Designing Virtual Reality (VR) Experience for Older Adults and Determine Its Impact on Their Overall Well-Being

by

Xueyang (Charles) Lin

B.S. in Robotics Engineering
B.S. in Mechanical Engineering
Worcester Polytechnic Institute, 2013

Thesis submitted to the Integrated Design & Management Program in
Partial Fulfillment of the Requirements for the Degree

of

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Massachusetts Institute of Technology

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Signature of Author ....

Xueyang (Charles) Lin
Integrated Design & Management
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Signature redacted

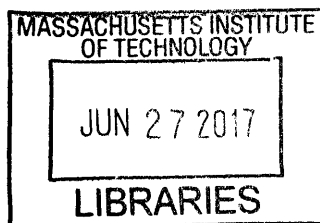Certified by ....

Joseph F. Coughlin
Senior Lecturer, Engineering Systems Division
Director, MIT AgeLab
Thesis Advisor

Signature redacted

Certified by ....

Matthew S. Kressy
Director of MIT Integrated Design & Management

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Abstract

The United States is experiencing a significant growth of the older population. As people age, they are more likely to experience decrease in social activities, limitations in cognitive capabilities, and more symptoms indicative of depression. Among older adults that live in long-term care communities, more than a quarter develop some form of dementia or depression. Virtual Reality (VR) is believed to be beneficial to the older adults due to its immersive interaction capabilities.

This thesis seeks to understand how virtual reality as a technology will impact older adults' emotional and social well-being. Human-centered design process was applied to develop the Rendever VR platform. Following the development of the system, a field study was carried out with sixty-three residents from four assisted living communities. The field study was conducted over two weeks, during which residents interacted with one of two intervention conditions - VR (i.e. experiment condition) or TV (i.e. control condition). Questionnaires were filled out by participants prior to and after the intervention for comparison. The results have shown that VR provided more positive outcomes than the control group that used a TV showing the same content. Results suggest that VR has the potential to improve older adults' well-being in general.

Thesis Supervisor:
Joseph F. Coughlin
Senior Lecturer, Engineering Systems Division
Director, MIT AgeLab

Acknowledgement

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1. Introduction

1.1. Motivation and background

The United States will experience significant growth of the older population from today to 2050 with a projected population of 83.7 million aged 65 and older (Ortman, Velkoff, & Hogan, 2014). Many older adults seek long-term care services, which provide help with health, personal care, and supportive services. 70% of Americans will require long-term care solutions in their lifetime and many of these individuals will face challenges related to mental distress and cognition (Figure 1) (Harris-Kojetin, Sengupta, Park-Lee, & Valverde, 2013).
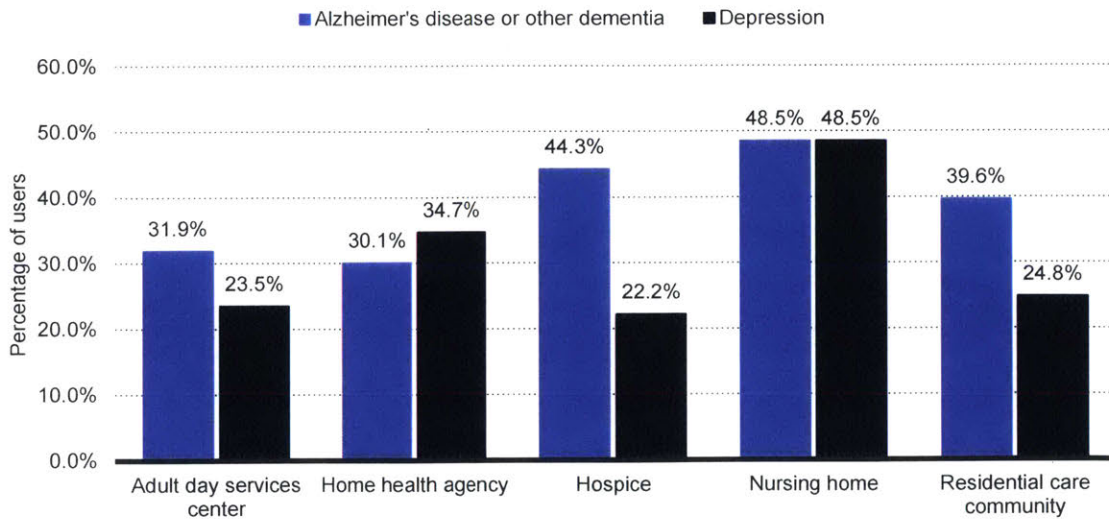
Figure 1 Long-term Care Diseases

Depression is associated with other forms of distress and suffering and can lead to impairments in physical, mental, and social functioning. The presence of depressive disorders often adversely affects

8

the course and complicates the treatment of other chronic diseases – a particular concern among older

adults given the high prevalence of multiple chronic conditions in this age group. Older adults with

depression also visit the doctor and emergency room more often, use more medication, incur higher

outpatient charges, and stay longer in the hospital (U.S. Department of Health and Human Services,

1999). Although the rate of older adults with depressive symptoms tends to increase with age,

depression should not be considered a normal part of growing older. Rather, in 80% of cases it is a

treatable condition (Chapman, Perry, & Strine, 2005). Because depression is a highly treatable but

currently undertreated condition among community-based older adults, all disease prevention programs

for older adults should include a depression treatment component (Snowden, Steinman, & Frederick,

2008).

In addition to depression, cognitive impairment is a major healthcare epidemic older adults face. Every

67 seconds, someone in the U.S. develops Alzheimer's, a disease that cost the nation $226 billion in

2015 (Alzheimer's Association, & Centers for Disease Control and Prevention, 2013). Changes in

cognitive abilities affect individuals differently and can gradually compromise an individual's ability to

care for themselves; conduct necessary activities of daily living, such as meal preparation and money

management; and effectively manage medications and existing medical conditions (Alzheimer's

Association, & Centers for Disease Control and Prevention, 2013). There is an urgent need for non-

pharmacological interventions, such as cognitive training and behavioral interventions. According to

studies including a publication in Neurology, meaningful cognitive stimulation has been proven to

reduce the rate of cognitive decline and risk of Alzheimer's (Wilson, Scherr, Schneider, Tang, & Bennett,

2007).

Technologies are sought to help improve isolation, depression, and cognitions problems of older adults;

on the other hand, the older population is not perceived as a group that is tech-savvy. In order to create

a good solution for this dilemma, a human-centered design approach was used for creating the technology intervention.

1.2.   Thesis questions

This thesis seeks to understand how virtual reality as a technology will impact older adults' emotional and social well-being. Specifically, this thesis aims to answer the following questions:

1) Will virtual reality work as an intervention tool that improves isolation, depression, and general perceived well-beings of older adults?

This question aims to understand the potential positive effects of virtual reality for the issues older adults are facing nowadays. To answer this question, pre and post surveys were created to capture the changes over a 2-week intervention period.

2) Is virtual reality a better form for delivering content than traditional television form?

This question aims to understand if virtual reality truly has the positive impact on older adults or not due to its form factor. In order to rule out the fact that there is something new in the community, which potentially brings positive outcome on its own, a controlled group of TV intervention showing the same content was recruited (see Appendix F: Content Schedule). To answer this question, both VR and TV groups were given the same content selection for the same amount of time and the same pre and post survey. The two group results were compared in the thesis.

1.3.   Thesis overview

The remainder of the thesis is structured as below:

Chapter 2 discusses existing works related to technology intervention for older adults, technology adoption, and virtual reality as an intervention. The lack of research of using virtual reality as a technology intervention for the older adults is discussed.

Chapter 3 discusses how Rendever virtual reality platform uses human-centered design approach as part of the product development cycle. One challenge the team faced was how to design the virtual reality experience for a population that is not tech-savvy. The design process is further discussed in this chapter.

Chapter 4 discusses the methodology about research protocol design, participant recruitment, and survey design.

Chapter 5 discusses the results of the survey collected, and the analysis of the results, specifically to answer the thesis questions presented earlier.

Chapter 6 discusses the summary of the thesis and future work by bring all pieces from the research together.

2. Related works

Existing research provides information about technologies provided to the older adults and their effects, as well as how virtual reality is used for both general public and the older population as an intervention. However, very limited research has been done to show the effectiveness of using virtual reality for older adults in terms of isolation, depression, and general well-being. Furthermore, the content of the virtual reality experience was also limited and not by the older adults' choice in previous studies.

This chapter provides a summary of technology intervention in long-term care communities and how virtual reality is used as an intervention both in general and for older adults. This chapter also explores the limitations in existing research that need to be further discussed.

2.1. Technologies in long-term care communities

The older adults in long-term care communities are often spatially and socially separated from the general public. Television program is often considered as a conversation catalyst among older adults, however, according to a research done in Science & Technology Research Laboratories in Japan, the results were not promising. The post questionnaire about "the effect of the TV programs on communication", the percentage of subjects who answered "TV programs can become a catalyst of communication" remained at 20% (Miyazaki, et al., 2013). Information and communication technology (ICT) is commonly used in long-term care communities in order to address the isolation and loneliness issues among older adults. Internet, being one of the ICTs, is widely adopted in the communities. A research study done by University of Alabama shows that a 1-point increase in the frequency of going online was associated with a 0.147-point decrease in loneliness scores (P=.005) among older adults in assisted and independent living communities (Cotten, Anderson, & McCullough, 2013). Besides the Internet usage, the Wii exergames, with which older adults can use a physical controller on their hands to do exercise games such as bowling or golf, are also used in communities. A pilot study has shown significant improvement on balance using Wii interventions (Chao, Scherer, Wu, Lucke, & Montgomery, 2013). Then the same group of researchers did a follow up study with results showing positive effects of physical function, decreasing depression, and increasing cognition and quality of life in older adults (Chao, Scherer, & Montgomery, Effects of using Nintendo Wii™ exergames in older adults: a review of the literature, 2015). Tablet is another technology that is broadly used in long-term care communities. A

study shows that using iPad for social interaction can increase overall social activity (Burmeister, Bernoth, Dietsch, & Cleary, 2016).

2.2. Virtual reality as an intervention

Virtual reality (VR) is an emerging technology that immerses a user into an alternate environment, giving a complete sense of presence. Presence as immersion also includes a psychological component. When users feel immersive presence they are involved, absorbed, engaged, engrossed (Lombard & Ditton, 1997). A study conducted by leading researchers at Stanford concluded that virtual environments have the potential to influence and in some cases, change human behavior – "The pen experiment is a standard test for gauging empathy...the data show that heroic behavior in a virtual environment can transfer to altruistic behavior in the real world" (Rosenberg, Baughman, & Bailenson, 2013).

Preliminary research studies have shown the benefits of using virtual reality to address the issues related to mental distress and cognition. A recent study that looked at the potential to address depression using VR concluded that there was evidence of significant reductions in depression severity and self-criticism, as well as increases in self-compassion; The results indicated that interventions using immersive virtual reality may have considerable clinical potential and that further development of these methods preparatory to a controlled trial is now warranted (Falconer, et al., 2016). Another study published in the Journal for Alzheimer's Disease that looked at using virtual reality for cognitive training of the elderly concluded that VR-based cognitive rehabilitation systems support procedures for mitigating behavioral and psychological symptoms of patients having mild cognitive impairment and early-stage Alzheimer's disease (García-Betances, Jiménez-Mixco, Arredondo, & Cabrera-Umpiérrez, 2015). Yet another study published in Neurorehabilitation and Neural Repair looked at using VR as a potential solution to discover new approaches to the treatment of memory deficits in elderly individuals. That study concluded that virtual reality memory training may improve memory function in

elderly adults by enhancing focused attention; the experimental group showed significant improvements in memory tests, both in long-term recall and several other aspects of cognition. In contrast, the control group showed progressive decline (Optale, et al., 2010).

2.3.   Gaps in application of VR for older adults' emotional and social well-being

Multiple literatures have shown that technologies can help the elderly to live better lives by improving physical health and mental health, decreasing loneliness, and creating more social interactions. Virtual reality has shown the potential for cognition and memory training. However, there are very few studies using VR for the emotional and social well-beings for older adults. Virtual Environment (VE), where a large flat screen is used, for mood induction is the most similar study. One research conducted in Spain shows that VE can significant increase in positive mood scores (joy and relaxation) and significantly decrease in negative mood scores (sadness and anxiety) (Baños, et al., 2012).

This thesis is to fill the gap of using VR as an intervention for the older adults' emotional and social well-beings. Specifically, residents in long-term care communities are studied.

3. Design of the system

This chapter reviews the current VR systems in the market, discusses why the team built a better platform specifically for the elder population, and describes the human-centered design process the team went through, and presents the final VR system configuration.

3.1.   Current VR systems

There are 3 types of typical VR systems on the market.

1) Cardboard VR

This type of VR is using either a cardboard or plastic goggle as the viewer. Users then insert a phone with certain apps that support VR experience into the goggle to view the content. This type of VR is often low quality with significant delays when users move their heads for another viewing angle.

2) Samsung Gear VR

The Samsung Gear VR uses micro-USB to connect the built-in sensors in the VR goggle with the phone so that the head movement is directly captures with much less delay. The Samsung Gear VR only supports Samsung Galaxy phones.

3) Oculus/HTC

The 2 types mentioned above are both mobile solutions with phones inserted inside a goggle. Neither of them are able to track the user's location within a room. The Oculus Rift and HTC Vive are some of the higher-end consumer VR systems that uses goggles that have built-in screens. Both the Oculus and HTC have connecting cables from a PC to the headset. They are able to tracking the location of users in a room so that users can walk around in the virtual world. However the systems are much more expensive than the cardboard and Samsung Gear VR.

Due to the low quality of cardboard and high price point with Oculus/HTC, Samsung Gear VR was selected as the hardware platform. The advantages of Samsung Gear VR are described as follows:

- Good screen resolution for image quality
- Reasonable price point
- Less likely to create motion sickness compared to the cardboard
- Light weight
- Mobile and easy to carry around

- Minimum space requirement

- Easy to develop software for

Current VR software is very limited and hard to use. The researcher partnered with a MIT startup Rendever to utilize their customized software for this study.

3.2. Human-centered design for the Rendever VR platform

The Rendever VR platform used human-centered design (or user-centered design; UCD) process throughout the product development cycle. There are 5 major steps for UCD: empathize, define, ideate, prototype, and test (Both & Baggereor, 2017). Each step is explained in details in this chapter.

3.2.1. Empathize

Empathize is a process to understand the people who are involved with the product. There are 3 components for empathizing: observe, engage, and immerse.

The researcher and Rendever team first started by visiting a few local assisted living communities, from privately owned single community to large chain communities. The team sat down with the residents, watched their daily activities, had conversations with them, and participated their activities. The team also lived in a community for a week to fully immerse themselves to understand the older adults.

During the Empathize phase, a few interesting remarks were noted:

- All communities had a monthly calendar with plenty of activities for the residents to choose from.

- All communities we visited had a weekly bus ride from the community to local points of interests. The van driver served as a tour guide for the residents, kept the residents engaged with conversations, fun facts, and educational lessons.

- Residents smiled to people walking by, but they did not talk to each other. They sat on the couch relaxing for a long time until someone started a conversation with them.

- Residents loved animals and kids when they showed up in the community.

- Residents loved to talk about places they have been to when they were younger, their children and grandchildren, and their pets.

