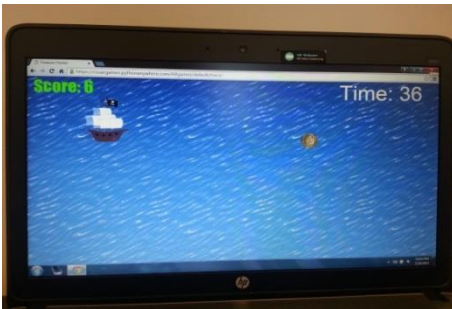
Gator Games included an internet-based system of six games: Maze, Meteors, Pirates Cove, Water Drops, Whack-A-Mole, and Dolphin Run (see Figure 4). These games were accessed through the CSU AR Games dashboard, available through the internet. All six games required visual scanning of the laptop screen as well as various arm movements to successfully navigate each game's obstacle. The second researcher and I adjusted each game's difficulty level through speed, sensitivity and time permitted, in order for the complexity of the task to match each individual's pre-determined ability. The results of each game were tabulated and provided instantly to the participant in a graph format showing the score and progress throughout that specific trial. Results also were provided to us so we could monitor the individual's progress, and make any necessary adjustments, based on the individual's initial progress. Additionally, we set goals for the participants: how many games, which games to be played, for how long each game should be played each day, and at what level of difficulty. These goals were adjusted throughout the intervention time depending on the participants' performance.



a) Maze



b) Asteroids



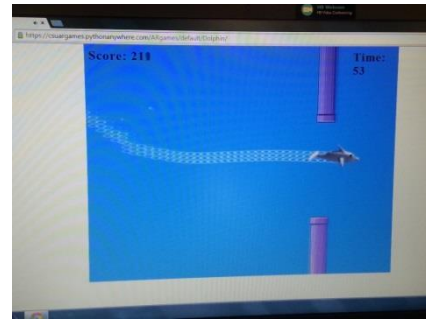
c) Pirate's Cove



d) Water Drops



e) Whack-A-Mole



f) Dolphin Run

Figure 4. Individual Gator Games

Intervention

Study participants used the Gator Games program for 60 minutes each day in two 30 minute sessions, with at least a 15 minute break between the sessions. Gator Games was used Monday through Friday, for a five day period. Each participant was called, by me or the other researcher, once during the week while they were using Gator Games, to see if there were further adjustments needed, and to identify if there were any problems with the system. Participants also

had the CSU IRL phone number and could call at any time to leave a message, which would be returned within a 24 hour period. At the end of the five days, I picked up the system from each participant to return to the CSU IRL after conducting their second interview.

Data Collection

For this study, I collected two forms of data: a series of audio-recorded interviews with each participant, and my reflexive notes written throughout the intervention process. Each individual was interviewed three times throughout the intervention. The first interview was conducted the week prior to the first day of the intervention. The second interview was completed on day five, which was the final day of the intervention. The final interview was conducted one month after the end of the intervention. One participant was scheduled to have major surgery by week four, and subsequently, his third interview was conducted only three weeks after the second interview. The interviews were conducted in each individual's home, in order to provide the most comfortable environment for each individual in which to share his experiences as a stroke survivor using AR technology. Interviews were kept to a maximum of 60 minutes to prevent increased fatigue or re-traumatization. Interviews were recorded with an audio recorder, and all recorded interviews were stored in password-guarded digital files for the duration of the project, and the recordings were given coded labels, rather than using the names of the participants. The six audio recordings will remain stored in password-guarded digital files for three years, and then subsequently will be erased. Each interview broadly addressed the following topic areas:

- 1) What has been your overall life experience?
- 2) Tell me how you go through your days now, since your stroke?
- 3) What has been your experience: in using technology in rehabilitation? And, using it in your home?

The first interview focused primarily on topics #1 and #2 above. I did not collect information on topic #3 in the first interview. For the second and third interviews, I added questions to topics #1 and #2 that built upon and clarified information from the first interview, and then focused more intently on information from topic #3. In the final interview, I began with questions about topics #1 and #2, which sought to learn of changes that may have occurred in the participants' lives, since the beginning of the intervention. These questions were broader than typical evaluation questions, and allowed the participants to bring up any information on how their lives were impacted currently and how using the AR system affected their lives, if at all.

More focused questions and probes to clarify the original questions or to assist the participant in talking more deeply on each topic were introduced and are listed below (Creswell, 2013). These questions and probes are a selection, used only, in the first interview with each participant, and do not constitute an exhaustive list of all questions that I asked. I added probing statements to encourage more thorough and detailed answers from the participants, as I completed the series of interviews.

Topic #1: Overall life experience until now:

- "Tell me about yourself and your story."

Questions/Probes: Birth, life locations, education, job training (if any), employment, marriage, children, health (ending with the stroke and outcomes from it)

Topic #2: Typical day for the person:

- "What is a typical day like for you?"

Questions/Probes: What do you enjoy doing during the day?
Is there anything you have difficulty doing throughout your day?
What tasks do you need/want to do each day?
What are some activities that you had to give up after your stroke?

Topic #3: Experiences of using the AR system:

- Why did you volunteer to participate in this study, with the AR system?

Questions/Probes: How would you, if at all, incorporate a system like this into your daily routine?

What would be your plans for using the AR system each day, in the future?
Would you use this system on a long-term basis?

