Efficacy of Virtual Reality Content Types for Engagement in Assisted Care Communities

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1. Introduction

1.1 Definition of Virtual Reality

Virtual Reality is defined as a computer generated immersive environment that can represent either a real world or artificial scenario[1]. The advent of Virtual Reality (VR) has allowed for the novel and unique delivery of content to a variety of users. VR has been used in entertainment, training, therapy, advertising, data visualization [2], education [3], and in many other applications. Due to the inherent physical essence of a VR experience, one of its best uses is to demonstrate the spatial relationship of objects in space, for instance, the plotting of data points in three-dimensional space[4], or a model of a human heart[5]. Additionally, VR also has been shown to be effective at emulating a natural environment, simulating an alternate place that the user views as if they were present at that location. This technique is most commonly used in conjunction with 360 degree photography and videography, allowing content creators to capture an environment as an image or video, and present it to the user such that when they look around in the virtual environment, they see the simulated view of the alternate location. This is most commonly used in mobile VR, for instance Google Cardboard, which offers a cheap entry-level smartphone-based VR experience[6].

1.2 Impact In Healthcare

Virtual Reality is changing the healthcare landscape. Advances in software[7] and hardware[8 are allowing VR to expand into a wider range of applications, including in senior living communities[9]. Though VR has already been shown to decrease cognitive decline in the older demographic, it is still unknown what specific VR media type will prove most effective

when presented to the senior demographic. However, through quantifiable parameters the effects of such media can be obtained. By analyzing user behavior, content can be better suited to the demographic present in a senior assisted living facility, rather than attempting to adapt content targeted at a much younger audience to an older population.

Virtual Reality has the potential to bring comfort to individuals experiencing both chronic[10] and acute pain[11]. By immersing the patient in a virtual world, they are distracted and may perceive less discomfort. VR can serve as an analgesic across a gamut of patients both in clinical[12] and non-clinical settings[13]. The massive increase in popularity of and interest in consumer VR over the past two years has given rise to low-cost and user-friendly devices that are easily used in an array of environments[14]. One such device, the Samsung Gear VR headset, offers a clean and contained experience without the hassle of cables and complicated hardware, simply using a compatible Samsung smartphone. This solution has proven viable in the elderly assisted care setting and as such has potential to be widely distributed as a pain reliever product. Existing experiments examine VR's use as a distraction primarily with burn patients in the clinical setting before, during, and after therapy or surgery.

1.3 Problem

A major hurdle lies in the direct and accurate quantification of engagement[15]. In select instances, functional Magnetic Resonance Imaging (fMRI) is used to visualize the brain's reaction to various stimuli, such as in testing the reaction to pain[16]. Although fMRI can reveal a signature for specific activity in the brain, this method is difficult to employ given its physical constraints and the technical impossibility of the presence of a VR headset during such a session.

A more common approach measuring engagement or interest is via simple conversation, however this method cannot serve as a true quantification due to the variability and subjectivity of human assessment. It is still unknown what specific VR media types will prove most effective. However, through the use of quantifiable parameters the effects of such media may be obtained. Through the examination of the way participants react to various VR experiences, a better understanding of specifically what content should be implemented for maximum engagement may be gained.

Although VR has been shown to reduce cognitive decline within those in the senior assisted living setting, it is unclear specifically what content is ideal for use in this environment. Since the majority of content is targeted at the younger high school to young adult population, it cannot be assumed an effective choice for use by senior citizens.

2. Statement of Purpose

This study explores the reaction of senior citizens in assisted living communities when exposed to varying types of Virtual Reality content, with the objective of delivering a better collection of media content targeted specifically at this demographic. Using a widely available consumer Virtual Reality system, an application exists for widespread delivery of such content to this demographic to help improve the lives of the elderly. By crafting the experience to maximize engagement, more cognitively beneficial content can be delivered.

3. Materials & Methods

3.1 Participant Locations

An Institutional Review Board (IRB) was assembled in a high school setting where the corresponding research plan was approved by a Psychologist, Science Teacher, and the Principal. The experiment was conducted at a local high school and at two senior living communities, with a total of 52 participants. Research involving human subjects was conducted under the supervision of an experienced teacher or researcher and followed state and federal regulatory guidance applicable to the humane and ethical conduct of such research.

3.2 High School Participants

25 high school students age 15 to 18 (avg = 15.68, sd = 1.09), 10 of whom were males, were recruited during periods when they did not have class or had received prior consent from the teacher to participate in this study. High school participants under the age of 18 signed and returned informed parental consent/assent forms, while participants over the age of 18 signed informed consent/assent forms. 5 groups each with 5 participants participated during school hours in a classroom or library. Grouping was determined based on availability of the student and explicitly not based on any prior relationship the students may have had with each other.