- Some residents had smart phones. One resident's alarm clock rung but could not stop it. He tried a few times, peeked on the researcher, and then put the ringing phone back into his jacket to hide the sound.

- Residents did most activities in groups.

Five stakeholders were identified during this process.

Primary end-user:

- Older adult: the residents in the long-term care communities

- Activity director: the person in the community running all the activities for the residents

Other stakeholders:

- Executive director: the CEO of the specific one community

- Marketing director: the person in charge of advertising the communities to perspective families

- Family: family members of the residents. Typically the oldest daughter or daughter in-law.

For older adults, 4 typical personas were categorized based on their personality and physical capability. Their participation of activities in the community was largely correlated to their categories (Figure 2).

Personality

	Social	Shy	Independent
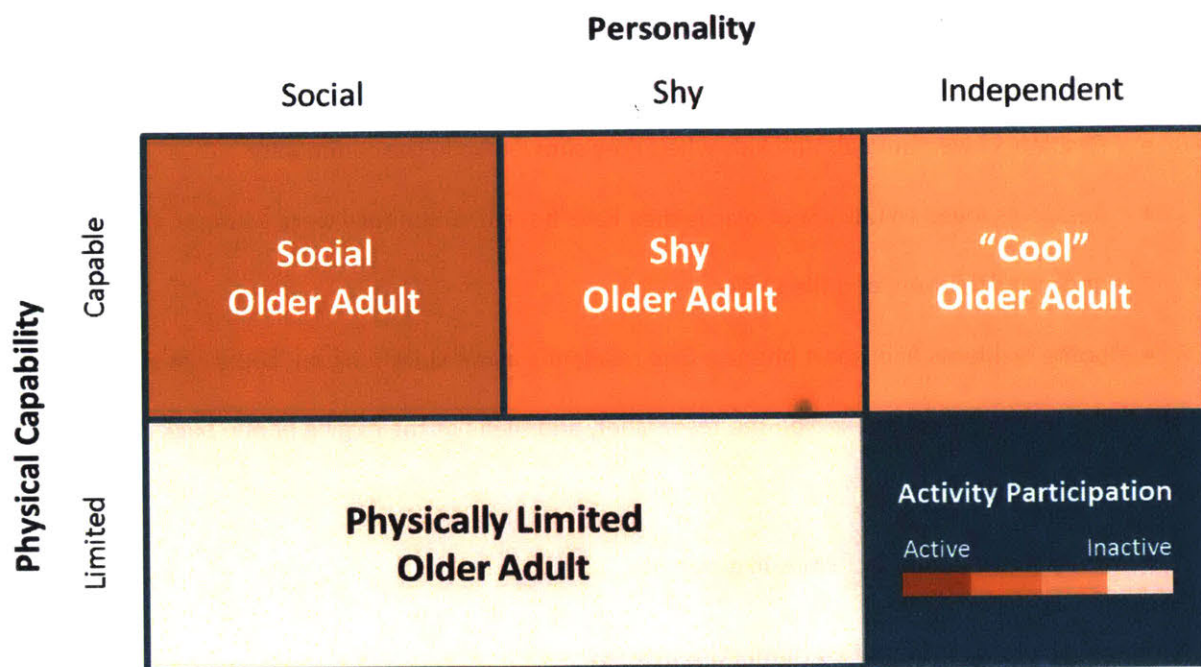
Figure 2 Older Adults Personas

The personas are as described below. To protect people's privacy, photos of them were removed for this thesis.

1) Social Older Adults – Primary End-User (VR)

Name: Norma

Age: 82   Gender: Female   Careers: Teacher

Length of stay: 2 Years   Previous location: Detroit, MI
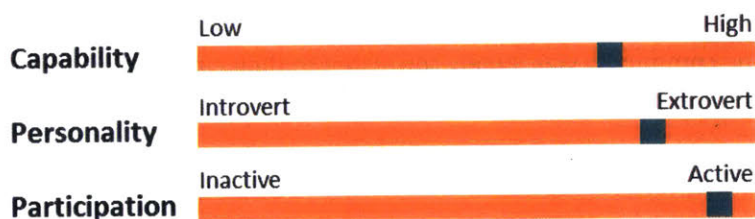
Favorites

- Something new that she has never seen before (e.g. watching the baby bold eagle on the live streaming)

- Pre-school kids nearby the facility

- Meeting with grandchildren

- Exercise activities that are good for her health

- Going outside

- Interacting with other older adults during activities

Frustrations

- Few times to go out

- Losing contact with friends living in Detroit where she lived before

2) Shy Older Adult – Secondary End-User (VR)

Name: Dorothy

Age: 93   Gender: Female   Careers: House wife

Length of stay: 1 Year   Previous location: Cambridge, MA

	Low	High
Capability		

	Introvert	Extrovert
Personality		

	Inactive	Active
Participation		
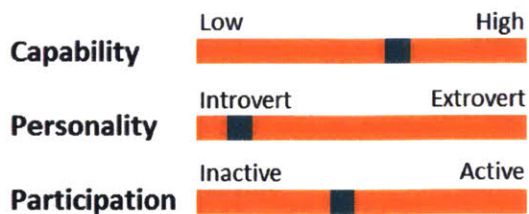
- Doesn't like to socialize too much

- Likes to do something alone

- Feels like she doesn't fit in the community

3) "Cool" Older Adult – Secondary End-User (VR)

Name: Grady

Age: 75   Gender: Male   Careers: Engineer

Length of stay: 2 Months   Previous location: Somerville, MA

	Low		High
Capability			■ (near High)

	Introvert		Extrovert
Personality		■ (middle)	

	Inactive		Active
Participation		■ (middle)	
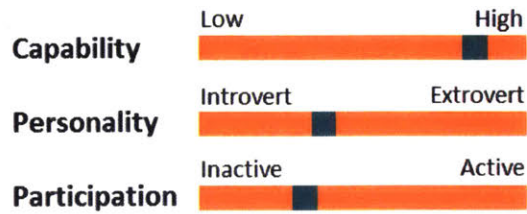
- Activities are too childish and too simple

- Doesn't like to interact much with other older adults

- Talks with people who are in the same group or have similar interests

4) Physically Limited Older Adult – Secondary End-User (VR)

Name: Betty

Age: 100   Gender: Female   Careers: Nurse

Length of stay: 4 Years   Previous location: Waltham, MA

	Low		High
Capability	■ (near Low)		

	Introvert		Extrovert
Personality		■ (middle)	

	Inactive		Active
Participation	■ (near Inactive)		
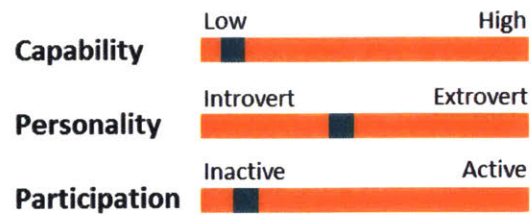
- Embarrassed to participate group activities

- Likes one-way communication (just observes)

- Trusts families, activity directors, and CNA (Certified Nursing Assistant) more

We also created personas for other stakeholders:

5) Activity Director – Primary End-User (Guide)

Name: Melissa

Age: 42   Gender: Female   Work Location: Sudbury, MA

Experience in the facility: 2 Years

	Quality		Efficiency
Priority			

	Trivial		Impactful
Decision to purchase			

	Distant		Trustworthy
Relationship with older adult			

Favorites

- Watching older adults enjoying activities

- Using her own creativity to make new activities within the limited budget

- Conversation with older adults

- Feeling her work is respected and enjoyed by the executive director and families

Frustrations

- Limited budget

- Some older adults do not participate her activities

- Needs a long time to find new content or new places to explore for the activities

Key Performance Indicator (KPI)

- Residents engagement (number of participants, satisfaction of activities)

- Planning the monthly activity calendar

- Execution of activities

6) Executive Director

Name: Elizabeth

Age: 46   Gender: Female

Work Location: Natick, MA

Experience in the facility: 7 Years

	Quality		Efficiency
Priority		■	
	Trivial		Impactful
Decision to purchase			■
	Distant		Trustworthy
Relationship with older adult	■		

KPI

- Budget and occupancy rate

- Staff turnover rate

- Customer satisfaction

7) Marketing Director

Name: Jen

Age: 38   Gender: Female

Work Location: Cambridge, MA

Experience in the facility: 3 Years

	Quality		Efficiency
Priority		■	

	Trivial		Impactful
Decision to purchase			■

	Distant		Trustworthy
Relationship with older adult		■	

KPI

- Lead generation and admission rates

- Budget and occupancy rates

- Public image

8) Family Member

Name: Sarah

Age: 54   Gender: Female

Occupation: Housewife

Relation: Daughter   Location: Wayland, MA

	Quality		Efficiency
Priority	■		

	Trivial		Impactful
Decision to purchase		■	

	Distant		Trustworthy
Relationship with older adult			■

- Explored many assisted living facilities

- Forced her parent to move into the facility

- Had crazy family dynamics issues when moving

- Pays the bill for assisted living

- Visits the facility once a week

3.2.2. Define

After the Empathize phase, the team compiled all the findings into user needs and insights. The observations described in 3.2.1 are explained as follows:

- All communities had a monthly calendar with plenty of activities for the residents to choose from.
  - Older adults need to have a sense of choice.
- All communities we visited had a weekly bus ride from the community to local points of interests. The van driver served as a tour guide for the residents, kept the residents engaged with conversations, fun facts, and educational lessons.
  - Older adults need to get out of their rooms to explore the world. These trips are educational and fun, which give them a sense of achievement and mental stimulation.
- Residents smiled to people walking by, but they did not talk to each other. They sat on the couch relaxing for a long time until someone started a conversation with them.
  - Older adults are willing to talk to people however if there is no trigger point for them to start a conversation, they will wait until someone else to start.
- Residents loved animals and kids when they showed up in the community.
  - Older adults enjoy lively stimulations.
- Residents loved to talk about places they have been to when they were younger, their children and grandchildren, and their pets.
  - Older adults enjoy telling other people their experiences, which brings them a sense of accomplishment.
- Some residents had smart phones. One resident's alarm clock rung but could not stop it. He tried a few times, peeked on the researcher, and then put the ringing phone back into his jacket to hide the sound.

- o Older adults do not "like" technologies because if they are unable to use them, they feel it is because they are too old. Showing that weakness in front of other people will make them embarrassed, therefore they prefer not to use the high tech to start with, rather than embarrass themselves later on.
- Residents did most activities in groups.
    - o Older adults enjoy group activities for the sense of belonging.

With these insights in mind, the team created a user needs list for the VR platform.

- The product needs to be easy enough to use in order to not embarrass the users.
- The product needs to be group activity.
- The product needs to provide a sense of choice.
- The product needs to provide a sense of achievement.
- The product needs to trigger conversations.
- The product needs to provide stimulations.

3.2.3. Ideate

The Ideate phase is the process to generate a large amount of design alternatives based on user needs list. Brainstorming sessions were conducted multiple times in the team. Since the design process is iterative, multiple ideate-prototype-test session have been conducted. The final high-level product specification is as follows:

- **Variety of Contents for Older Adults**

360 Videos, Google Street View, Games, Family videos, Physical activities and more

- **Remote Control for Multiple VR Device**

Tablet device & App allows activity director to control multiple VR device in the activity

- **Guided User Interface for Activity Director**

Helpful information for facilitator such as question and interaction samples for the VR session

3.2.4. Prototype

The Prototype phase is the process to transforming the ideas into the physical world. Multiple iterations of Ideate-Prototype-Test were conducted in order to make the product more successful (Figure 3).

Process	Iteration 1	Iteration 2	Iteration 3	Iteration 4
Hypothesis	Older adults will like VR	Older adults can use Samsung GearVR with intuitive interface	Recreation directors/caregivers are able to use remote table controls	Recreation directors/caregivers and residents are interested in using the product over the long run
Test	Demo off-the-shelf VR	**Prototype 1.0:** Netflix-style content dashboard controlled by headset touchpad button	**Prototype 2.0:** 1.0 plus remote tablet controls	**Prototype 2.1 ~** for one month pilot
Result	Older adults laugh, smile, relax and reminisce	Many but not all older adults can use touchpad after short tutorial	Recreation directors provided feedback on tablet design	TBD

Figure 3 Prototype Iterations

The Rendever engineers were given the specifications after iteration 3 since the first 2 were off-the-shelf and easy to test.

3.2.5. Test

The Test phase is the process to quickly get feedback on the solution. The team used different prototypes as described in 3.2.4 in various communities to get user feedbacks. After the first test of showing off-the-shelf VR, the team learned that VR was liked by older adults; after the second test of showing touchpad control over the headset, the team learned that not all older adults were able to operate the touchpad on their own; after the third test of using a remote tablet control, the team

learned that the Recreation/Activity Directors loved the remote control and older adults were able to enjoy the whole session. The first 3 tests finalized the product used for this research.

3.3. Final VR system

The final Rendever system used for the research is shown in Figure 4. The system is consisted of

- A tablet that can control all VR headsets for activity director
- Multiple VR headsets that play the same content in group settings for older adults

Samsung GearVR + Samsung S7

Tablet

+

Variety of Content

Figure 4 Rendever VR Platform

4. Methodology

In this chapter, the intervention method is discussed. The purpose of study, procedures, eligibility for participation, recruitment, location, consent forms, confidentiality, risks, pre-survey/post-survey design and data collection are further discussed in details.

4.1. Purpose of study

The AgeLab and Rendever planned to explore how Rendever's virtual reality (VR) platform might provide an affordable intervention to improve the lives of older adults suffering from isolation, depression as well as selected emotional and cognitive disorders. The purpose of the study was to look at the impact of the VR experience on reducing social isolation and improved emotional well-being by providing older adults with access to immersive virtual reality experiences including relaxation, cultural and travel experiences. In this study, residents were provided non-invasive virtual reality headsets that immersed the user in a virtual environment in order to measure the potential benefits of using the device.

4.2. Experimental procedures

Older adults had access to and were scheduled to use Rendever's virtual reality technology for a period of 2 weeks. The technology consists of a mobile phone that was placed in a headset that allowed the user to immerse themselves in a virtual environment with varying content including travel and cultural experiences. The VR goggles were consisted of the off-the-shelf Samsung GearVR and Samsung Galaxy S7 cell phones. The GearVR face foam was also coated with skin-safe antimicrobial (AEM 5700 Antimicrobial). When the subject started the session, the activity directors helped to put the GearVR on the subject's head to fully cover his or her eyes with comfortable position. The subject looked at the VR (phone screen) through the GearVR. In addition, there was a tablet that allowed the activity directors to

access and manage the content for older adults who were not technologically savvy or otherwise unable to manage the device. The residents as a group decided on what topics or content of their choice for each session. The activity directors were given instructions and practiced how to use the system during the initial visit. Throughout the 2-week intervention, there were constant communications between the researcher and the community.

The experiment consisted of 2 arms: the control arm with TV and another study arm with VR. Both arms had the same content selections and schedules for the types of content. The TV group used existing TV to project the content for the participants to watch together, while the VR group used Rendever for the group activity.