The second form of data I collected during the course of this study were my reflexive notes. These notes included my experiences with the intervention process, and my interactions with the participants (Creswell, 2013). This process was meant to keep me on task and unbiased when interviewing the participants. Important analytic ideas concerning thematic codes, categories, and potential themes additionally were written into my notes, as they came to me. I also used my reflexive notes to identify how the interviews and study process were influencing me in my personal life, and as an occupational therapy professional.

Data Analysis

Using a qualitative, phenomenological approach, I transcribed and analyzed each interview for common themes across the series of interviews, across the individuals' descriptions of using Gator Games, and within the study. These themes provided insight to each individual's experience as a stroke survivor using AR technology, a remotely-monitored home-based therapeutic intervention. Word/phrase topical coding was completed through the analysis of each transcription. The coded topical data were analyzed across each participant to determine if there were any similar categories of perceptions and experiences. These categories were organized and combined into thematic statements that came from all of the data, and that addressed the original purpose and goal of this study. Then, in one final level of analysis, I reviewed my reflexive journal entries to ascertain if the themes were a result of participants' statements, assembled through my rigorous, inquiry-based, on-going thought process, and not through a set of assumptions and biases, which I had created unconsciously.

As mentioned above, I maintained a reflexive journal to relay my experiences and perceptions about the study, throughout the intervention, data collection, and data analysis process. These journal data were used for bracketing purposes to identify any personal biases or assumptions I had, and then determined how to minimize subjectivity and prevent personal biases from interfering with future interviews and the data analysis process.

Additional research rigor in this phenomenological study was addressed using the following strategies. First, I maintained the above-mentioned reflexive journal, in order to monitor my own thoughts and feelings as the study progressed. Second, in order to ensure that the themes were clear, relevant, and appropriate, the transcriptions were analyzed using a triangulating coder, my thesis advisor, who has been teaching, conducting, and publishing qualitative research for 25 years. Third, once the results were identified, a peer review process was completed by another OT-MS student, who also has been involved in both course and thesis efforts using the qualitative paradigm, and who had been trained in her analysis approach in a fashion similar to mine (Creswell, 2013). Fourth, member checking occurred, once the results were identified, to ensure that the findings I prepared and presented matched what the participants believed they had been communicating to me. As a result of my member checking activity with each of the two participants, I received specific clarification from them and adjusted wording, definition, and examples, accordingly, for the theme *Perseverance*, and the sub-theme of *Internet or Computer-based Games* under the theme *Hope: Still trying new therapies in hopes of getting better*. My final contribution of the learnings from this phenomenological study is found below in the Discussion section, in which I present my perspective on the general problems of the participants together and individually as they began the intervention process, and

also presented my perspectives on the AR system intervention experience, and what kind of impact it did, or did not seem to make on the participants.

RESULTS

Though the expectation was that the augmented reality (AR) technology would play a large part in each participant's life, at least during the five days in which they piloted it, due to continued technological difficulties with Gator Games, the intervention only minimally influenced their daily lives. This study was impacted very early when the technological difficulties resulted in only two participants having the opportunity to take part in the home-based piloting of the AR system. Both participants were Caucasian males who are married and retired, living close to family. Participant number One (P1) was originally from Great Britain, and had a long career as a cargo pilot and engineer. He still flies when he is assessing planes that are for sale, for a friend of his, who has interest in buying a plane. He does not fly very often, but would like to fly more. He has lived in northern Colorado since 2007. He has four children; two are close by in Colorado, one on the west coast and one in Central America. The rest of his extended family is scattered throughout the world, mainly in England, Australia, and Canada. P1 had a left-sided cerebral vascular accident (CVA) in 2008 affecting his right side.

Participant number Two (P2), originally from Wyoming, has been based in rural northern Colorado, focusing on the family farming business. He was a teacher for over thirty years and transitioned to farming more recently. He has a passion for gardening and is proud of his produce. His two sons live nearby and took over the farming business once P2 sustained a right CVA in 2009, affecting his left side. He takes care of his three grandsons on a daily basis. His extended family still resides in Wyoming, where he and his wife have an additional family home that they are renovating, slowly.

As was stipulated in this study’s protocol, two participants were interviewed three times each. Each interview was transcribed (resulting in 132 single-spaced, typed pages), and then analyzed, using the process described above in the Methods section. Upon completing transcription analysis, four themes and subsequent sub-themes were identified (see Table 1). As mentioned above, the primary topics addressed in the interviews for this study were:

- 1) What has been your overall life experience?
- 2) Tell me how you go through your day now?
- 3) What has been your experience using technology in rehabilitation?

To answer these questions, descriptions of each theme and sub-theme are provided below:

Table 1. List of Themes and Sub-Themes for P1 and P2.

Themes and Sub-Themes for P1 and P2
*No Time to Be Impaired Role as a Family Member Role as a Caregiver
*Perseverance
*Hope: Still trying new therapies in hopes of getting better Traditional and Alternative Therapies Internet or Computer Games
*Having a Primary Hobby: A way to see me improve and get better

Theme 1: No Time to Be Impaired

Both participants in this study are very involved in their family’s lives and offer support to other family members, which follows that the two men find no time to be impaired or to let their impairments affect their daily routines. Each participant’s daily routines revolve around supporting family members. P1’s daily routine includes completing projects around his house or for his children. He explained, “Well, I do most, ya know, all sort of fix it type projects. So...I tend to do things myself. And, there always seems to be plenty to do” (P1.Int.1. p 9).