3.3 Assisted Living Participants

27 senior citizen participants ages 62 to 99 (avg = 84.44, sd = 9.39), 8 of whom were males, volunteered to participate after consent was obtained from the two senior living communities where the study was conducted. Participants completed the activity during their

regularly scheduled activity times, as not to conflict with their meal times or group events. 6 groups of 5 participants performed the study in an activity room at the respective communities.

3.4 Hardware

The Rendever content delivery platform was used to deliver media to participants such that all were viewing the same content at once. The platform consisted of a Galaxy Tab A tablet running the Android Marshmallow operating system controlling the content shown on participant headsets. The media was pre-chosen and the tablet was used to advance to the next scene as well as to trigger the engagement survey to display on screen. The smartphone-based Samsung Gear VR headsets (generations 2 & 3) were used in this experiment due to their comparatively low cost, ease of use, and reliability. Verizon Samsung Galaxy S7 (SM-G930V) smartphones running either Android Marshmallow (6) or Android Nougat (7) were used in conjunction with the Gear VR. A pair of Onn On-Ear Headphones was provided to each participant and connected to the Samsung Galaxy S7 to deliver the audio during the videos and interactive content.

3.5 Software

The Rendever platform, comprised of VR headsets and a tablet control system, allows for easy and intuitive delivery of content to seniors in assisted living communities. As the goal of this study is to determine the efficacy of VR content in such a setting, this product was used as a framework for the content delivery system in this study. The existing application allows a senior living community to set up an array of content for use at their facility, including 360° images, curated 360° videos, and various interactive activities, and also use the Google Street View

application in Virtual Reality, whereby participants may request to view different locations as if they were actually present there.

3.6 Setup

Given some participant's unfamiliarity with this new technology, an information session was held prior to the start of the experiment introducing VR, the rationale and applications of the study, and the activities to be completed during the study. Upon fitting the GearVR headset to participant's heads, they were asked to provide any feedback on the comfortability of the headset, and necessary adjustments were made to ensure minimal distraction due to uncomfortability. An acclimatization period of 5 minutes was allowed for participants to become comfortable in the welcome screen virtual environment shown in *Figure 2*.

3.7 Content

As explored earlier, VR has potential to yield a variable response from patients, depending on content type. A variety of media content was employed to determine which content type yields the most interest and thus engagement, including a variety of environments and experiences, ranging from national parks to outer space. The 24 pieces of content delivered encompass the three main types of media found in the consumer VR field: imagery, video, and games. 20 static 360° images, 3 360° videos, and and interactive balloon-popper game. By providing participants with this variation in content, the opportunity exists for them to experience a range of VR experiences and rank them in order of preference for future viewing. The order and procedure of the trials are outlined in *Figure 1*.

The images used were comprised of the publicly available Google Street View content from around the world, while the videos were downloaded online from public repositories and screened for any inappropriate language or scenes. The balloon-popper game (Figure 3) was developed by the student and mentor to provide a fun, multiplayer experience for participants. The objective was for the participant to pop as many balloons of an assigned color as possible, each time gaining a point for a correct color popped and losing a point for an incorrect color. Unlike the imagery and video content, the balloon-popper game offered the interactive component of gaze-controlled balloon popping (participants simply rotated their heads until the center of their vision was over a virtual balloon, which then popped), which was designed to heighten participant engagement within the VR world, in addition to the socially competitive nature of the multiplayer environment.

All content was shown to all users at the same time, with 20 seconds for each image, 1 minute, 2 minutes, and 1 minute for each video respectively, and a total of two 2 minute rounds of the balloon-popper game. The trials which took place in the high school took an average of 30 minutes to complete, while the trials in the senior community took an average of 45 minutes.

Figure 1: Outline of Trial

Stages 1-3 constitute setup prior to data collection, while the delivery of content and data collection occurs in stages 4-6. Stage 7 is a post trial survey.

3.8 Data Collection

The Gear VR's orientation (yaw, pitch, and roll) was recorded to a text file every tenth of a second during the simulation, along with a timestamp of both the time since the local application had launched on the VR headset and the time of day, allowing for reconstruction of any data subject to device malfunction which could affect the framerate of the game. The resolution at which the data was recorded allowed for fine post-test analysis of participants' gaze without significant impact on performance. The data was input into a 2D scatter plot to visualize the location of participant gaze as a heatmap. Analysis of the variance in rotation of participant's heads was compared between the High school and Senior groups.

After each piece of content, participants were instructed to rate the content on how engaging they felt it was on a scale of 1 to 5, 5 being the highest engagement or "presence" either using the on-screen number scale (*Figure 4*) or by declaring their rating verbally. The on-screen number scale allowed participants to rate content using gaze control; by looking directly at the number they intended to rate the content, they would select that rating which would then be recorded to a text file for analysis (*Figure 5*).