The participants were given both pre-study and post-study surveys that were accompanied with optional interviews, during which the participants were able to further explain their responses to the questions if they desired to. The survey questions consisted primarily of well-being metrics inluding emotional and physical characteristics. Surveys before and after the study were recorded with consent so that the entire study team could review them. The pre-study and post-study survey questionnaires are attached in the Appendix A: Pre-Survey and Appendix B: Post-Survey.

4.3.   Type and number of subjects involved

Sixty-three male and female older adults were recruited from 4 different assisted living communities. Among the 4 communities, 2 were assigned as the TV control group and the other 2 were the VR group.

4.4.   Method of recruitment

Since we were looking to recruit volunteering older adults, we relied on the employees of the Benchmark Senior Living communities to determine who would be representative candidates since they were familiar

with all the residents' conditions and personal preferences. We provided the Benchmark staff with a recruitment flyer (attached in the **Appendix C: Recruitment Flyer**).

4.5.   Length of subject involvement

The length of the study was 14 days. The research team spent **approximately** 30 minutes interviewing/surveying each participant prior to the beginning and at the completion of the study. The participants utilized the TV or virtual reality intervention for 20 minutes each day for the 14 days.

4.6.   Location of research

The locations of this study were in various Benchmark Senior Living Communities around New England including 3 in Massachusetts and 1 in New Hampshire. All communities were mid to high-end with 50+ residents.

4.7.   Procedures for obtaining informed consent

Once Benchmark staff identified potential participants, those who were interested in taking part in the study were given a consent form that described the study in greater detail. In order to ensure that participants may give their informed consent, the employees at the assisted living community met with each participant individually to review each portion of the consent form orally and to check for participant understanding of the consent (e.g., asking them what will happen to them during the study, what kind of information the researchers will collect, the possible benefits and risks of the study, their knowledge that participation is voluntary and that the subject can withdraw from the study at any time, what will happen to their information, and so on), as well as to answer any questions he or she may have. If the researcher/staff believed that the potential participant was incapable of understanding the consent form and what he or she was being asked to do, then the researcher would not enroll the

person in the study. Further, if the potential participant had a legal representative or guardian, and the staff from the community believed that the resident was unable to consent himself/herself, the legal representative would also be given a copy of the consent form to review and sign.

The goals of the study were not focused on people's mental or cognitive status, so we did not seek to measure these characteristics. We sought, however, to protect potentially vulnerable participants in several different ways. First, Benchmark staff would only identify participants whom they knew would be capable of complying with the instructions around using the virtual reality/TV equipment and participating in the study in a group setting, as well as taking part in interviews and completing questionnaires, ensuring that there would be a degree of cognitive capacity among participants. Second, the process the staff undertook to review the consent form with each participant ensured that potential participants understood the nature of the study and what it entailed, as well as to ensure that participants possessed the capability to take part in the research.

In order to protect any participants who might be part of a vulnerable population further, members of the research team reminded participants throughout the study that they could halt their participation at any time without any negative repercussions. Any indicator that any participant was upset, confused or bothered by taking part in the study or any piece of the study materials (e.g., the virtual reality headset) would result in the researcher removing the participant from the study in order to protect them.

Finally, while a population of older adults with possible cognitive limitations was not singled out for this particular research project, it was anticipated that the benefits of this technology and its application as in this study might ultimately accrue greatly to this group.

The consent form that was given to the participants are attached in Appendix D: Consent Form – VR and Appendix E: Consent Form – TV.

4.8.   Procedures to ensure confidentiality

All data were stored in a secure server protected with security software and password identification. Participants were identified using codes that corresponded with the collected data. Physical copies were scanned and stored securely at MIT. The investigators would not know about individual answers. Instead, the overall results were analyzed for the purpose of this study. The data would remain anonymous and secured on the MIT server for potential future analysis and study. No data that can harm the relationship between the older adults and other people were collected.

4.9.   Risks

Some people might get discomforts such as eyestrain, nausea, or motion sickness. To minimize the risks, we asked subjects to sit on a fixed chair to prevent potential physical movement injuries; we asked everyone to let us know if there was any eyestrain, nausea, or motion sickness during the study; we only showed selected content that do not create nausea or motion sickness; we only showed the content less than 30 minutes.

For monitoring procedure, we asked the staff from the senior living facility to closely monitor all subjects. The staff were consisted of the activity directors or activity associates who were trained by the facility to run activities for the residents. They were familiar with all the residents and would be able to identify any anomalies of the subjects. The staff informed all subjects at the beginning of each session regardling potential risks and how to inform the staff if there was any discomfort during or after the session. The staff watched all individual subjects during the session and paid attention to any anomalies during and after the session.

4.10. Survey Design

The survey was designed in a way to capture any potential impact by the interventions regardless the form factor of VR or TV. There were two surveys created: one pre-survey and one post-survey. Both surveys were asking the same questions except for some basic personal information that was not repeated. The overlapping questions covered perceived quality of life, health, social activity, physical well-being, emotional well-being, depression, isolation, experience with technology, and impression with the intervention system.

The survey started with introduction and guidelines of how to be filled out, indicating that all questions are voluntary to answer.

For pre-survey basic information, age, gender, disease history, marital status, education, ethnicity, employment status, and household income were collected. For post-survey, the same information was not asked again. Instead, the intervention usage, satisfaction, effect, and comfortableness were asked.

The first set of questions asked about the general perceived well-being. All questions were on the scale from 1 to 5 with 5 being the best condition.

- Overall, how satisfied would you say you are with your life?

- How would you describe your overall health?

- How would you describe your current emotional well-being?

- How would you describe your current social well-being?

- How would you describe your current physical well-being?

The next set questions asked about their health conditions. These questions could be used to find out if there was any correlations between their intervention results and their health conditions.

- Compared to one year ago, how would you rate your health in general now?

- Please check if you have been diagnosed (told by a doctor) that you have had, or currently have, any of the following medical conditions.
    - List of diseases in Appendix A: Pre-Survey
- Do you currently have any medical conditions not listed above?
- Approximately how many times have you seen a medical doctor in the past 12 months?

The following questions were rated on a scale of 1 (not at all) to 5 (extremely).

- The following items are about activities you might do during a typical day. To what extent would you say that your health limits you in these activities?
    - Vigorous activities (e.g. running, lifting heavy objects, strenuous sports)
    - Moderate activities (e.g. moving a table, pushing a vacuum cleaner, bowling, playing golf)
    - Entertainment/recreational activities
- How much bodily pain have you had during the past few weeks?
- During the past few weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

The next set of questions asked about their perceived social activity interference. Each question is rated on a scale of 1 (not at all) to 5 (extremely).

- During the past few weeks, to what extent has your physical health interfered with your normal social activities with family, friends, neighbors, or groups?
- During the past few weeks, to what extent have your emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

The next set of questions were the PANAS (Positive and Negative Affect Schedule) that consisted 10-item scales to measure both positive and negative affect (Mackinnon, et al., 1999). Each affect is rated on a scale of 1 (not at all) to 5 (extremely). The first 5 affects were positive and last 5 were negative. The scores were added up during the analysis.

- The terms below describe different feelings and emotions. Please indicate the extent to which you have felt this way over the past few weeks.
    - Determined
    - Alert
    - Excited
    - Enthusiastic
    - Inspired
    - Scared
    - Distressed
    - Upset
    - Nervous
    - Afraid

The next set of questions used the short version of Big Five Inventory for measuring personality (Rammstedt & John, 2007). Questions were answered from the scale of 1 (strongly disagree) to 5 (strongly agree).

- To what extent do you agree with the following statements about yourself? "I see myself as someone who _____"
    - Is reserved
    - Is generally trusting

- o Is relaxed

- o Is outgoing, sociable

- o Gets nervous easily

- o Tends to find fault with others

- o Handles stress well

The next set of questions used the 15-item Geriatric Depression Scale (GDS) for access depression condition (Yesavage & Sheikh, 1986). Questions were answered with yes or no.

- For the following questions, please circle the best answer for how you have felt over the past week.
    - o Are you basically satisfied with your life?
    - o Have you dropped many of your activities and interests?
    - o Do you feel your life is empty?
    - o Do you often get bored?
    - o Are you in good spirits most of the time?
    - o Are you afraid that something bad is going to happen to you?
    - o Do you feel happy most of the time?
    - o Do you feel helpless?
    - o Do you prefer to stay at home, rather than go out and do new things?
    - o Do you feel you have more problems with your memory than most?
    - o Do you think it is wonderful to be alive now?
    - o Do you feel pretty worthless the way you are now?
    - o Do you feel full of energy?
    - o Do you feel that your situation is hopeless?
    - o Do you think that most people are better off than you are?

The next set of questions asked about isolation. Questions were answered from the scale of 1 (hardly ever) to 3 (often).

- How often do you feel that you lack companionship?

- How often do you feel left out?

- How often do you feel isolated from others?

The next set of questions asked about technology experience. Each question was rated from a scale of 1 (negative) to 10 (positive). These answers were used to find out if there was any correlations between the results and the technology experience.

- How would you rate your level of experience with technology?

- Some people prefer to avoid new technologies as long as possible while others like to try them out as soon as they become available. In general, how would you rate yourself as being an avoider of new technology or an early user of new technology?

- How would you rate your ability to learn how to use new technologies?

- How would you rate your overall level of trust in technology?

The last set of questions were adapted from a set of technology adoption factors described by Lee (Lee, 2014) asked about the intervention itself. These answers were used to analyze the participants' acceptance of technology used in the study (either the VR or TV).

The following questions were rated as yes or no:

- How much do you agree with the following statements regarding the armchair travel system that you will be using for this study? "I think the armchair travel _____"

  o Will be valuable and useful

  o Will be easy to use

- Would be inexpensive if I were to buy it

- Will be easy to find where to purchase the system

- Will have good technical assistance

- Is something that my family and friends would approve of

- Will provide emotional benefits to me

- Will enable me to stay independent

- Will provide me a sense of accomplishment

- Makes me feel confident about using the system

- Will work over time without breaking

- Is backed up by a trustable service structure

- Will fit into my lifestyle

- Will improve my daily life

- Will work in a way that makes sense to me

The following questions were rated from a scale of 1 (very dissatisfied/not at all likely) to 10 (very satisfied/very likely):

- How satisfied are you with the armchair travel system?

- How likely are you to consider using the armchair travel system in the future?

- How likely are you to recommend to a friend or family member that they consider trying the armchair travel system?

For the post-survey, additional questions were asked regarding the intervention tool (armchair travel).

- During the study experience, about how many times per day did you use the armchair travel on average? _____

- During the study experience, on average, how many minutes did you use the armchair travel for each time? _____

The following question set was rated from a scale of 1 (Not enjoyable at all) to 5 (very enjoyable):

- Based on your study experience, how did you feel about the different type of content?
    - Meditation
    - Travel
    - Cultural
    - Memory Lane
    - Relaxation

The following question set was rated as Negatively/No effect/Positively:

- How did participating in the study affect the following?
    - Quality of diet
    - Taking medications on time
    - Ability to have new conversations
    - Quality of sleep
    - Amount that you've slept
    - Social activities
    - Physical activities
    - Desire to be more social in the community

The following question was rated from a scale of 1 (Not comfortable at all) to 10 (very comfortable):

- Based on your study experience, how comfortable were you using the armchair travel system?

Both pre-survey and post-survey can be found in the Appendix A: Pre-Survey and Appendix B: Post-Survey.

4.11. Data collection

The researcher set up meetings with the executive directors and activity directors with each community to give instructions for recruiting residents. After they have recruited 16 participants, the researcher went on site of each community to conduct the surveys. The surveys took 5-8 hours for each visit for a total of 8 visits. If the resident opted out the research, no post-survey was collected. The surveys were all printed and stapled. Participants were given pens to circle or check their desired answer on paper.

5. Results and Discussions

This chapter discusses the survey results and investigations of the data. Paired-sample T test was used for analyzing the pre and post survey data with VR or TV groups. The individual community was also discussed to capture certain discrepancies between communities using the same intervention.

5.1. Samples overview

Sixty-three pre-surveys were conducted and 52 of the 63 continued throughout the research with post-surveys after the 2-week intervention. The gender distribution is shown in Table 1. In the pre-survey, 24 males (38.1%) and 39 females (61.9%) were recruited; for the post-survey, 18 males (34.6%) 34 females (65.4%) remained. The retention rate was 82.5% for the study after 2 weeks. The TV group had a retention rate of 75% while the VR group had a retention rate of 88.6%. When the researcher asked about why residents dropped off, the answer was that they were not interested in the system anymore. Although it varied between communities due to the activity directors' willingness to keep residents

engaged for the study, the researcher heard more negative comments in the TV group. More overall

satisfaction of both systems are discussed in Chapter 5.4.

Table 1 Gender Distributions across 4 Sites

		Site F (TV)	Site N (TV)	Site M (VR)	Site B (VR)
Pre-survey	Male	6	6	5	7
	Female	9	7	14	9
	Total	**15**	**13**	**19**	**16**
Post-survey	Male	5	3	4	6*
	Female	8	5	12	9*,**
	Total	**13**	**8**	**16**	**15**

*: One male and one female did not fill out this part. The researcher added this information for analysis.

**: One female circled the gender of male in the survey. The researcher used female for analysis.

In terms of age, the mean was 87-year-old with 61 valid data and 2 missing data. Both the mean and

median year of birth were 1930 (N=61) (Table 2, Table 3).

Statistics

Birth_Year

N	Valid	61
	Missing	2
Mean		1930.74
Median		1930.00
Std. Deviation		5.839
Range		32
Minimum		1918
Maximum		1950

Table 2 Year of Birth Statistics
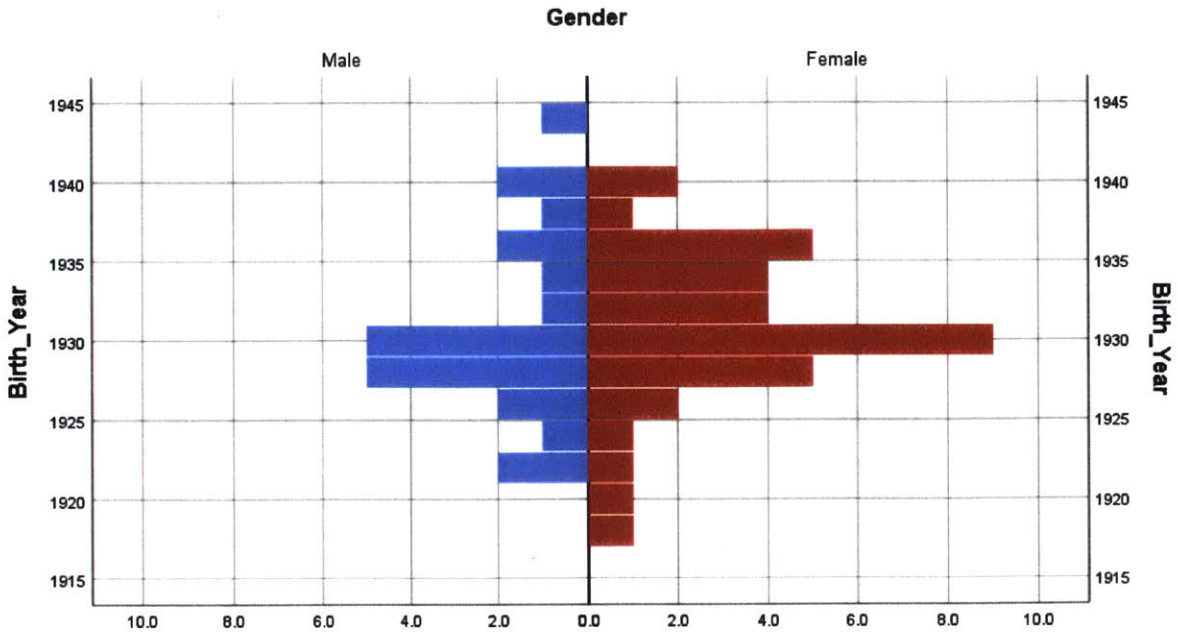
Table 3 Year of Birth Distribution by Gender

For diseases, the most common diseases the residents had were high blood pressure and arthritis

rheumatism (Table 4).