Additionally, P2 mentioned, “Mm, well, ya know, I, I do, I shop for groceries, cook the meals, do the laundry and clean the house, that kind of stuff. And I work in the shop” (P2.Int.2.p 6). In their daily lives and while supporting their families, the participants did not rely on others for

assistance. P2 explained, “Well, ya know, you can’t turn around every five minutes and ask. Pretty soon, you get to, the, the, you’re not functional anymore. You’re just a pain in the butt. So you have to decide where that is” (P2.Int.1.p 27). Daily life continues regardless of the impairment experienced by these participants.

Sub-theme: Role as a Family Member

A sub-theme to having no time to be impaired is the importance of the role of being a family member. P1 explained how he and his wife watch their school-aged grandchildren a few afternoons a week while their daughter finishes her workday. “My wife picks up the kids, most, two days a week? Or two or three days a week and from [school], which is way over on the other side of town” (P1.Int.2.p 10). P1 and his wife provide support for their daughter while she works, which allows them to have additional time with their grandchildren.

P2 also demonstrated his commitment to his family members. He handed the family business down his two sons when he experienced his stroke and now plays a supportive role for his sons while they run the business. In describing his day, he said,

“Oh, I get up about between 4AM and 6AM...the kids come at around eight. We feed them breakfast and then they watch a show and the little one goes to bed....so like right now, I’m cooking stroganoff and doing laundry...uh we have eight cows...three lamas, rabbits...chickens, ducks, dogs, cats. They all have to be fed and watered everyday...Ya know, shop and you cook dinner and you fix lunch for the kids. They’ve been coming out here for about five years everyday” (P2.Int.1.p 15-16).

P2’s day revolves around maintaining the household so his wife and sons can work and not be concerned about housework when they get home.

Sub-theme: Role as a Caregiver

Another sub-theme to having not time to be impaired is the importance these participants feel in their role as a caregiver. Both support their families in various ways and often put their

family's needs above their own. P1 assists his son, who has paraplegia, as well as watches his grandchildren in the afternoon twice a week. He explained,

“Ah, usually I go to the gym twice a week. I didn't go Tuesday because I went down to...help my son with his wheelchair, so...He was having trouble with, with um, those little, tiny thorns...He had a thorn-proof tube but it managed to puncture that one. So, and then, he patched it, and it didn't stay up, it went down again, so I said I'd come down. And, I brought a tube with me but it wasn't a thorn-proof...I, I keep supplies for his wheelchair” (P1.Int.2.p 1).

P1 also installed hand controls in a vehicle so his son can drive it when he visits; he patches tubes to ensure that his son has supplies for his wheelchair; and will offer additional transportation if his son cannot travel via public transportation.

P2 also is a caregiver on a daily basis, not only for his grandchildren, especially the two younger ones who are not school-aged, but also for the animals he has on his property. He and his family see the animals more as pets than livestock. In regards to his cows, P2 mentioned, “Ya know, when they give them names you can't do anything else with them... You do just silly things uh, with your pets that you wouldn't do with a herd of cows” (P2.Int.2.p 3). P2 and his grandson were even going back and forth in deciding what name to give a new calf- Frostbite, Sirloin or T-bone (P2.Int.2.p 3). He also talked about the extent to which he and his family care for their animals, especially the cows.

“Ya know, we spent uh, two days with that little guy on the floor out in the laundry room and it croaked...So people that live on ranches, ya know, if it's (the cow) around, it's around and if it's not, it's just not around. Uh, ya know, they wouldn't go to the trouble... They would have just left it” (P2.Int3.p 2).

P2 cares for their cows, llamas, ducks, rabbits, dogs, cats and even the Orioles that return every year to their house in the spring.

Theme 2: Perseverance

A second theme that developed focused on perseverance and the self-determination each participant demonstrated to be available as a support to their family members. Without perseverance each participant would not be successful in providing support and overcoming symptoms from their strokes was something both men automatically did. P1's physical symptoms post-stroke include a constant tightness on the right side of his body from his shoulder down to his ankle and a blind spot on the right side. In regards to the tightness, P1 described it saying, "It's pretty consistent. Yeah, it's there all the time. But, uh, it's something I can override. I can use my arm. It just takes a bit more effort to really straighten it" (P1.Int.1.p 7). Overriding the tightness has become part of his daily life. P1 also expressed that his blind spot does not interfere with his day to day life and he usually functions as though it did not exist.

"I've never come across anything I can think of where I didn't see something because it was in the, in the blind spot...But, I tend to sort of scan, which is something that ya know, they always teach you as a pilot. You should always scan the sky, looking for other airplanes. Don't just look straight ahead because you'll miss things that are out there" (P1.Int.1.p 12, 17).

P1 compensates for his physical limitations by persevering and pushing through the symptoms to maintain a functional level that permits him to participate successfully in his day to day activities and be available to assist his family.

P2 demonstrates the same focus in overcoming his physical symptoms to maintain his daily functional status and not become a liability to his family members.

"Alright, so I'm going to go out there and weed the garden. I couldn't even get off the patio. How do you get to the garden? I couldn't walk...Well, ya know, if you're on cement, everything's fine. But if you're on the lawn...bumps and humps and divets and uh ya know a little downhill. Uh, so I ended up crawling to the garden...Yeah, so, ya know, the next year I could walk. I walked to the garden...Well, ya know, it's taken five years to get that going. So, ya know, you don't look at it like, "Well, did I solve the problem today?" You just see what the problem is and you take it back to the drawing board, and say, "What can I do about it?" (P2.Int.1.p 26-27).