Table 4 Diseases Count - Self Reported

On average residents visited medical doctor 3.4 times in the past year (N=59) (Table 5).

Statistics

Pre_Q28_MedicalVisits

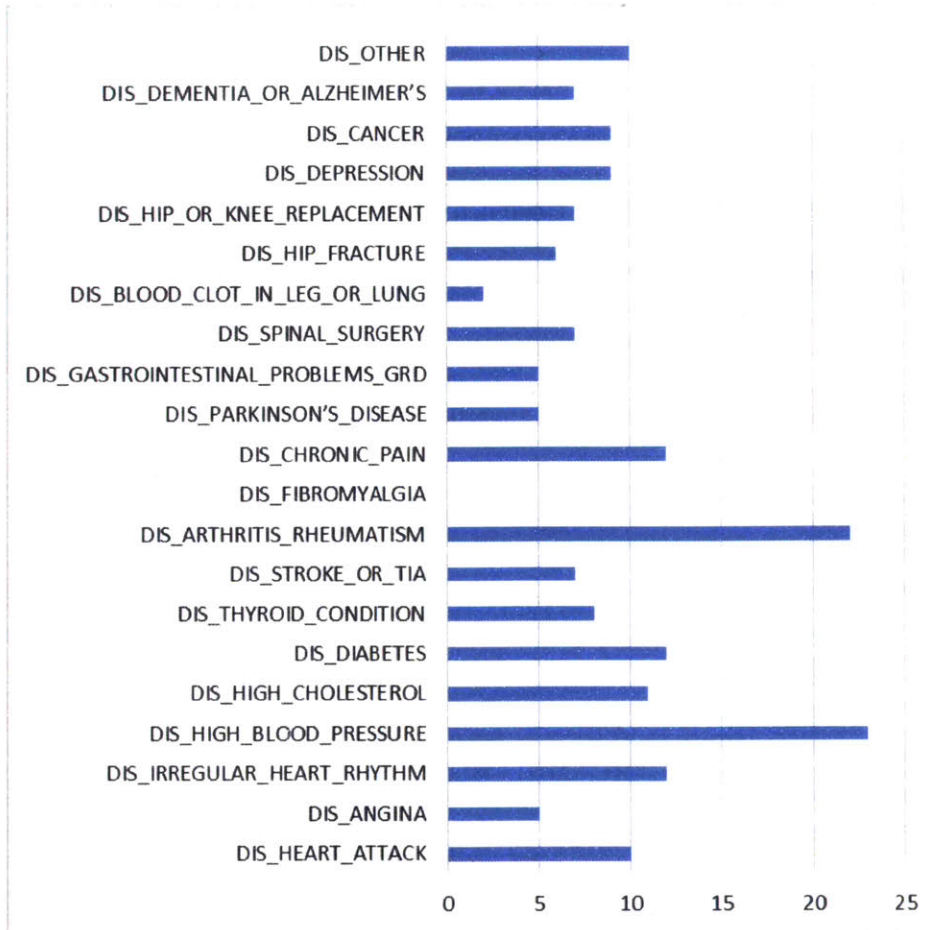| N	Valid	59
	Missing	4
Mean		3.39
Median		3.00
Std. Deviation		3.190
Range		16
Minimum		0
Maximum		16

Table 5 Number of Medical Visits Past Year

5.2. Pre and post results of VR

Paired-sample T test was used for analyzing each variable. For statistical significance, the P-Value (Sig) of 0.05 was used. In Table 6 on the right-most column, a cutoff of <0.05 was used to state "significantly" better or worse, and <0.20 for stating "much" better or worse. The "better" or "worse" was depending on the variables. If a larger number in the post results meant better condition, "better" was stated in the column. Both VR sites M and B were examined together and separately.

QID_Pre	QID_Post	Variable	Pre	Post	t	df	Sig	Notes		
Both Site M & B										
3	1	LifeSatisfaction	4.129	3.613	1.833	30	0.077		Much	Worse
4	2	OverallHealth	3.484	3.903	-2.437	30	0.021	Perceived overall health improved significantly	Significantly	Better
5	3	WellBeingEmotional	3.983	3.900	0.456	29	0.652		A little	Worse
6	4	WellBeingSocial	3.667	3.800	-0.643	29	0.526	Perceived social well-being improved, not significant	A little	Better
7	5	WellBeingPhysical	3.516	3.710	-1.360	30	0.184	Perceived physical well-being improved, not significant	Much	Better
10	8	SocialInterference_Physical	2.345	2.379	-0.150	28	0.882		A little	Worse
11	9	SocialInterference_Emotional	1.633	1.733	-0.462	29	0.647		A little	Worse
14	12	PANAS_Positive	14.742	14.419	0.319	30	0.752		A little	Worse
14	12	PANAS_Negative	8.452	8.129	0.338	30	0.737	Negative affect experienced less, not significant	A little	Better
15	13	Reserved	2.367	2.000	1.690	29	0.102	Became more reserved, not significant	Much	Worse
15	13	Trusting	2.133	1.767	1.408	29	0.170	Became more trusting, not significant	Much	Better
15	13	Relaxed	2.172	2.345	-0.757	28	0.455		A little	Worse
15	13	Outgoing	2.367	2.533	-0.571	29	0.573		A little	Worse
15	13	GetsNervous	3.200	3.833	-3.357	29	0.002	Became significantly less likely to get nervous	Significantly	Better
15	13	FindFault	3.839	3.613	1.070	30	0.293		A little	Worse
15	13	HandlesStress	2.290	2.355	-0.349	30	0.730		A little	Worse
16	14	GDS	4.29	4.065	0.745	30	0.462	Depression decreased, not significant	A little	Better
17	15	SocialCompanionship	1.379	1.483	-0.769	28	0.448		A little	Worse
17	15	SocialLeftout	1.484	1.484	0.000	30	1.000			Same
17	15	SocialIsolated	1.419	1.323	0.769	30	0.448		A little	Better
20	18	TechLearning	6.100	5.467	1.727	29	0.095	Worse ability to learn new technologies, not significantly	Much	Worse
21	19	TechTrust	6.897	7.034	-0.425	28	0.674		A little	Better
23	21	Satisfied	6.130	6.739	-1.078	22	0.293	Satisfaction with system increased, not significant	A little	Better
24	22	LikelyToUse	4.960	5.520	-1.016	24	0.320	Became more likely to use system, not significant	A little	Better
25	23	LifelyToRecommend	4.391	5.391	-1.973	22	0.061	Became more likely to recommend system, not significant	Much	Better

Table 6 VR Overall Pre vs. Post Results

QID_Pre	QID_Post	Variable	Pre	Post	t	df	Sig	Notes		
		Only Site M								
3	1	LifeSatisfaction	4.188	4.000	0.565	15	0.580		A little	Worse
4	2	OverallHealth	3.938	4.000	-0.324	15	0.751		A little	Better
5	3	WellBeingEmotional	4.233	4.267	-0.151	14	0.882		A little	Better
6	4	WellBeingSocial	3.813	3.875	-0.293	15	0.774		A little	Better
7	5	WellBeingPhysical	3.750	3.875	-0.565	15	0.580		A little	Better
10	8	SocialInterference_Physical	1.929	2.571	-2.090	13	0.057	Physical health interfered more with social activities, significant under α=0.1	Much	Worse
11	9	SocialInterference_Emotional	1.625	1.813	-0.527	15	0.606		A little	Worse
14	12	PANAS_Positive	15.500	14.813	0.435	15	0.670		A little	Worse
14	12	PANAS_Negative	7.188	8.000	-0.964	15	0.350		A little	Worse
15	13	Reserved	2.267	1.867	1.031	14	0.320	Became more reserved, not significant	A little	Worse
15	13	Trusting	2.333	1.800	1.075	14	0.301	Became more trusting, not significant	A little	Better
15	13	Relaxed	2.200	2.467	-0.673	14	0.512		A little	Worse
15	13	Outgoing	2.188	2.500	-0.639	15	0.533		A little	Worse
15	13	GetsNervous	3.267	3.600	-1.435	14	0.173		Much	Better
15	13	FindFault	4.063	3.750	1.046	15	0.312		A little	Worse
15	13	HandlesStress	1.875	2.125	-0.808	15	0.432		A little	Worse
16	14	GDS	2.81	3.375	-1.781	15	0.095	More depressed, not significant	Much	Worse
17	15	SocialCompanionship	1.267	1.400	-0.807	14	0.433		A little	Worse
17	15	SocialLeftout	1.313	1.438	-0.696	15	0.497		A little	Worse
17	15	SocialIsolated	1.188	1.375	-1.145	15	0.270		A little	Worse
20	18	TechLearning	6.000	6.063	-0.126	15	0.901		A little	Better
21	19	TechTrust	7.125	7.688	-1.346	15	0.198		Much	Better
23	21	Satisfied	7.400	7.500	-0.145	9	0.888		A little	Better
24	22	LikelyToUse	6.000	6.583	-0.845	11	0.416	Became more likely to use system, not significant	A little	Better
25	23	LifelyToRecommend	5.091	6.727	-2.104	10	0.062	Became more likely to recommend system, significant under α=0.1	Much	Better

Table 7 VR Site M Pre vs. Post Results

QID_Pre	QID_Post	Variable	Pre	Post	t	df	Sig	Notes			
Only Site B											
3	1	LifeSatisfaction	4.067	3.200	1.899	14	0.078			Much	Worse
4	2	OverallHealth	3.000	3.800	-3.055	14	0.009	Perceived overall health improved significantly		Significantly	Better
5	3	WellBeingEmotional	3.733	3.533	0.676	14	0.510			A little	Worse
6	4	WellBeingSocial	3.500	3.714	-0.563	13	0.583	Perceived social well-being improved, not significant		A little	Better
7	5	WellBeingPhysical	3.267	3.533	-1.468	14	0.164	Perceived physical well-being improved, not significant		Much	Better
10	8	SocialInterference_Physical	2.733	2.200	1.948	14	0.072	Physical health interfered less with social activities, significant under α=0.1		Much	Better
11	9	SocialInterference_Emotional	1.643	1.643	0.000	13	1.000				Same
14	12	PANAS_Positive	13.933	14.000	-0.052	14	0.959			A little	Better
14	12	PANAS_Negative	9.800	8.267	0.884	14	0.392	Negative affect experienced less, not significant		A little	Better
15	13	Reserved	2.467	2.133	1.581	14	0.136	Became more reserved, not significant		Much	Worse
15	13	Trusting	1.933	1.733	1.146	14	0.271	Became more trusting, not significant		A little	Better
15	13	Relaxed	2.143	2.214	-0.322	13	0.752			A little	Worse
15	13	Outgoing	2.571	2.571	0.000	13	1.000				Same
15	13	GetsNervous	3.133	4.067	-3.287	14	0.005	Became significantly less likely to get nervous		Significantly	Better
15	13	FindFault	3.600	3.467	0.435	14	0.670			A little	Worse
15	13	HandlesStress	2.733	2.600	0.695	14	0.499			A little	Better
16	14	GDS	5.87	4.800	2.416	14	0.030	Depression decreased significantly		Significantly	Better
17	15	SocialCompanionship	1.500	1.571	-0.322	13	0.752			A little	Worse
17	15	SocialLeftout	1.667	1.533	0.695	14	0.499	Significantly less likely to feel left out		A little	Better
17	15	SocialIsolated	1.667	1.267	2.449	14	0.028	Significantly less likely to feel isolated		Significantly	Better
20	18	TechLearning	6.214	4.786	2.994	13	0.010	Significantly worse ability to learn new technologies		Significantly	Worse
21	19	TechTrust	6.615	6.231	0.789	12	0.445			A little	Worse
23	21	Satisfied	5.154	6.154	-1.170	12	0.265	Satisfaction with system increased, not significant		A little	Better
24	22	LikelyToUse	4.000	4.538	-0.616	12	0.549	Became more likely to use system, not significant		A little	Better
25	23	LifelyToRecommend	3.750	4.167	-0.646	11	0.532	Became more likely to recommend system, not significant		A little	Better

Table 8 VR Site B Pre vs. Post Results

The following insights were identified for the overall VR group:

- Perceived overall health improved significantly

- Became significantly less likely to get nervous

- Perceived social well-being improved, not significant

- Perceived physical well-being improved, not significant

- Negative affect experienced less, not significant

- Became more reserved, not significant

- Became more trusting, not significant

- Depression decreased, not significant

- Worse ability to learn new technologies, not significantly

- Satisfaction with system increased, not significant

- Became more likely to use system, not significant

- Became more likely to recommend system, not significant

5.3.   Pre and post results of TV

Same statistical analyses was conducted for the TV group as shown in Table 9, Table 10, and Table 11.