P2's perseverance is what enabled him to be successful in gardening and improving in participating in his day to day activities. He remarked that,

“...you just have to figure out something out on your own, you make the best out of whatever you can. You just, you don't worry about how you got there you just worry about the results. Well, uh, ya know, I know this sounds simplistic, but...for a year it was an objective of mine to get from point A to point B with a cup of coffee, without spilling it all over the floor...Well, when you finally get it, ya felt like you really accomplished something. But it only took 300 or 400 cups of coffee” (P2.Int.2.p 16).

The willingness to continue trying and focusing on the end result is what made P2 persevere and in the end successfully accomplish his personal goals and gain back some of his prior abilities.

Pushing through his symptoms is how he prevents himself from becoming a liability to his family. “Ya know, life's a challenge. It is. Uh, you make out of it, the, the best you can. And ya, ya have good times and then you have bad. Well, you just have to keep in mind which is which” (P2.Int.3.p 11).

Theme 3: Hope: Still trying new therapies in hopes of getting better

Both participants were open to different strategies or tools that might assist them with their symptoms. Their experiences with the different types of therapies were varied, however, the end result was that both continued to be open to new possible therapeutic options.

Traditional and Alternative Therapies

For P1, he has not had any success in trying various therapeutic tools to relieve the tightness in his right side. He explained, “Yes, I, I've been to yoga classes. I even went, had acupuncture. I've been to about three different physiotherapists who thought they could maybe do something. But uh, nothing has made any real difference” (P1.Int.2.p 2). Though P1 has not experienced success in trying these different tools, he does say that “anything is worth trying. If,

if it can get, improve it or somehow or something has got to tell the brain to not kill that signal or whatever it is that is saying contract all the muscles on the right side” (P1.Int.2.p 2).

P2 shared the same sentiment in stating that “anything you can be involved in is gonna benefit you” (P.2.Int.2.p 22). P2 kept an open mind and found that he was successful when trusting the professional working with him during his rehabilitation.

“So your right foot would step over your left and then next thing you know you’re going 90 degrees in the other direction. Well, you’re not ready for that. And BANG! Down you go...So, she (his physical therapist), she started teaching me how to do the country two-step...So, it was as shuffle...And ya know, she said when you doubt uh, your perception remember you know what you know. What it is, is what it is. It’s what it always was and what it always will be...She said the ground is there. The ground has always been there. It’s always going to be there. Put your foot down” (P2.Int.1.p 12-13).

Being open to different strategies and tools is what helped P2 be successful in his progress.

Sub-theme: Internet or Computer Games

Both participants described their experience using Gator Games along with additional internet-based brain games. P1 completes crossword puzzles every day with his wife. He also uses *Lumosity*, an internet-based site with puzzles and games designed for brain training (Lumosity, n.d.). It is recommended to participate in the games or puzzles three times a week. Once signed up to be part of *Lumosity*, daily puzzles and games are sent to participants and these activities will be graded according to the last performance.

“I try to do that three times a week is what they recommended as a minimum, ya know...And it’s quite fun to do, ya know. I found *Lumosity* actually more fun than your program. Yours is a bit more frustrating. Well, mainly because sometimes it didn’t respond, right. With this one, with *Lumosity*, you’re moving the mouse...Whereas using your arm, it, it feels like, ya know, that you’re attached to the moving object, whatever it’s the mouse or meteor, I mean the spaceship and so on but it feels like you’re attached with an elastic band almost. It doesn’t seem to react the same way as your arm moves, ya know” (P1.Int.2.p 19).

P1 explained that using *Lumosity* helps his concentration and he hopes his memory. He also responded that if the Gator Games were more fluid and his arm movements corresponded better

to what was happening on the screen that they would be “pretty good” (P.1.Int.2.p 20).

Currently, though, Gator Games were not providing enough positive feedback.

“It seemed like it wasn’t positive enough, ya know, it was too fluid. Ya know, it was and, and, again, you don’t know quite, what is it (the Leap Motion Controller©) looking at? The whole arm? Or just the hand? Is it just one spot that is right underneath the sensor that it’s actually looking at” (P1.Int.2.p 20)?

P1 expressed that the system focusing on his physical capabilities was not as enjoyable. If, however, the games focused more on his memory and mental capacities, he might have continued interest in them. He also needed additional information on how exactly Gator Games was functioning in order to understand what was expected of him, in addition to just playing the individual games. He wanted to ensure, as well, that he was playing the games correctly and accurately and that the scores he was receiving were truly what he had earned.

P2 also mentioned playing other games on the internet. He enjoys doing brain fitness and in regards to Gator Games, he believed that “You should do it...This is great eye-hand coordination. It really is” (P.2.Int.2.p 15). Though he believed the system had potential, P2 also expressed having difficulties with the system. “So the games would not start...I found all of the three games that, off and on it works, and it didn’t, didn’t work” (P.2.Int.2.p 8, 10). The difficulty with the technology prevented P2 from being able to completely engage in the games.

Additionally, he found that some of the games were not challenging enough for his performance. In regards to Meteors, he mentioned, “So, I think this game would be a lot more challenging if the stars were random” (P2.Int.2.p 12). P2 demonstrated arm movements, in multiple directions, that would be more challenging for him if repeated over a period of time, rather than continually moving back and forth in one plane. More complex movements would increase his experience in using Gator Games. Even with these challenges, P2 was positive that if the issues were fixed, he would be interested in using the system on a long term basis. He said,

“Oh, they’re great. They really are. They’re (the games are) good...It would, it would work well” (P2.Int.2.p 15). In spite of the varied experiences with different therapeutic options, both participants remained open to trying new therapeutic tools.

Theme 4: Having a Primary Hobby: A way to see me improve and get better

Both participants mentioned multiple times having one primary hobby that they enjoy and about which they are passionate. These hobbies provide an opportunity for both participants to see progress in their participation and how far they have come since their original injuries. Both men mentioned that when they are engaged in their hobbies, they are less likely to notice their physical symptoms.

P1 described how much he enjoys flying and how much he identifies with being a pilot. His face lights up and he smiles as he tells stories about flying. He was a pilot for many years and now meets with a group to discuss building planes and reminiscing about their flight careers. He explained, “Yeah, I enjoy it. Ya know, I like flying...ya know, I don’t even notice anything different when I’m flying” (P1.Int.1.p 10, 12). He mentioned that when he’s concentrating on something else, he does not find his right-sided tightness a problem. He used to fly for *Wings of Hope*, an organization that assisted hospitals or brought supplies to areas that were in need.

“They basically, just anywhere where there’s a need, a humanitarian need for an aircraft or an airplane, they’ll station an airplane with a pilot and whatever and ya know...For quite a few years, they (*Wings of Hope*) provided an airplane (in Belize), and ya know, for the hospital...But uh, yeah it was kind of fun” (P1.Int.3.p 11).

P1 does not fly as regularly as he used to, though a friend of his wants the two of them to buy a plane together. P1 will travel with his friend to look at and fly various planes that are for sale.

“This guy had this little airplane. He had a grass strip in his backyard, ya know, in his ranch or farm or whatever had out there so I got to fly with him. And uh, just flew around for a bit”

(P1.Int.3.p 5). Other than these opportunities, he does not fly as often as he would like to. He, however, does mention that he would like to get back into flying since he can rent planes for various periods of time.

For P2, gardening is a hobby that was discussed throughout each of the interviews. When asked if there was something that P2 had hoped to return to that he enjoyed and he responded about his garden. He has a pantry full of jarred fruits and vegetables from his garden as well as gallons of apple juice. He and his wife have 14 apple trees and after pressing 126 gallons of apples, they had three, 42 gallon barrels of apple juice (P2.Int3.P. 5). P2 also discussed preparing his produce by saying, “Uh, when you harvest squash or pumpkins or anything like that, watermelons. You lay them out in the sun for about five days and then you take them somewhere where it’s cool...They’ll keep for 10 or 12 months” (P2.Int.3.p 5). Though maintaining his garden is very labor intensive, P2 is enthusiastic about what his produce.

Since his stroke, it has been a process for P2 to get back to his garden. “Uh, so on a Sunday, I went out there. I’m going to dig a hole and stick this tree in the ground. I tried, go uh, ya know, like when you have no proprioception, tried to dig with a shovel...Now, I go out there, five years later and I dig in the garden everyday” (P2.Int.1.p 28). While it was a process to return to working in his garden once again, P2 expressed pride in the results, and stated that he looks forward to returning to gardening every spring. It is through his gardening that P2 identifies the progress he has made since his stroke.

DISCUSSION

The intent of this study was to understand post-stroke survivors' experiences using an augmented reality (AR) system known as Gator Games in the context and convenience of their own homes. The feedback from participants yielded several themes and sub-themes that provided a comprehensive picture of their lived experiences. The premise of "No time to be impaired" was illustrated through the daily routines of the participants. Both participants had busy schedules that were filled with watching grandchildren, supporting their grown children, and also taking care of needed maintenance around their own homes. Both participants were needed by their families and therefore, there was no time for them to be distracted by their own post-stroke symptoms or impairments.

To be available to assist their family members and be supportive, both participants had to persevere and overcome the physical and cognitive symptoms they were experiencing. Each described having to get things done throughout the day- whether it was P1 fixing his son's wheelchair or P2 cooking and finishing laundry. Both described how they had to overcome what they were experiencing to successfully complete what they needed to do. P1 pushed through the tightness he felt and P2 worked up to what he needed to do by working through a process which included breaking down his goal into smaller steps in order to achieve each step. For instance, before P2 could walk out to his garden, he would physically crawl until he was able to walk again. Though both participants worked through their symptoms in different ways, the purpose of doing so was the same- to be more available to their families.

The participants tried a variety of traditional therapeutic tools to overcome their symptoms- physical therapy, yoga, exercise classes, and even talking to others who had endured

a life changing experience, such as a stroke or spinal cord injury. Both also tried internet-based games, in addition to the Gator Games they had pilot-tested for this study. When playing Gator Games, both participants had a desire to have a more in-depth understanding of the games than just how to play them. It was important for them to have a full conceptual understanding to fully engage in the games. While both participants did express having difficulties in playing the games, they also were enthusiastic about the potential of these games for future use. Though the two men both mentioned that they did not necessarily see the benefits of any of the various therapies they had tried, whether internet-based or traditional, they both still seemed willing to continue trying, since the tools might provide a means for both participants to overcome their symptoms.