QID_Pre	QID_Post	Variable	Pre	Post	t	df	Sig	Notes		
Both Site F & N										
3	1	LifeSatisfaction	3.667	3.667	0.000	20	1.000			Same
4	2	OverallHealth	3.450	3.300	0.767	19	0.453		A little	Worse
5	3	WellBeingEmotional	3.548	3.476	0.484	20	0.634		A little	Worse
6	4	WellBeingSocial	3.333	3.333	0.000	20	1.000			Same
7	5	WellBeingPhysical	2.952	2.952	0.000	20	1.000			Same
10	8	SocialInterference_Physical	2.286	2.619	-1.323	20	0.201		A little	Worse
11	9	SocialInterference_Emotional	2.150	2.200	-0.224	19	0.825		A little	Worse
14	12	PANAS_Positive	11.095	13.190	-1.855	20	0.078	Positive affects increased, not significant	Much	Better
14	12	PANAS_Negative	8.632	8.684	-0.051	18	0.960		A little	Worse
15	13	Reserved	2.350	2.350	0.000	19	1.000			Same
15	13	Trusting	1.650	1.900	-1.228	19	0.234	Less trusting, not significant	A little	Worse
15	13	Relaxed	2.400	2.500	-0.384	19	0.705		A little	Worse
15	13	Outgoing	2.206	2.412	-0.647	16	0.527		A little	Worse
15	13	GetsNervous	3.368	3.000	1.046	18	0.309		A little	Worse
15	13	FindFault	3.444	3.333	0.622	17	0.542		A little	Worse
15	13	HandlesStress	2.579	2.368	0.809	18	0.429		A little	Better
16	14	GDS	4.30	5.400	-1.854	19	0.079	More depressed, not significant	Much	Worse
17	15	SocialCompanionship	1.600	1.550	0.438	19	0.666		A little	Better
17	15	SocialLeftout	1.476	1.571	-0.698	20	0.493		A little	Worse
17	15	SocialIsolated	1.450	1.500	-0.370	19	0.716		A little	Worse
20	18	TechLearning	4.857	5.810	-2.351	20	0.029	Better ability to learn new technologies, significant.	Significantly	Better
21	19	TechTrust	6.571	6.619	-0.079	20	0.938		A little	Better
23	21	Satisfied	5.667	5.667	0.000	17	1.000			Same
24	22	LikelyToUse	4.211	4.316	-0.224	18	0.826		A little	Better
25	23	LifelyToRecommend	4.053	4.895	-1.153	18	0.264	More likely to recommend, not significant.	A little	Better

Table 9 TV Site Overall Pre vs. Post Results

QID_Pre	QID_Post	Variable	Pre	Post	t	df	Sig	Notes		
Only Site F										
3	1	LifeSatisfaction	3.692	3.615	0.221	12	0.829		A little	Worse
4	2	OverallHealth	3.692	3.538	0.805	12	0.436		A little	Worse
5	3	WellBeingEmotional	3.615	3.538	0.322	12	0.753		A little	Worse
6	4	WellBeingSocial	3.231	3.308	-0.365	12	0.721		A little	Better
7	5	WellBeingPhysical	3.154	3.308	-0.805	12	0.436		A little	Better
10	8	SocialInterference_Physical	1.846	2.462	-1.979	12	0.071	Physical health interfer more with social activities, not significant	Much	Worse
11	9	SocialInterference_Emotional	1.917	2.167	-0.897	11	0.389		A little	Worse
14	12	PANAS_Positive	10.385	13.615	-1.945	12	0.076	Positive affects increased, not significant	Much	Better
14	12	PANAS_Negative	9.182	9.273	-0.051	10	0.961		A little	Worse
15	13	Reserved	2.250	2.500	-0.821	11	0.429		A little	Worse
15	13	Trusting	1.667	1.917	-1.000	11	0.339		A little	Worse
15	13	Relaxed	2.333	2.500	-0.394	11	0.701		A little	Worse
15	13	Outgoing	2.182	2.583	-0.841	10	0.420		A little	Worse
15	13	GetsNervous	3.417	2.583	1.701	11	0.117	More nervous, not significant	Much	Worse
15	13	FindFault	3.300	3.400	-0.429	9	0.678		A little	Better
15	13	HandlesStress	2.455	2.000	1.456	10	0.176	Handles stress better, not significant	Much	Better
16	14	GDS	3.85	5.460	-2.298	12	0.040	More depressed, significant	Significantly	Worse
17	15	SocialCompanionship	1.583	1.583	0.000	11	1.000			Same
17	15	SocialLeftout	1.462	1.692	-1.389	12	0.190	Feels more left out, not significant	Much	Worse
17	15	SocialIsolated	1.500	1.583	-0.432	11	0.674		A little	Worse
20	18	TechLearning	4.846	5.692	-2.269	12	0.043	Better ability to learn new technologies, significant.	Significantly	Better
21	19	TechTrust	5.923	6.769	-1.048	12	0.315		A little	Better
23	21	Satisfied	5.364	4.727	0.763	10	0.463		A little	Worse
24	22	LikelyToUse	4.250	3.833	0.767	11	0.459		A little	Worse
25	23	LifelyToRecommend	4.167	3.500	1.609	11	0.136	More likely to recommend, not significant.	Much	Worse

Table 10 TV Site F Pre vs. Post Results

Only Site N										
QID_Pre	QID_Post	Variable	Pre	Post	t	df	Sig	Notes		
3	1	LifeSatisfaction	3.625	3.750	-0.552	7	0.598		A little	Better
4	2	OverallHealth	3.000	2.857	0.311	6	0.766		A little	Worse
5	3	WellBeingEmotional	3.438	3.375	1.000	7	0.351		A little	Worse
6	4	WellBeingSocial	3.500	3.375	0.357	7	0.732		A little	Worse
7	5	WellBeingPhysical	2.625	2.375	0.683	7	0.516		A little	Worse
10	8	SocialInterference_Physical	3.000	2.875	0.314	7	0.763		A little	Better
11	9	SocialInterference_Emotional	2.500	2.250	0.683	7	0.516		A little	Better
14	12	PANAS_Positive	12.250	12.500	-0.239	7	0.818		A little	Better
14	12	PANAS_Negative	7.875	7.875	0.000	7	1.000			Same
15	13	Reserved	2.500	2.125	0.893	7	0.402		A little	Worse
15	13	Trusting	1.625	1.875	-0.683	7	0.516		A little	Worse
15	13	Relaxed	2.500	2.500	0.000	7	1.000			Same
15	13	Outgoing	2.250	3.714	0.183	5	0.862		A little	Worse
15	13	GetsNervous	3.286	3.714	-1.441	6	0.200	Gets less nervous, not significant	A little	Better
15	13	FindFault	3.625	3.250	1.426	7	0.197	Find more fault, not significant	Much	Worse
15	13	HandlesStress	2.750	2.875	-0.284	7	0.785		A little	Worse
16	14	GDS	5.14	5.290	-0.135	6	0.897		A little	Worse
17	15	SocialCompanionship	1.625	1.500	0.552	7	0.598		A little	Better
17	15	SocialLeftout	1.500	1.375	0.552	7	0.598		A little	Better
17	15	SocialIsolated	1.375	1.375	0.000	7	1.000			Same
20	18	TechLearning	4.875	6.000	-1.230	7	0.259	Better ability to learn new technologies, not significant.	A little	Better
21	19	TechTrust	7.625	6.375	1.722	7	0.129	Less trusting in technologies, not significant	Much	Worse
23	21	Satisfied	6.143	7.143	-0.935	6	0.386		A little	Better
24	22	LikelyToUse	4.143	5.143	-1.225	6	0.267		A little	Better
25	23	LifelyToRecommend	3.857	7.286	-2.400	6	0.053	More likely to recommend, not significant.	Much	Better

Table 11 TV Site N Pre vs. Post Results

The following insights were identified for the overall TV group:

- Better ability to learn new technologies, significant.

- Positive affects increased, not significant

- Less trusting, not significant

- More depressed, not significant

- More likely to recommend, not significant.

By comparing with VR results, the TV group had more variables getting worse than before. For the GDS score, VR group improved a bit on the depression scale (Sig = 0.462, degree of freedom =30) while the TV group did much worse (Sig=0.079, degree of freedom = 19).

5.4. TV vs. VR post-intervention results comparison for each variable

After comparing pre and post results in the same group, the posts results of each variable for both TV and VR groups were compared in Table 12. Without comparing the pre-survey results yet, it was still useful to evaluate how residents in each group perceived the survey questions.

Group Statistics					
ID_TV_VR		N	Mean	Std. Deviation	Std. Error Mean
Post_Q1_LifeSatisfaction	TV	21	3.667	1.3904	0.3034
	VR	31	3.613	1.3827	0.2483
Post_Q2_OverallHealth	TV	21	3.286	1.3093	0.2857
	VR	31	3.903	0.9783	0.1757
Post_Q3_WellBeingEmotional	TV	21	3.476	0.8136	0.1775
	VR	31	3.903	0.9783	0.1757
Post_Q4_WellBeingSocial	TV	21	3.333	1.3166	0.2873
	VR	30	3.800	0.7611	0.1390
Post_Q5_WellBeingPhysical	TV	21	2.952	1.2836	0.2801
	VR	31	3.710	0.9379	0.1684
Post_Q7_1_HealthLimitsActivities_Vigorous	TV	13	4.308	1.0316	0.2861
	VR	8	4.000	0.7559	0.2673
Post_Q7_2_HealthLimitsActivities_Moderate	TV	15	3.467	1.1872	0.3065
	VR	12	3.833	0.9374	0.2706
Post_Q7_3_HealthLimitsActivities_Entertainment	TV	17	2.824	1.0146	0.2461
	VR	20	2.800	1.1965	0.2675
Post_Q8_SocialInterference_Physical	TV	21	2.619	1.3220	0.2885
	VR	31	2.290	1.3710	0.2462
Post_Q9_SocialInterference_Emotional	TV	21	2.238	1.1792	0.2573
	VR	30	1.733	1.1121	0.2030
Post_PANAS_Positive	TV	21	13.190	3.5724	0.7796
	VR	31	14.419	4.3953	0.7894
Post_PANAS_Negative	TV	20	8.500	4.1612	0.9305

	VR	31	8.129	4.7801	0.8585
Post_Q13_1_Reserved	TV	21	2.381	0.7400	0.1615
	VR	30	2.000	0.9469	0.1729
Post_Q13_2_Trusting	TV	21	1.905	0.6249	0.1364
	VR	31	1.806	0.8725	0.1567
Post_Q13_3_Relaxed	TV	21	2.476	0.9284	0.2026
	VR	30	2.400	0.9322	0.1702
Post_Q13_4_Outgoing	TV	20	2.300	1.0311	0.2306
	VR	30	2.533	1.0743	0.1961
Post_Q13_5_GetsNervous	TV	20	3.000	1.2140	0.2714
	VR	31	3.774	0.9205	0.1653
Post_Q13_6_FindFault	TV	21	3.476	0.9284	0.2026
	VR	31	3.613	1.1454	0.2057
Post_Q13_7_HandlesStress	TV	21	2.524	0.9808	0.2140
	VR	31	2.355	1.0816	0.1943
Post_GDS	TV	20	5.40	3.662	0.819
	VR	31	4.06	2.816	0.506
Post_Q15_1_SocialCompanionship	TV	21	1.571	0.6761	0.1475
	VR	31	1.516	0.6768	0.1216
Post_Q15_2_SocialLeftout	TV	21	1.571	0.7464	0.1629
	VR	31	1.484	0.6768	0.1216
Post_Q15_3_SocialIsolated	TV	21	1.476	0.6016	0.1313
	VR	31	1.323	0.5408	0.0971
Post_Q21_Satisfied	TV	18	5.667	2.6122	0.6157
	VR	29	7.034	2.2438	0.4167
Post_Q22_LikelyToUse	TV	19	4.316	2.3107	0.5301
	VR	30	5.867	3.2667	0.5964
Post_Q23_LifelyToRecommend	TV	19	4.895	3.0165	0.6920
	VR	28	5.679	2.9821	0.5636

Table 12 TV vs. VR for Each Variable Comparison

After running a t-test for mean comparison, with a confidence level of α=0.1(See Appendix G: T-Test for TV & VR Post-Intervention Results Comparison for Each Variable), some interesting findings were identified:

- The VR group had a significant higher perceived current overall health compared to TV group
- The VR group had a significant higher perceived current physical well-being compared to TV group
- The VR group had a significant higher likelihood to get nervous compared to TV group
- The VR group was significantly more satisfied with the system compared to TV group
- The VR group was significantly more likely to use the system compared to TV group
- The VR group had a higher perceived current emotional well-being compared to TV group
- The VR group had a higher perceived current social well-being compared to TV group
- The VR group had a less emotional problems interfered with normal social activities compared to TV group
- The VR group saw themselves more reserved compared to TV group
- The VR group had a lower depression score compared to TV group

All results above were showing that VR group had a better end results than the TV group, except the personality test for being reserved, which was a neutral question.

5.5. TV vs. VR comparison for pre- and post-intervention differences

Since the TV and VR groups might have different baselines for the pre-survey, a post-pre difference comparison analysis was conducted. In this analysis, the post mean value was subtracted from the pre

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mean value. A positive number indicated increase in score and negative values corresponded to

decrease (Table 13).

Group Statistics					
ID_TV_VR		N	Mean	Std. Deviation	Std. Error Mean
D_Q1_LifeSatisfaction	TV	21	0.000	1.0488	0.2289
	VR	31	-0.516	1.5678	0.2816
D_Q2_OverallHealth	TV	20	-0.150	0.8751	0.1957
	VR	31	0.419	0.9583	0.1721
D_Q3_WellBeingEmotional	TV	21	-0.071	0.6761	0.1475
	VR	30	-0.083	1.0007	0.1827
D_Q4_WellBeingSocial	TV	21	0.000	0.8367	0.1826
	VR	30	0.133	1.1366	0.2075
D_Q5_WellBeingPhysical	TV	21	0.000	0.8367	0.1826
	VR	31	0.194	0.7924	0.1423
D_Q7_1_HealthLimitsActivities_Vigorous	TV	6	0.167	0.9832	0.4014
	VR	5	-0.800	0.4472	0.2000
D_Q7_2_HealthLimitsActivities_Moderate	TV	8	0.000	0.5345	0.1890
	VR	8	-0.125	1.1260	0.3981
D_Q7_3_HealthLimitsActivities_Entertainment	TV	16	0.375	1.0878	0.2720
	VR	14	0.071	1.4917	0.3987
D_Q8_SocialInterference_Physical	TV	21	0.333	1.1547	0.2520

	VR	29	0.034	1.2387	0.2300
D_Q9_SocialInterference_Emotional	TV	20	0.050	0.9987	0.2233
	VR	30	0.100	1.1847	0.2163
D_PANAS_Positive	TV	21	2.095	5.1760	1.1295
	VR	31	-0.323	5.6296	1.0111
D_PANAS_Negative	TV	19	0.053	4.5274	1.0386
	VR	31	-0.323	5.3065	0.9531
D_Q13_1_Reserved	TV	20	0.000	1.1239	0.2513
	VR	30	-0.367	1.1885	0.2170
D_Q13_2_Trusting	TV	20	0.250	0.9105	0.2036
	VR	30	-0.367	1.4259	0.2603
D_Q13_3_Relaxed	TV	20	0.100	1.1653	0.2606
	VR	29	0.172	1.2268	0.2278
D_Q13_4_Outgoing	TV	17	0.206	1.3117	0.3181
	VR	30	0.167	1.5992	0.2920
D_Q13_5_GetsNervous	TV	19	-0.368	1.5352	0.3522
	VR	30	0.633	1.0334	0.1887
D_Q13_6_FindFault	TV	18	-0.111	0.7584	0.1788
	VR	31	-0.226	1.1750	0.2110
D_Q13_7_HandlesStress	TV	19	-0.211	1.1343	0.2602
	VR	31	0.065	1.0307	0.1851
D_GDS	TV	20	1.100	2.6537	0.5934
	VR	31	-0.226	1.6874	0.3031

D_Q15_1_SocialCompanionship	TV	20	-0.05	0.510	0.114
	VR	29	0.10	0.724	0.135
D_Q15_2_SocialLeftout	TV	21	0.095	0.6249	0.1364
	VR	31	0.000	0.7303	0.1312
D_Q15_3_SocialIsolated	TV	20	0.050	0.6048	0.1352
	VR	31	-0.097	0.7002	0.1258
D_Q21_Satisfied	TV	18	0.000	2.8284	0.6667
	VR	23	0.609	2.7092	0.5649
D_Q22_LikelyToUse	TV	19	0.105	2.0520	0.4708
	VR	25	0.560	2.7550	0.5510
D_Q23_LifelyToRecommend	TV	19	0.842	3.1844	0.7305
	VR	23	1.000	2.4309	0.5069

Table 13 TV vs. VR Post-Pre Differences Comparison

Same as single post-survey variable comparison, after running a t-test under confidence level α=0.1 (See

Appendix H: T-Test for TV & VR Pre and Post-Intervention Differences Comparison), some findings were

identified as follows:

- The VR group had a significant change of having higher perceived current overall health

  compared to TV group

- The VR group had a significant change of having better capability of performing vigorous

  activities compared to TV group

- The VR group had a significant change of being more trusting compared to TV group

- The VR group had a significant change of getting less nervous compared to TV group

- The VR group had a significant change of having a lower depression score compared to TV group

- The VR group had a change of having less life satisfaction compared to TV group

- The VR group had a change of having less positive affects compared to TV group

All the statistically significant results showed that VR had a better intervention results than TV, while 2 categories suggested that TV had better interventions than VR non-significantly.