For the two men, having a primary hobby was an important element in their daily lives. Though both participants expressed that they did not always see the benefits of the therapeutic tools they tried, they were able to see progress made since their stroke. Additionally, when focusing on the hobby of their choice, they believed their experience of their symptoms or impairments was lessened. They were able to participate in their primary hobbies, without constantly being reminded of the symptoms or impairment they were experiencing. In focusing intently on an activity without noticing physical and cognitive symptoms, both participants could be achieving a flow state (Csikszentmihalyi, 1997). Csikszentmihalyi (1997) has stated that individuals experience life through the act of doing, and flow is achieved when an individual is able to concentrate on an activity intently enough that other life circumstances are minimized in that moment. In participating in these main hobbies, both participants may have been able to see their progress since their stroke and momentarily forget their current physical condition.

Limitations

Throughout this study, there was one important limitation involving Gator Games. There were various technological difficulties preventing both participants from fully engaging in the program and games. As mentioned above, these technological difficulties included the games not loading properly, games starting and stopping in the middle of a session, inversion of the playing so a movement to the right was a movement to the left on the screen, and delayed game play due to the Leap Motion Controller© not recognizing the participant's arm. Due to the continued issues, the sample size was limited to two participants. Though the participant feedback collected was valuable, continued study of the users' experiences with a system in their homes, that is fully functioning, is warranted.

Implications for Practice

In regards to occupational therapy, AR technology has the potential to be a very valuable tool as a remotely-monitored, at-home therapeutic option for individuals who have survived a stroke, in order to continue making progress in their daily lives. This system is not meant to replace occupational therapy, however, it is meant to complement and be an extension of occupational therapy, when an individual is no longer participating in continued therapy or cannot access therapy. For instance, this system may be beneficial to use when individuals are going through that transition home. It could be an extension of outpatient therapy where an individual no longer needs to travel to a clinic, however, it can assist with the transition to being independent at home. Having assistance through the remotely-monitored piece of this system provides access to rehabilitation specialists as a continued resource. Currently, augmented reality systems for therapy are built and designed specifically with post-stroke survivors in mind and then the technology is provided to individuals to pilot test the system. This process focuses more

on the individual's impairment rather than obtaining information on what is important to the individual, and then creating a system based off of that information. If such a system were created, a true client-centered, occupation-based approach could be put in place, and provide a remotely-monitored, at-home therapeutic option. The personal reports of the two participants in this study have indicated that they are interested in having this type of tool available at home. The obstacle is to find an option that starts with the interests and specialized needs of the individual and leads to customized technology versus beginning with the technology in the hopes it will pique the individual's interests.

Future Research

To create an authentic AR system that focuses on the individual first, it is essential for both the technological and therapeutic professionals to test a product like this with an increased number of participants for a longer period of time and within the home. Before doing so, it is also important to test the system in a laboratory setting to ensure that all technological difficulties are rectified and that there is some engagement in the system before setting it up in the home. There may be additional unknown benefits to maintaining such a system in a laboratory setting. It also is important to combine feedback of the participants using the system, along with their identified interests in order to design a gaming system that will provide a meaningful opportunity to increase participation of the users. Customization of such a gaming system is key to providing a remotely-monitored, at-home, therapeutic option.

CONCLUSION

While this augmented reality (AR) system was used only with two participants in this pilot study, the potential for this product to be successful for individuals is great. Once the technological difficulties are corrected and each individual's experiences and interests are taken into account when upgrading the system, an easily-accessible, enjoyable and affordable option could be feasible with this remotely-monitored, at-home therapeutic tool. Having an option like this will provide continued support to post-stroke survivors in maintaining or increasing their daily function and possibly assisting them to obtain and maintain a form of "flow," (Csikszentmihalyi, 1997), which can decrease their awareness of pain and altered function, and ultimately increase their quality of life. As was evident in this study, post-stroke survivors can lead rich lives, and it is essential to include their interests and goals when designing post-stroke therapeutic options.

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APPENDIX A- Health History Questionnaire

**NEUROREHABILITATION RESEARCH LABORATORY
COLORADO STATE UNIVERSITY
CONFIDENTIAL HEALTH HISTORY QUESTIONNAIRE**
The information obtained in this questionnaire will be kept confidential and in a secure area.
Please do **NOT** write your name on these forms.

STUDY _____ DATE _____ SUBJECT ID # _____

Reviewed by : _____

PLEASE PRINT

GENERAL MEDICAL HISTORY

Do you have any current medical conditions? YES NO If Yes, please explain:

Have you had any major illnesses in the past? YES NO If Yes, please explain:

Have you ever been hospitalized or had surgery? YES NO If Yes, please explain:
(include date and type of surgery, if possible)

Have you ever had a seizure? YES NO If Yes, please explain:

Have you been diagnosed with epilepsy? YES NO If Yes, please explain:

Do you have a family history of epilepsy? YES NO If Yes, please explain:

Are you or do you believe you could be pregnant? YES NO

Have you an alcohol or drug abuse problem YES NO
within the past year?

Do you have a history of heart disease? YES NO If Yes, please explain:

Do you have claustrophobia? YES NO
(Claustrophobia is an anxiety disorder that involves the fear of enclosed or confined spaces. Claustrophobes may experience panic attacks, or fear of having a panic attack, in situations such as being in elevators, trains or aircraft.)

Have you ever been diagnosed with any of the Following?

- | | | |
|---|--|-------------------------|
| Traumatic Brain Injury | YES <input type="checkbox"/> NO <input type="checkbox"/> | |
| Parkinson's disease | YES <input type="checkbox"/> NO <input type="checkbox"/> | |
| Dementia | YES <input type="checkbox"/> NO <input type="checkbox"/> | |
| Alzheimer's disease | YES <input type="checkbox"/> NO <input type="checkbox"/> | |
| Cerebral Palsy | YES <input type="checkbox"/> NO <input type="checkbox"/> | |
| Brain Tumor | YES <input type="checkbox"/> NO <input type="checkbox"/> | |
| Bipolar disorder or other psychiatric condition | YES <input type="checkbox"/> NO <input type="checkbox"/> | If Yes, please explain: |
| Other neurological disorder | YES <input type="checkbox"/> NO <input type="checkbox"/> | If Yes, please explain: |

MEDICATIONS

Are you currently taking any medications? YES NO If Yes, please explain:

PLEASE NOTE: IF YOU STOP TAKING ANY OF THESE MEDICATIONS OR YOU START TAKING A NEW MEDICATION OR DIFFERENT DOSE OF MEDICATION DURING YOUR TIME IN THE STUDY, YOU MUST IMMEDIATELY NOTIFY THE RESEARCHERS.

<u>Medication</u>	<u>Reason</u>	<u>Times taken per Day</u>	<u>Taken for how long?</u>
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Please continue to next page.

IMPLANTED DEVICES AND METAL *

- | | | |
|--|------------------------------|-----------------------------|
| Do you have a pacemaker? | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Do you have an implanted medication pump? | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Do you have an implanted deep brain stimulator? | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Do you have any other type of implanted device?
(excluding dental implants) | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Do you have any implanted metal in your upper body?
(excluding dental work) | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Do you have any metal piercings in your upper body?
(piercings will need to be removed) | YES <input type="checkbox"/> | NO <input type="checkbox"/> |

**If you answered "YES" to any questions under IMPLANTED DEVICES AND METAL, please explain here:*

APPENDIX B- Consent to Participate in a Research Study

Consent to Participate in a Research Study Colorado State University

TITLE OF STUDY: Augmented Reality Technology for Rehabilitation

PRINCIPAL INVESTIGATOR: Matt Malcolm, PHD, OTR
Department of Occupational Therapy
Colorado State University
(970) 491-5202

CO-PRINCIPAL INVESTIGATOR: Sudeep Pasricha, PHD
Department of Electrical and Computer Engineering
Colorado State University
(970) 491-0254

WHY AM I BEING INVITED TO TAKE PART IN THIS RESEARCH? You are being asked to participate in this study because you have had a stroke or traumatic brain injury (TBI) and have some difficulty using your arm or hand and/or some difficulty attending to all of your visual environment.

WHO IS DOING THE STUDY? This study is being conducted by researchers in the Colorado State University Department of Occupational Therapy and Department of Electrical and Computer Engineering and has been partially financially supported by the Department of Occupational Therapy.

WHAT IS THE PURPOSE OF THIS STUDY? The purpose of this study is to determine how easily a computerized, internet-based system of rehabilitation games may be used by individuals with a stroke or TBI and if the system helps to improve arm and hand movement and/or visual skills. The rehabilitation games use a technology known as “augmented reality”. In this study, augmented reality technology will allow for you to use your own body movements to control aspects of a computerized game.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST? The study will take place in Dr. Malcolm’s laboratory and at your place residence. The study will consist of a pre-test evaluation session, intervention period, post-test evaluation session, and 1-month follow-up evaluation session. Each of the three evaluation sessions will last approximately 2 hours, for a total of 6 hours. The intervention period will be delivered over 10 consecutive week days (for example, two work weeks: Week 1-Monday through Friday, no intervention on Saturday and Sunday, and Week 2-Monday through Friday). On each of the intervention days, you will practice with the computerized system for 1 hour per day, for a total of 10 intervention hours. So, the total time to participate in this study will be approximately 16 hours (6 hours of evaluation and 10 hours of intervention).

WHAT WILL I BE ASKED TO DO? You will be asked to participate with four major activities in this study in the following order: (1) pre-test evaluation, (2) intervention period, (3) post-test evaluation, and (4) 1-month follow-up evaluation. Details of these activities and their timing are provided in the following table:

Activity	Description	Timing
Pre-test evaluation	This approximately 2-hour session will evaluate your abilities related to arm and movement; visual perception; daily activity performance; community and social participation; daily routines; and your experience with rehabilitation programs carried out in your place of residence. This session will take place in our	This will occur 1 to 3 days prior to starting the intervention period.