6. Conclusion

This thesis work presented the first time of using human-centered design process for VR development specifically for older adults in long-term care communities. The results suggested that VR has much more benefits than TV even showing the same content. This Chapter answers the previous thesis questions as stated in Chapter 1.2.

6.1. Research conclusion

The two thesis questions that remained to be answers are as follows:

1) Will virtual reality work as an intervention tool that improves isolation, depression, and general perceived well-beings of older adults?

2) Is virtual reality a better form for delivering content than traditional television form?

For question 1, the results showed that VR significantly improved perceived overall health, and participants became significantly less likely to get nervous. Although other results were not statistically significant, there were more benefits than the baseline.

For question 2, the results were significantly enough to conclude that VR was a better form to delivery content to the older adults. All significant data suggested that VR produced better outcomes than the

TV. The overall review of the VR system was also better than the TV. Besides the survey results

suggested, the TV group had a retention rate of 75% while the VR group had a retention rate of 88.6%.

6.2.   Limitations

There are a few limitations that need to be acknowledged for this research. Firstly, the VR hardware was

very limited at the time of research. The resolution (how real it looked like), screen delay (that could

cause motion sickness), and interactions were so limited that participants did not feel it was real. This

could largely impact how participants perceived the VR system. Secondly, limited number of participants

were recruited. There were only 63 subjects for this research, and all of them were part of the research

because they were self-selected. These participants might have different results than others who might

not be interested in the research subject. Thirdly, the intervention was only for a short period of time

(two weeks). There might be more long-term results that was unable to be captured during this

research. Lastly, the survey results could be impacted by other variables. The weather, family incidents,

and the mood of the day, could largely impact the survey results.

6.3.   Contributions

The technology of tablet control for VR display in group settings developed for this study was one of the

first remotely synced control systems for VR. This thesis also advanced the VR field with a new

application in an underserved yet important market segment. By applying established affect measures

and technology adoption factors in a newly emerging field of technology, this thesis was one of the first

to explore ways of VR to improve the quality of life for older adults.

6.4.   Future work

Future studies should address the limitations as described in Chapter 6.2.

Hardware and content

As the VR hardware develops in the future with higher resolution, higher refresh rate, and lighter weight, a more real and better experience will be presented to the participants. One possible direction for future research is to utilize better hardware for testing. It is also recommended to compare two sets of low-end and high-end hardware for potential differences of results based on VR hardware attributes.

Future VR content would also need to be studied more by isolating control groups with different types of content. Comparing various types of content such as interactions, meditations, travel, reminiscence, and so on, would give future researchers perspectives on each category's effect on older adults.

Number of participants

The number of participants should be more statistically representable for a larger population. Various types of residents should be recruited, and various locations of communities should be included for data analysis.

Length of intervention

Future work should have a long-term intervention with potentially multiple surveys at the beginning, in the middle, and at the end. This will help the researchers to understand both short-term impact and long-term impact of VR on older adults.

Survey design

A more stable way of capturing the affect and well-being changes should be considered and implemented. Questions asked in the survey should not change based on the time of the day and mood the subject was in on that particular day.

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Appendix A: Pre-Survey

Pre-Study Questionnaire

For the following questions, please circle, mark or write the one best response unless otherwise noted. If you need more space for an answer, please note the question number and continue on the back of each sheet. Your participation in this study is completely voluntary, and you may refuse to answer any questions or end your participation in the survey at any time. Skipping any question that makes you feel uncomfortable will not exclude you from the study.

1. What is your date of birth? _____ (month / year)

2. Are you: Male   Female

3. Overall, how satisfied would you say you are with your life?

1	2	3	4	5
Very dissatisfied	Somewhat dissatisfied	Neither satisfied nor dissatisfied	Somewhat satisfied	Very satisfied

4. How would you describe your overall health?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

5. How would you describe your current emotional well-being?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

6. How would you describe your current social well-being?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

7. How would you describe your current physical well-being?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

8. Compared to one year ago, how would you rate your health in general now?

1	2	3	4	5
Much worse now	Somewhat worse now	About the same	Somewhat better	Much better

9. The following items are about activities you might do during a typical day. To what extent would you say that your health limits you in these activities?

		Not at all	A little	Moderately	Quite a bit	Extremely
9-1.	Vigorous activities (e.g. running, lifting heavy objects, strenuous sports)	1	2	3	4	5
9-2.	Moderate activities (e.g. moving a table, pushing a vacuum cleaner, bowling, playing golf)	1	2	3	4	5
9-3.	Entertainment/recreational activities	1	2	3	4	5

10. During the past few weeks, to what extent has your physical health interfered with your normal social activities with family, friends, neighbors, or groups?

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

11. During the past few weeks, to what extent have your emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

12. How much bodily pain have you had during the past few weeks?

1	2	3	4	5	6
None	Very mild	Mild	Moderate	Severe	Very severe

13. During the past few weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

14. The terms below describe different feelings and emotions. Please indicate the extent to which you have felt this way over the past few weeks:

		Not at all	A little	Moderately	Quite a bit	Extremely
14-1.	Determined	1	2	3	4	5
14-2.	Alert	1	2	3	4	5
14-3.	Excited	1	2	3	4	5
14-4.	Enthusiastic	1	2	3	4	5
14-5.	Inspired	1	2	3	4	5
14-6.	Scared	1	2	3	4	5
14-7.	Distressed	1	2	3	4	5
14-8.	Upset	1	2	3	4	5
14-9.	Nervous	1	2	3	4	5
14-10.	Afraid	1	2	3	4	5

15. To what extent do you agree with the following statements about yourself?
    "I see myself as someone who _____"

		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
15-1.	Is reserved	1	2	3	4	5
15-2.	Is generally trusting	1	2	3	4	5
15-3.	Is relaxed	1	2	3	4	5
15-4.	Is outgoing, sociable	1	2	3	4	5
15-5.	Gets nervous easily	1	2	3	4	5
15-6.	Tends to find fault with others	1	2	3	4	5
15-7.	Handles stress well	1	2	3	4	5

16. For the following questions, please circle the best answer for how you have felt over the past week. [GDS]

		Yes	No
16-1.	Are you basically satisfied with your life?	1	2
16-2.	Have you dropped many of your activities and interests?	1	2
16-3.	Do you feel your life is empty?	1	2
16-4.	Do you often get bored?	1	2
16-5.	Are you in good spirits most of the time?	1	2
16-6.	Are you afraid that something bad is going to happen to you?	1	2
16-7.	Do you feel happy most of the time?	1	2
16-8.	Do you feel helpless?	1	2
16-9.	Do you prefer to stay at home, rather than go out and do new things?	1	2
16-10.	Do you feel you have more problems with your memory than most?	1	2
16-11.	Do you think it is wonderful to be alive now?	1	2
16-12.	Do you feel pretty worthless the way you are now?	1	2

16-13.	Do you feel full of energy?	1	2
16-14.	Do you feel that your situation is hopeless?	1	2
16-15.	Do you think that most people are better off than you are?	1	2

17. Indicate how often each of the statements below is descriptive of you.

		Hardly ever	Some of the time	Often
17-1.	How often do you feel that you lack companionship?	1	2	3
17-2.	How often do you feel left out?	1	2	3
17-3.	How often do you feel isolated from others?	1	2	3

18. How would you rate your level of experience with technology?

1	2	3	4	5	6	7	8	9	10
Very inexperienced									Very experienced

19. Some people prefer to avoid new technologies as long as possible while others like to try them out as soon as they become available. In general, how would you rate yourself as being an avoider of new technology or an early user of new technology?

1	2	3	4	5	6	7	8	9	10
Avoid as long as possible									Try as soon as possible

20. How would you rate your ability to learn how to use new technologies?

1	2	3	4	5	6	7	8	9	10
Very poor									Very good

21. How would you rate your overall level of trust in technology?

1	2	3	4	5	6	7	8	9	10
Very distrustful									Very trustful

Please conduct a first session of Rendever armchair travel then ask the following questions

22. How much do you agree with the following statements regarding the armchair travel system that you will be using for this study?
   "I think the armchair travel _____ "

		Yes	No
22-1.	Will be valuable and useful	1	2
22-2.	Will be easy to use	1	2
22-3.	Would be inexpensive if I were to buy it	1	2
22-4.	Will be easy to find where to purchase the system	1	2
22-5.	Will have good technical assistance	1	2
22-6.	Is something that my family and friends would approve of	1	2
22-7.	Will provide emotional benefits to me	1	2
22-8.	Will enable me to stay independent	1	2
22-9.	Will provide me a sense of accomplishment	1	2
22-10.	Makes me feel confident about using the system	1	2
22-11.	Will work over time without breaking	1	2
22-12.	Is backed up by a trustable service structure	1	2
22-13.	Will fit into my lifestyle	1	2
22-14.	Will improve my daily life	1	2
22-15.	Will work in a way that makes sense to me	1	2

23. Based on your impression today, how satisfied are you with the armchair travel system?

1	2	3	4	5	6	7	8	9	10
Very dissatisfied									Very satisfied

24. Based on your impression today, how likely are you to consider using the armchair travel system in the future?

1	2	3	4	5	6	7	8	9	10
Not at all likely									Very likely

25. Based on your impression today, how likely are you to recommend to a friend or family member that they consider trying the armchair travel system?

1	2	3	4	5	6	7	8	9	10
Not at all likely									Very likely

26. Please check if you have been diagnosed (told by a doctor) that you have had, or currently have, any of the following medical conditions:

    26-1. _____ heart attack

26-2. _____ angina

26-3. _____ irregular heart rhythm

26-4. _____ high blood pressure

26-5. _____ high cholesterol

26-6. _____ diabetes

26-7. _____ thyroid condition

26-8. _____ stroke or TIA

26-9. _____ arthritis, rheumatism

26-10. _____ fibromyalgia

26-11. _____ chronic pain

26-12. _____ Parkinson's disease

26-13. _____ gastrointestinal problems, GRD

26-14. _____ spinal surgery

26-15. _____ blood clot in leg or lung

26-16. _____ hip fracture

26-17. _____ hip or knee replacement

26-18. _____ depression

26-19. _____ cancer

26-20. _____ dementia or Alzheimer's

27. Do you currently have any medical conditions not listed above?
    If yes, please list below. If no, please check here _____ and skip to the next question.

    27-1. _____

    27-2. _____

    27-3. _____

    27-4. _____

28. Approximately how many times have you seen a medical doctor in the past 12 months?

    _____

What is your current marital status?

1. Single, never married
2. Married or living as married
3. Widowed
4. Divorced
5. Other – please specify:_____
6. Prefer not to answer

What is the highest level of education you have completed?

1. Some high school or less
2. High school
3. Some college
4. Trade / technical / vocational school
5. College
6. Some post-graduate work
7. Post-graduate degree (MS, PhD, MBA, MPH, MSW, etc.)

What ethnicity do you most closely identify yourself with? Please choose all that apply.

1. White
2. Black or African-American
3. Hispanic or Latino
4. Asian or Asian-American
5. Native American
6. Hawaiian or Pacific Islander
7. Other – please specify: _____]

What is your current employment status? Please choose all that apply.

1. Employed full-time
2. Employed part-time
3. Not employed
4. Self-employed
5. Retired
6. Other – please specify: _____

What is your total annual household income, before taxes?

1. Under $25000
2. $25000 ~ $49999
3. $50000 ~ $74999
4. $75000 ~ $99999
5. $10000 ~ $149999
6. $150000 or more

Appendix B: Post-Survey

Post-Study Questionnaire

For the following questions, please circle, mark or write the one best response unless otherwise noted. If you need more space for an answer, please note the question number and continue on the back of each sheet. Your participation in this study is completely voluntary, and you may refuse to answer any questions or end your participation in the survey at any time. Skipping any question that makes you feel uncomfortable will not exclude you from the study.

1. Overall, how satisfied would you say you are with your life?

1	2	3	4	5
Very dissatisfied	Somewhat dissatisfied	Neither satisfied nor dissatisfied	Somewhat satisfied	Very satisfied

2. How would you describe your overall health?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

3. How would you describe your current emotional well-being?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

4. How would you describe your current social well-being?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

5. How would you describe your current physical well-being?

1	2	3	4	5
Poor	Fair	Average	Good	Excellent

6. Compared to one year ago, how would you rate your health in general now?

1	2	3	4	5

Much worse now	Somewhat worse now	About the same	Somewhat better	Much better

7. The following items are about activities you might do during a typical day. To what extent would you say that your health limits you in these activities?

		Not at all	A little	Moderately	Quite a bit	Extremely
7-1.	Vigorous activities (e.g. running, lifting heavy objects, strenuous sports)	1	2	3	4	5
7-2.	Moderate activities (e.g. moving a table, pushing a vacuum cleaner, bowling, playing golf)	1	2	3	4	5
7-3.	Entertainment/recreational activities	1	2	3	4	5

8. During the past few weeks, to what extent has your physical health interfered with your normal social activities with family, friends, neighbors, or groups?

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

9. During the past few weeks, to what extent have your emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

10. How much bodily pain have you had during the past few weeks?

1	2	3	4	5	6
None	Very mild	Mild	Moderate	Severe	Very severe

11. During the past few weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

12. The terms below describe different feelings and emotions. Please indicate the extent to which you have felt this way over the past few weeks:

		Not at all	A little	Moderately	Quite a bit	Extremely
12-1.	Determined	1	2	3	4	5
12-2.	Alert	1	2	3	4	5
12-3.	Excited	1	2	3	4	5
12-4.	Enthusiastic	1	2	3	4	5
12-5.	Inspired	1	2	3	4	5
12-6.	Scared	1	2	3	4	5
12-7.	Distressed	1	2	3	4	5
12-8.	Upset	1	2	3	4	5
12-9.	Nervous	1	2	3	4	5
12-10.	Afraid	1	2	3	4	5

13. To what extent do you agree with the following statements about yourself?
    "I see myself as someone who _____ "

		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
13-1.	Is reserved	1	2	3	4	5
13-2.	Is generally trusting	1	2	3	4	5
13-3.	Is relaxed	1	2	3	4	5
13-4.	Is outgoing, sociable	1	2	3	4	5
13-5.	Gets nervous easily	1	2	3	4	5
13-6.	Tends to find fault with others	1	2	3	4	5
13-7.	Handles stress well	1	2	3	4	5

14. For the following questions, please circle the best answer for how you have felt over the past week. [GDS]

		Yes	No
14-1.	Are you basically satisfied with your life?	1	2
14-2.	Have you dropped many of your activities and interests?	1	2
14-3.	Do you feel your life is empty?	1	2
14-4.	Do you often get bored?	1	2
14-5.	Are you in good spirits most of the time?	1	2

14-6.	Are you afraid that something bad is going to happen to you?	1	2
14-7.	Do you feel happy most of the time?	1	2
14-8.	Do you feel helpless?	1	2
14-9.	Do you prefer to stay at home, rather than go out and do new things?	1	2
14-10.	Do you feel you have more problems with your memory than most?	1	2
14-11.	Do you think it is wonderful to be alive now?	1	2
14-12.	Do you feel pretty worthless the way you are now?	1	2
14-13.	Do you feel full of energy?	1	2
14-14.	Do you feel that your situation is hopeless?	1	2
14-15.	Do you think that most people are better off than you are?	1	2

15. Indicate how often each of the statements below is descriptive of you.

		Hardly ever	Some of the time	Often
15-1.	How often do you feel that you lack companionship?	1	2	3
15-2.	How often do you feel left out?	1	2	3
15-3.	How often do you feel isolated from others?	1	2	3

16. How would you rate your level of experience with technology?

1	2	3	4	5	6	7	8	9	10
Very inexperienced									Very experienced

17. Some people prefer to avoid new technologies as long as possible while others like to try them out as soon as they become available. In general, how would you rate yourself as being an avoider of new technology or an early user of new technology?