Page 1 of 4 Participant’s initials _____ Date _____

CSU#: 14-5200H
APPROVED: x/x/2014 * EXPIRES: x/x /2015

Activity	Description	Timing
Intervention period	<p>laboratory.</p> <p>The intervention period will take place on 10 consecutive weekdays. On each day, you will complete two 30-minute intervention sessions (with a rest break of at least 15 minutes between these sessions). On the first two days, we will ask you to come to the laboratory to use the computerized rehabilitation system, which is called the "AR system". Using the AR system, you will participate with a variety of computerized games. You will use your more-affected arm and hand to control an "effector" (such as a space ship) in the game to either hit targets or avoid obstacles. The games will require you to use your eyes to scan the computer screen for targets or obstacles and your arm/hand to move the effector to hit a target or avoid an obstacle. Your arm and hand movements will be detected by a motion sensor that will be placed above your arm and hand (which will rest on a table). The motion sensor will be connected to the computer. We will adjust the game controls to make the games challenging but not too difficult to perform. On intervention days 3 through 10, you will use the AR system in your own place of residence. We will lend you a small laptop computer and the motion sensor to take with you during the intervention period. You will access the games through an internet website, for which we will provide you with your own unique username and password to log in. We will schedule phone call "check ins" with you on intervention days 3, 5, and 8 to find out how the games are working and if you have any questions or problems in using the AR system. We will also provide you with a phone number to call our laboratory should you encounter questions or problems when using the AR system. Finally, one of our staff will monitor your daily progress through the website that delivers the AR games. You will also be able to check your performance and progress on the website.</p>	<p>10 consecutive weekdays. For example, intervention days 1 through 5 will occur on Monday through Friday, followed by a weekend of no intervention, followed by intervention days 6-10 occurring Monday through Friday.</p>
Post-test evaluation	<p>As in the pre-test session, the 2-hour post-test session will again evaluate your abilities related to arm and movement; visual perception; daily activity performance; daily routines; and community and social participation. We will also ask you to participate with a brief interview to learn about your experience in using the AR technology.</p>	<p>This will occur 1 to 3 days following the intervention period.</p>
1-month follow-up evaluation	<p>As in the post-test session, the 2-hour 1-month follow-up session will again evaluate your abilities related to arm and movement; visual perception; daily activity performance; daily routines; and community and social participation.</p>	<p>This will occur 1 month following completion of the intervention period.</p>

Page 2 of 4 Participant's initials _____ Date _____

CSU#: 14-5200H
APPROVED: x/x/2014 * EXPIRES: x/x /2015

ARE THERE REASONS WHY I SHOULD NOT TAKE PART IN THIS STUDY? You should not take part in this study if any of the following apply to you:

1. You had a stroke or TBI less than 1 month ago
2. You cannot voluntarily lift your more affected arm to table-height or move your arm across the table
3. You lack the thinking and communication skills necessary to understand the study procedures
4. You are unable to tolerate two 30-minute sessions of activity using your more-affected arm
5. You are under the age of 18 years
6. You have another neurological disease or injury besides a stroke or TBI
7. You have a muscular, bone, or joint injury or disease that affects your more-affected arm/hand
8. You have a visual condition or disease that prevents you from easily seeing objects on a computer screen

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS? It is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

There may be a risk that you experience fatigue (for example, tiredness) or pain (for example, sore muscles) during the intervention period because you may be using your more-affected arm/hand more than you are used to. To help reduce this risk, you will need to take breaks between game trials and between game sessions. We will give you a schedule to help you know when to take such breaks. We will also ask you if you are experiencing fatigue or pain during phone call "check ins". You may also call the laboratory if you are experiencing fatigue or pain. In the event that you are experiencing lasting fatigue or pain, you should stop playing the intervention games and notify us.

There may also be a risk of you experiencing frustration when playing the games. Individuals who participate with rehabilitation sometimes experience frustration because therapeutic activities are challenging. We will help to reduce the risk of frustration by doing the following a) regularly check in with you to help problem solve if you are frustrated; b) provide you with a phone number to our lab so you can call if you are frustrated; c) we will monitor your performance with the games to see if the difficulty settings are set too high so that we may adjust them to a better level for you.

ARE THERE ANY BENEFITS FROM TAKING PART IN THIS STUDY? Potential direct benefits to you of participating in this study may include improved arm/hand movement and improved visual-perceptual skills. The study results may also benefit future individuals who have experienced a stroke or TBI by developing a new rehabilitation technique to promote better recovery.

DO I HAVE TO TAKE PART IN THE STUDY? Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

WHO WILL SEE THE INFORMATION THAT I GIVE? We will keep private all research records that identify you, to the extent allowed by law. For this study, we will assign a code to your data (for example, "AR01") so that the only place your name will appear in our records is on the consent and in our data spreadsheet which links you to your code. Only the research team will have access to the link between you, your code, and your data. The only exceptions to this are if we are asked to share the research files for audit purposes with the CSU Institutional Review Board ethics committee, if necessary. When we write about the study to share with other researchers, we will write about the combined information we have gathered. You will not be identified in these written

Page 3 of 4 Participant's initials _____ Date _____

CSU#: 14-5200H
APPROVED: x/x/2014 * EXPIRES: x/x /2015

APPENDIX C- Sample Tracking Sheet

Sample Tracking Sheet

Date:

Game	1	2	3	4	5
Maze					
Pirate's Cove					
Whack-A-Mole					
Water Drops					
Dolphin Run					
Meteors					

Date:

Game	1	2	3	4	5
Maze					
Pirate's Cove					
Whack-A-Mole					
Water Drops					
Dolphin Run					
Meteors					

Date:

Game	1	2	3	4	5
Maze					
Pirate's Cove					
Whack-A-Mole					
Water Drops					
Dolphin Run					
Meteors					

Date:

Game	1	2	3	4	5
Maze					
Pirate's Cove					
Whack-A-Mole					
Water Drops					
Dolphin Run					
Meteors					