1	2	3	4	5	6	7	8	9	10
Avoid as long as possible									Try as soon as possible

18. How would you rate your ability to learn how to use new technologies?

1	2	3	4	5	6	7	8	9	10
Very poor									Very good

19. How would you rate your overall level of trust in technology?

1	2	3	4	5	6	7	8	9	10
Very distrustful									Very trustful

20. How much do you agree with the following statements regarding the armchair travel system that you have used for the past 2 weeks?

"I think the armchair travel _____"

		Yes	No
20-1.	Will be valuable and useful	1	2
20-2.	Will be easy to use	1	2
20-3.	Would be inexpensive if I were to buy it	1	2
20-4.	Will be easy to find where to purchase the system	1	2
20-5.	Will have good technical assistance	1	2
20-6.	Is something that my family and friends would approve of	1	2
20-7.	Will provide emotional benefits to me	1	2
20-8.	Will enable me to stay independent	1	2
20-9.	Will provide me a sense of accomplishment	1	2
20-10.	Makes me feel confident about using the system	1	2
20-11.	Will work over time without breaking	1	2
20-12.	Is backed up by a trustable service structure	1	2
20-13.	Will fit into my lifestyle	1	2
20-14.	Will improve my daily life	1	2
20-15.	Will work in a way that makes sense to me	1	2

21. Based on your study experience, how satisfied are you with the armchair travel system?

1	2	3	4	5	6	7	8	9	10
Very dissatisfied									Very satisfied

22. Based on your study experience, how likely are you to consider using the armchair travel system in the future?

1	2	3	4	5	6	7	8	9	10
Not at all likely									Very likely

23. Based on your study experience, how likely are you to recommend to a friend or family member that they consider using the armchair travel system?

1	2	3	4	5	6	7	8	9	10
Not at all likely									Very likely

24. During the study experience, about how many times per day did you use the armchair travel on average? _____

25. During the study experience, on average, how many minutes did you use the armchair travel for each time? _____

26. Based on your study experience, how did you feel about the different type of content?

		Not enjoyable at all				Very enjoyable
26-1.	Meditation	1	2	3	4	5
26-2.	Travel	1	2	3	4	5
26-3.	Cultural	1	2	3	4	5
26-4.	Memory Lane	1	2	3	4	5
26-5.	Relaxation	1	2	3	4	5

27. How did participating in the study affect the following?

27-1.	Quality of diet	Negatively	No effect	Positively
27-2.	Taking medications on time	Negatively	No effect	Positively
27-3.	Ability to have new conversations	Negatively	No effect	Positively
27-4.	Quality of sleep	Negatively	No effect	Positively
27-5.	Amount that you've slept	Negatively	No effect	Positively
27-6.	Social activities	Negatively	No effect	Positively
27-7.	Physical activities	Negatively	No effect	Positively
27-8.	Desire to be more social in the community	Negatively	No effect	Positively

28. Based on your study experience, how comfortable were you using the armchair travel system?

1	2	3	4	5	6	7	8	9	10
Not comfortable at all									Very comfortable

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Guided tours allow multiple residents to enjoy shared experiences. Tours include lesson plans and tips for the activity leader

"I get to know part of the world that I've thought about and never knew what it looks like...and now I do"
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MIT AGELAB

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rendever.com

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Appendix D: Consent Form – VR

CONSENT TO PARTICIPATE IN NEW PRODUCT RESEARCH

Exploratory study on use of armchair travel system in older adults

You are asked to participate in a research study conducted by Joseph F. Coughlin, Ph.D., Lisa D'Ambrosio, Ph.D., Chaiwoo Lee, Ph.D., Masakazu Nagata, and Charles Lin from the MIT AgeLab and Massachusetts Institute of Technology (M.I.T.). You were selected as a possible participant in this study because you are a resident of a Benchmark Senior Living property. You should read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

- **PARTICIPATION AND WITHDRAWAL**

Your participation in this study is completely voluntary and you are free to choose whether to be in it or not. If you choose to be in this study, you may subsequently withdraw from it at any time without penalty or consequences of any kind. The investigator may withdraw you from this research if circumstances arise which warrant doing so. The circumstances under which your participation in the study would be terminated by us without your consent would include misuse or inappropriate use of the system, and other materials provided.

- **PURPOSE OF THE STUDY**

The purpose of the study will be to look at the impact of the armchair travel experience on reducing social isolation and improved emotional well-being by providing older adults with access to immersive experiences including relaxation, cultural and global travel experiences. In this study, residents will be provided non-invasive headsets that immerse the user in a virtual environment in order to measure the potential positive benefits of using the device. Charles Lin and Masakazu Nagata have worked in Rendever for the MIT accelerator this summer, however this study is for the purpose for Charles Lin's Master thesis.

- **PROCEDURES**

If you volunteer to participate in this study, we would ask you to do the following things:

First of all, you will read and sign a consent form. We will help narrate this form to you. Once you have signed the form, research staff will visit you to ask you to complete a questionnaire with a short interview, install and test the study equipment, and train you on the use of the system. The questionnaire and interview will take no more than 30 minutes to complete. We expect the training to last anywhere from 30 minutes until you feel comfortable with the study equipment.

The technology consists of a mobile phone that is placed in a headset that allows the users to immerse themselves in a virtual environment with varying content including enjoyable travel and cultural experiences. The VR goggles are consisted of the off-the-shelf Samsung GearVR and Samsung Galaxy S7 cell phones. The GearVR face foam is also coated with skin-safe antimicrobial (AEM 5700 Antimicrobial). When the you start the session, the activity associate will help to put the GearVR on the your head to fully cover yours eyes with comfortable position. You will look at the VR(phone screen) through the GearVR. In addition, there is a tablet that allows activity associate to access and manage the content for you to go through the variety of content for instance traveling, lessons, and childhood homes.

The study equipment will be in the community for 2 weeks. During this period, you will be asked to participate in immersive cultural, relaxation and travel experiences using the armchair travel system for about 20 minutes per day. During these 20-minute sessions, you will have the opportunity to select from a variety of content to enjoy. The activity associates from the facility will guide you through all the activities. They will be presented at all times while you are using the equipment.

At the end of the study period, research staff will visit your community to collect the study equipment and you will be asked to complete an exit survey questionnaire with a short interview. The questionnaire and interview will take no more than 30 minutes to complete.

- **POTENTIAL RISKS AND DISCOMFORTS**

Using armchair travel can sometimes cause people discomfort. Some residents who are prone to nausea and motion sickness may have this discomfort. Our staff has curated a variety of content to avoid this problem. Most of the content will be still images. We can show videos upon request. If you begin to feel related symptoms, we recommend you to inform the activity associate and remove the headset. After removing the goggles, you may still experience some nausea and/or vertigo. If you do, please do not stand up on your own. If you feel that you need medical attention, please contact the staff immediately.

- **POTENTIAL BENEFITS**

Armchair travel has been shown to be an enjoyable experience for many by providing new opportunities to experience immersive entertainment such as a trip to Paris or a canoe ride down the Colorado River without having to leave the comfort of your own home. In previous studies, armchair travel has been shown to reduce pain, depression and symptoms related to cognitive decline.

The results from this research will indicate how well this armchair travel system, which was created for use in long-term care communities, can help improve well-being for older adults.

- **PAYMENT FOR PARTICIPATION**

If you remain in the study throughout the period in which the armchair travel system is in your community, participate in the daily armchair travel activities and complete the exit survey, you will receive MIT memorabilia and enter a raffle for a $50 gift card.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.

Information from this study may be used for research purposes and may be published; however, your name or any information that would identify you or your family uniquely will not be used in any publications. Information from the study including personal quotes you may provide the research staff with in terms of feedback or open responses to questionnaire items, which may be used in future publications, will be kept anonymous.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about the research, please feel free to contact Charles Lin, 99 Bay State Road, Boston, 02215 (508-713-3118) or Dr. Joseph Coughlin, 77 Massachusetts Avenue, E40-278, Cambridge, MA 01238 (617-253-4978)

- **EMERGENCY CARE AND COMPENSATION FOR INJURY**

If you feel you have suffered an injury, which may include emotional trauma, as a result of participating in this study, please contact the person in charge of the study as soon as possible.

In the event you suffer such an injury, M.I.T. may provide itself, or arrange for the provision of, emergency transport or medical treatment, including emergency treatment and follow-up care, as needed, or reimbursement for such medical services. M.I.T. does not provide any other form of compensation for injury. In any case, neither the offer to provide medical assistance, nor the actual provision of medical services shall be considered an admission of fault or acceptance of liability. Questions regarding this policy may be directed to MIT's Insurance Office, (617) 253-2823. Your insurance carrier may be billed for the cost of emergency transport or medical treatment, if such services are determined not to be directly related to your participation in this study.

- **RIGHTS OF RESEARCH SUBJECTS**

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you feel you have been treated unfairly, or you have questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143B, 77 Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253 6787.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Name of Subject

_____

Name of Legal Representative (if applicable)

_____   _____

Signature of Subject or Legal Representative   Date

SIGNATURE OF INVESTIGATOR

In my judgment the subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

_____   _____

Signature of Investigator   Date

Appendix E: Consent Form – TV

CONSENT TO PARTICIPATE IN NEW PRODUCT RESEARCH

Exploratory study on use of armchair travel system in older adults

You are asked to participate in a research study conducted by Joseph F. Coughlin, Ph.D., Lisa D'Ambrosio, Ph.D., Chaiwoo Lee, Ph.D., Masakazu Nagata, and Charles Lin from the MIT AgeLab and Massachusetts Institute of Technology (M.I.T.). You were selected as a possible participant in this study because you are a resident of a Benchmark Senior Living property. You should read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

- **PARTICIPATION AND WITHDRAWAL**

Your participation in this study is completely voluntary and you are free to choose whether to be in it or not. If you choose to be in this study, you may subsequently withdraw from it at any time without penalty or consequences of any kind. The investigator may withdraw you from this research if circumstances arise which warrant doing so. The circumstances under which your participation in the study would be terminated by us without your consent would include misuse or inappropriate use of the system, and other materials provided.

- **PURPOSE OF THE STUDY**

The purpose of the study will be to look at the impact of the armchair travel experience on reducing social isolation and improved emotional well-being by providing older adults with access to 360 experiences including relaxation, cultural and global travel experiences. In this study, residents will be provided 360-degree content on the TV in order to measure the potential positive benefits of using the device. Charles Lin and Masakazu Nagata have worked in Rendever for the MIT accelerator this summer, however this study is for the purpose for Charles Lin's Master thesis.

- **PROCEDURES**

If you volunteer to participate in this study, we would ask you to do the following things:

First of all, you will read and sign a consent form. We will help narrate this form to you. Once you have signed the form, research staff will visit you to ask you to complete a questionnaire with a short interview, install and test the study equipment, and train you on the use of the system. The questionnaire and interview will take no more than 30 minutes to complete. We expect the training to last anywhere from 30 minutes until you feel comfortable with the study equipment.

The technology consists of a tablet that controls the content showing on a TV with varying content including enjoyable travel and cultural experiences. When the you start the session, the activity associate will help setup the TV and tablet. You will look at the TV. In addition, there is a tablet that allows activity

associate to access and manage the content for you to go through the variety of content for instance traveling, lessons, and childhood homes.

The study equipment will be in the community for 2 weeks. During this period, you will be asked to participate in cultural, relaxation and travel experiences using the armchair travel system for about 20 minutes per day. During these 20-minute sessions, you will have the opportunity to select from a variety of content to enjoy. The activity associates from the facility will guide you through all the activities. They will be presented at all times while you are using the equipment.

At the end of the study period, research staff will visit your community to collect the study equipment and you will be asked to complete an exit survey questionnaire with a short interview. The questionnaire and interview will take no more than 30 minutes to complete.

- **POTENTIAL RISKS AND DISCOMFORTS**

Using armchair travel can sometimes cause people discomfort. Some residents who are prone to nausea and motion sickness may have this discomfort. Our staff has curated a variety of content to avoid this problem. Most of the content will be still images. We can show videos upon request. If you begin to feel related symptoms, we recommend you to inform the activity associate. Please do not stand up on your own. If you feel that you need medical attention, please contact the staff immediately.

- **POTENTIAL BENEFITS**

Armchair travel has been shown to be an enjoyable experience for many by providing new opportunities to experience entertainment such as a trip to Paris or a canoe ride down the Colorado River without having to leave the comfort of your own home. In previous studies, armchair travel has been shown to reduce pain, depression and symptoms related to cognitive decline.

The results from this research will indicate how well this armchair travel system, which was created for use in long-term care communities, can help improve well-being for older adults.

- **PAYMENT FOR PARTICIPATION**

If you remain in the study throughout the period in which the armchair travel system is in your community, participate in the daily armchair travel activities and complete the exit survey, you will receive MIT memorabilia and enter a raffle for a $50 gift card.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.

Information from this study may be used for research purposes and may be published; however, your name or any information that would identify you or your family uniquely will not be used in any publications. Information from the study including personal quotes you may provide the research staff with in terms of feedback or open responses to questionnaire items, which may be used in future publications, will be kept anonymous.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about the research, please feel free to contact Charles Lin, 99 Bay State Road, Boston, 02215 (508-713-3118) or Dr. Joseph Coughlin, 77 Massachusetts Avenue, E40-278, Cambridge, MA 01238 (617-253-4978)

- **EMERGENCY CARE AND COMPENSATION FOR INJURY**

If you feel you have suffered an injury, which may include emotional trauma, as a result of participating in this study, please contact the person in charge of the study as soon as possible.

In the event you suffer such an injury, M.I.T. may provide itself, or arrange for the provision of, emergency transport or medical treatment, including emergency treatment and follow-up care, as needed, or reimbursement for such medical services. M.I.T. does not provide any other form of compensation for injury. In any case, neither the offer to provide medical assistance, nor the actual provision of medical services shall be considered an admission of fault or acceptance of liability. Questions regarding this policy may be directed to MIT's Insurance Office, (617) 253-2823. Your insurance carrier may be billed for the cost of emergency transport or medical treatment, if such services are determined not to be directly related to your participation in this study.

- **RIGHTS OF RESEARCH SUBJECTS**

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you feel you have been treated unfairly, or you have questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143B, 77 Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253 6787.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Name of Subject

_____

Name of Legal Representative (if applicable)

_____   _____

Signature of Subject or Legal Representative   Date

SIGNATURE OF INVESTIGATOR

In my judgment the subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

_____   _____

Signature of Investigator   Date

Appendix F: Content Schedule

The following message was sent to all participating communities:

All content should be picked so that residents all agreed to watch. Otherwise it is forcing someone watching a bad movie.

All residents should have 8 sessions of 20-min using time, not including setup time.

Day 1 pick some videos that is ~20 min long in total (do not use up all videos, maximum half)

Day 2 do one activity guide

Day 3 do one activity guide

Day 4 do one activity guide

Day 5 explore different places around the world

Day 6 do one activity guide

Day 7 in custom search, visit people's childhood homes by asking for address (number and street, town name), ask people to tell stories

Day 8 pick some videos that is ~20 min long in total

Appendix G: T-Test for TV & VR Post-Intervention Results Comparison

for Each Variable

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post_Q1_LifeSatisfaction	Equal variances assumed	0.000	0.993	0.137	50	0.891	0.0538	0.3917	-0.7329	0.8404
	Equal variances not assumed			0.137	42.928	0.892	0.0538	0.3921	-0.7370	0.8445
Post_Q2_OverallHealth	Equal variances assumed	5.145	0.028	-1.947	50	0.057	-0.6175	0.3172	-1.2547	0.0197
	Equal variances not assumed			-1.841	34.680	0.074	-0.6175	0.3354	-1.2987	0.0636
Post_Q3_WellBeingEmotional	Equal variances assumed	0.027	0.870	-1.650	50	0.105	-0.4270	0.2589	-0.9470	0.0929
	Equal variances not assumed			-1.710	47.796	0.094	-0.4270	0.2498	-0.9293	0.0752
Post_Q4_WellBeingSocial	Equal variances assumed	8.585	0.005	-1.600	49	0.116	-0.4667	0.2916	-1.0526	0.1193
	Equal variances not assumed			-1.462	29.345	0.154	-0.4667	0.3191	-1.1190	0.1857
Post_Q5_WellBeingPhysical	Equal variances assumed	2.268	0.138	-2.460	50	0.017	-0.7573	0.3079	-1.3757	-0.1389
	Equal variances not assumed			-2.317	34.107	0.027	-0.7573	0.3269	-1.4215	-0.0931
Post_Q7_1_HealthLimitsActivities_Vigorous	Equal variances assumed	2.188	0.155	0.729	19	0.475	0.3077	0.4222	-0.5759	1.1913
	Equal variances			0.786	18.253	0.442	0.3077	0.3915	-0.5140	1.1294

									Lower	Upper
	not assumed									
Post_Q7_2 _HealthLim itsActivities _Moderate	Equal variances assumed	1.011	0.324	-0.873	25	0.391	-0.3667	0.4200	-1.2317	0.4983
	Equal variances not assumed			-0.897	25.000	0.378	-0.3667	0.4089	-1.2088	0.4755
Post_Q7_3 _HealthLim itsActivities _Entertain ment	Equal variances assumed	2.063	0.160	0.064	35	0.949	0.0235	0.3685	-0.7245	0.7716
	Equal variances not assumed			0.065	35.000	0.949	0.0235	0.3635	-0.7144	0.7615
Post_Q8_S ocialInterfe rence_Phys ical	Equal variances assumed	0.149	0.701	0.861	50	0.394	0.3287	0.3820	-0.4385	1.0960
	Equal variances not assumed			0.867	44.139	0.391	0.3287	0.3793	-0.4356	1.0930
Post_Q9_S ocialInterfe rence_Emo tional	Equal variances assumed	0.191	0.664	1.556	49	0.126	0.5048	0.3243	-0.1470	1.1566
	Equal variances not assumed			1.540	41.550	0.131	0.5048	0.3278	-0.1569	1.1665
Post_PANA S_Positive	Equal variances assumed	1.157	0.287	-1.064	50	0.292	-1.2289	1.1548	-3.5484	1.0906
	Equal variances not assumed			-1.108	48.235	0.274	-1.2289	1.1095	-3.4593	1.0015
Post_PANA S_Negative	Equal variances assumed	0.208	0.650	0.284	49	0.777	0.3710	1.3050	-2.2515	2.9935
	Equal variances not assumed			0.293	44.634	0.771	0.3710	1.2660	-2.1796	2.9215
Post_Q13_ 1_Reserved	Equal variances assumed	0.000	0.986	1.542	49	0.130	0.3810	0.2471	-0.1156	0.8775
	Equal variances not assumed			1.610	48.331	0.114	0.3810	0.2366	-0.0946	0.8565
Post_Q13_ 2_Trusting	Equal variances assumed	1.598	0.212	0.444	50	0.659	0.0983	0.2213	-0.3461	0.5428
	Equal variances			0.473	49.802	0.638	0.0983	0.2077	-0.3190	0.5156

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
	not assumed									
Post_Q13_3_Relaxed	Equal variances assumed	0.011	0.916	0.288	49	0.775	0.0762	0.2648	-0.4559	0.6083
	Equal variances not assumed			0.288	43.313	0.775	0.0762	0.2646	-0.4573	0.6097
Post_Q13_4_Outgoing	Equal variances assumed	0.468	0.497	-0.764	48	0.448	-0.2333	0.3052	-0.8471	0.3804
	Equal variances not assumed			-0.771	42.029	0.445	-0.2333	0.3027	-0.8442	0.3775
Post_Q13_5_GetsNervous	Equal variances assumed	0.478	0.493	-2.585	49	0.013	-0.7742	0.2995	-1.3760	-0.1724
	Equal variances not assumed			-2.436	32.848	0.020	-0.7742	0.3178	-1.4209	-0.1274
Post_Q13_6_FindFault	Equal variances assumed	1.665	0.203	-0.455	50	0.651	-0.1367	0.3007	-0.7407	0.4672
	Equal variances not assumed			-0.474	48.284	0.638	-0.1367	0.2887	-0.7171	0.4437
Post_Q13_7_HandlesStress	Equal variances assumed	0.192	0.663	0.574	50	0.569	0.1690	0.2946	-0.4228	0.7607
	Equal variances not assumed			0.585	45.804	0.562	0.1690	0.2890	-0.4129	0.7508
Post_GDS	Equal variances assumed	5.701	0.021	1.468	49	0.148	1.335	0.909	-0.492	3.163
	Equal variances not assumed			1.388	33.200	0.175	1.335	0.962	-0.622	3.293
Post_Q15_1_SocialCompanionship	Equal variances assumed	0.000	0.993	0.289	50	0.774	0.0553	0.1912	-0.3287	0.4393
	Equal variances not assumed			0.289	43.121	0.774	0.0553	0.1912	-0.3302	0.4408
Post_Q15_2_SocialLeftout	Equal variances assumed	0.448	0.507	0.439	50	0.662	0.0876	0.1994	-0.3129	0.4880
	Equal variances			0.431	40.174	0.669	0.0876	0.2032	-0.3232	0.4983

	not assumed									
Post_Q15_3_SocialIsolated	Equal variances assumed	1.417	0.239	0.960	50	0.341	0.1536	0.1599	-0.1676	0.4749
	Equal variances not assumed			0.941	39.917	0.353	0.1536	0.1633	-0.1765	0.4837
Post_Q21_Satisfied	Equal variances assumed	0.309	0.581	-1.908	45	0.063	-1.3678	0.7170	-2.8120	0.0764
	Equal variances not assumed			-1.840	32.054	0.075	-1.3678	0.7434	-2.8820	0.1464
Post_Q22_LikelyToUse	Equal variances assumed	6.471	0.014	-1.801	47	0.078	-1.5509	0.8613	-3.2836	0.1818
	Equal variances not assumed			-1.944	46.332	0.058	-1.5509	0.7979	-3.1567	0.0550
Post_Q23_LifelyToRecommend	Equal variances assumed	0.222	0.639	-0.880	45	0.383	-0.7838	0.8905	-2.5773	1.0097
	Equal variances not assumed			-0.878	38.502	0.385	-0.7838	0.8925	-2.5898	1.0221

Appendix H: T-Test for TV & VR Pre and Post-Intervention Differences

Comparison

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
									Lower	Upper
D_Q1_LifeSatisfaction	Equal variances assumed	3.859	0.055	1.320	50	0.193	0.5161	0.3911	-0.2694	1.3017
	Equal variances not assumed			1.422	49.999	0.161	0.5161	0.3629	-0.2127	1.2450
D_Q2_OverallHealth	Equal variances assumed	0.968	0.330	-2.142	49	0.037	-0.5694	0.2658	-1.1036	-0.0351
	Equal variances not assumed			-2.185	43.341	0.034	-0.5694	0.2606	-1.0948	-0.0439
D_Q3_WellBeingEmotional	Equal variances assumed	5.561	0.022	0.047	49	0.962	0.0119	0.2512	-0.4928	0.5166
	Equal variances not assumed			0.051	48.963	0.960	0.0119	0.2348	-0.4600	0.4838
D_Q4_WellBeingSocial	Equal variances assumed	2.113	0.152	-0.457	49	0.650	-0.1333	0.2916	-0.7193	0.4526
	Equal variances not assumed			-0.482	48.840	0.632	-0.1333	0.2764	-0.6888	0.4222
D_Q5_WellBeingPhysical	Equal variances assumed	0.007	0.932	-0.845	50	0.402	-0.1935	0.2290	-0.6536	0.2665
	Equal variances not assumed			-0.836	41.481	0.408	-0.1935	0.2315	-0.6609	0.2738
D_Q7_1_HealthLimitsActivities_Vigorous	Equal variances assumed	0.722	0.417	2.018	9	0.074	0.9667	0.4791	-0.1171	2.0504
	Equal variances			2.156	7.234	0.067	0.9667	0.4485	-0.0869	2.0202

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
	not assumed									
D_Q7_2_HealthLimitsActivities_Moderate	Equal variances assumed	1.626	0.223	0.284	14	0.781	0.1250	0.4407	-0.8202	1.0702
	Equal variances not assumed			0.284	10.002	0.782	0.1250	0.4407	-0.8569	1.1069
D_Q7_3_HealthLimitsActivities_Entertainment	Equal variances assumed	0.124	0.727	0.642	28	0.526	0.3036	0.4725	-0.6643	1.2715
	Equal variances not assumed			0.629	23.502	0.535	0.3036	0.4826	-0.6936	1.3007
D_Q8_SocialInterference_Physical	Equal variances assumed	0.104	0.748	0.866	48	0.391	0.2989	0.3451	-0.3950	0.9927
	Equal variances not assumed			0.876	44.934	0.386	0.2989	0.3412	-0.3884	0.9861
D_Q9_SocialInterference_Emotional	Equal variances assumed	0.442	0.509	-0.155	48	0.877	-0.0500	0.3218	-0.6970	0.5970
	Equal variances not assumed			-0.161	45.268	0.873	-0.0500	0.3109	-0.6761	0.5761
D_PANAS_Positive	Equal variances assumed	0.116	0.735	1.569	50	0.123	2.4178	1.5411	-0.6775	5.5131
	Equal variances not assumed			1.595	45.443	0.118	2.4178	1.5159	-0.6346	5.4703
D_PANAS_Negative	Equal variances assumed	0.481	0.491	0.256	48	0.799	0.3752	1.4651	-2.5706	3.3210
	Equal variances not assumed			0.266	42.847	0.791	0.3752	1.4097	-2.4679	3.2184
D_Q13_1_Reserved	Equal variances assumed	0.064	0.802	1.092	48	0.280	0.3667	0.3358	-0.3086	1.0419
	Equal variances not assumed			1.104	42.438	0.276	0.3667	0.3320	-0.3032	1.0365
D_Q13_2_Trusting	Equal variances assumed	0.791	0.378	1.712	48	0.093	0.6167	0.3602	-0.1075	1.3408
	Equal variances			1.866	47.946	0.068	0.6167	0.3305	-0.0479	1.2812

	not assumed									
D_Q13_3_Relaxed	Equal variances assumed	0.232	0.632	-0.207	47	0.837	-0.0724	0.3495	-0.7754	0.6306
	Equal variances not assumed			-0.209	42.354	0.835	-0.0724	0.3461	-0.7707	0.6259
D_Q13_4_Outgoing	Equal variances assumed	0.332	0.568	0.086	45	0.932	0.0392	0.4564	-0.8799	0.9584
	Equal variances not assumed			0.091	39.028	0.928	0.0392	0.4318	-0.8342	0.9126
D_Q13_5_GetsNervous	Equal variances assumed	1.430	0.238	-2.734	47	0.009	-1.0018	0.3664	-1.7388	-0.2647
	Equal variances not assumed			-2.507	28.363	0.018	-1.0018	0.3995	-1.8197	-0.1838
D_Q13_6_FindFault	Equal variances assumed	4.938	0.031	0.371	47	0.712	0.1147	0.3093	-0.5075	0.7369
	Equal variances not assumed			0.415	46.369	0.680	0.1147	0.2766	-0.4419	0.6713
D_Q13_7_HandlesStress	Equal variances assumed	1.082	0.303	-0.882	48	0.382	-0.2750	0.3120	-0.9023	0.3522
	Equal variances not assumed			-0.861	35.391	0.395	-0.2750	0.3193	-0.9231	0.3730
D_GDS	Equal variances assumed	4.039	0.050	2.185	49	0.034	1.3258	0.6066	0.1067	2.5449
	Equal variances not assumed			1.990	28.957	0.056	1.3258	0.6663	-0.0370	2.6886
D_Q15_1_SocialCompanionship	Equal variances assumed	1.196	0.280	-0.817	47	0.418	-0.153	0.188	-0.531	0.225
	Equal variances not assumed			-0.870	46.960	0.389	-0.153	0.176	-0.508	0.201
D_Q15_2_SocialLeftout	Equal variances assumed	0.078	0.781	0.488	50	0.627	0.0952	0.1950	-0.2965	0.4870
	Equal variances not assumed			0.503	47.196	0.617	0.0952	0.1892	-0.2854	0.4758

	not assumed								
D_Q15_3_SociallIsolated	Equal variances assumed	0.052	0.821	0.770	49	0.445	0.1468	0.1907	-0.2364	0.5300
	Equal variances not assumed			0.795	44.836	0.431	0.1468	0.1847	-0.2252	0.5188
D_Q21_Satisfied	Equal variances assumed	0.364	0.550	-0.700	39	0.488	-0.6087	0.8691	-2.3667	1.1493
	Equal variances not assumed			-0.697	35.882	0.491	-0.6087	0.8738	-2.3811	1.1637
D_Q22_LikelyToUse	Equal variances assumed	2.189	0.146	-0.603	42	0.550	-0.4547	0.7543	-1.9769	1.0674
	Equal variances not assumed			-0.627	41.992	0.534	-0.4547	0.7247	-1.9173	1.0078
D_Q23_LifelyToRecommend	Equal variances assumed	0.649	0.425	-0.182	40	0.856	-0.1579	0.8666	-1.9093	1.5935
	Equal variances not assumed			-0.178	33.205	0.860	-0.1579	0.8892	-1.9665	1.6507