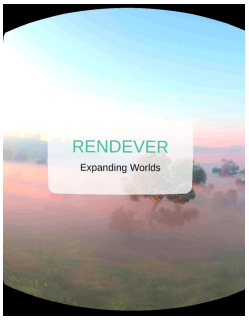


Figure 2
Intro screen shown at start of experiment

Figure 3
Balloon-popper game in action

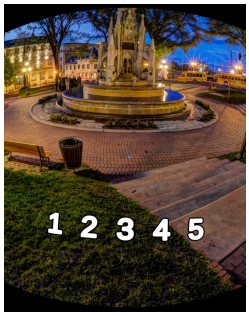


Figure 4
Survey pop-up overlay on image

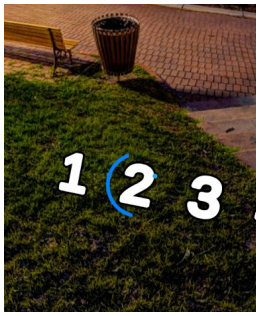


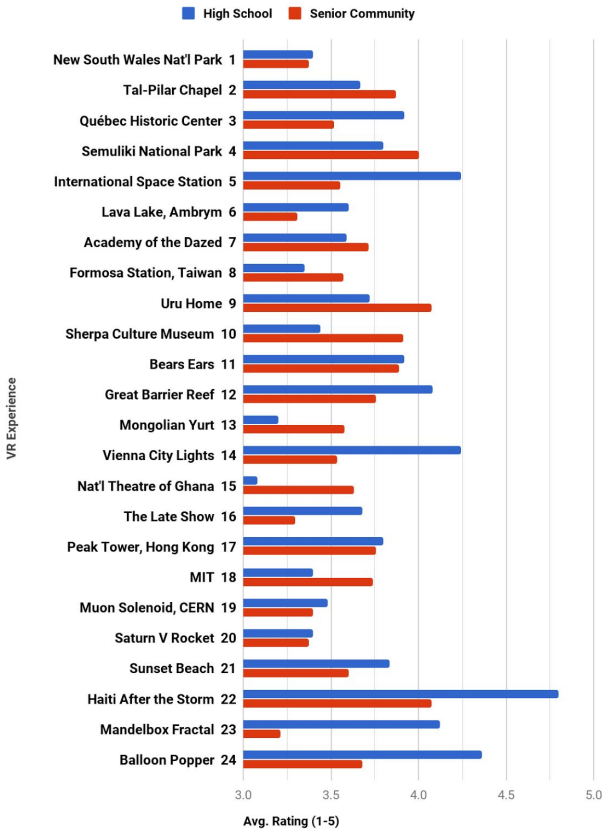
Figure 5
Gaze control used to select rating "2"

4. Results

4.1 User-Reported Content-Specific Ratings

Content-Specific Engagement Rating

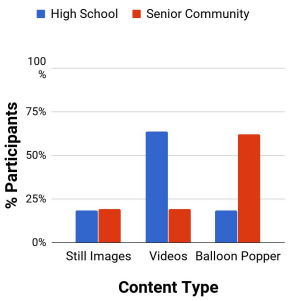
Figure 6



Average Engagement Rating

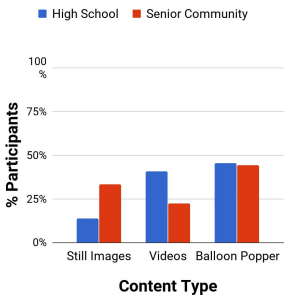
Post-Test Content Ranking

Figure 7



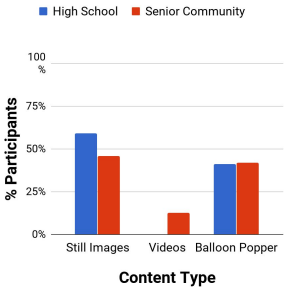
Most Enjoyable

Figure 8



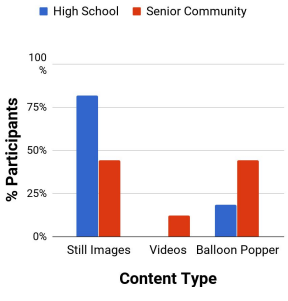
Most Engaging

Figure 9



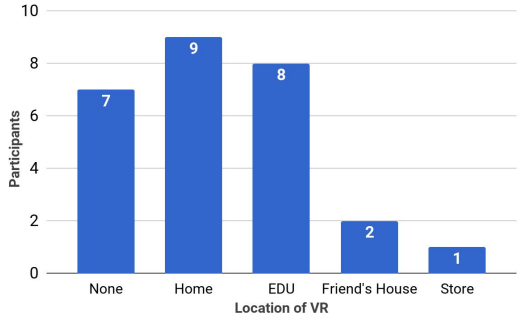
Least Enjoyable

Figure 10



Least Engaging

Figure 11



Prior VR Experience - High School Group

Note: Only one participating senior had experienced VR prior to the start of the experiment.

4.2 Head Orientation in VR

Shown below is the gaze of participants' heads as angles on a coordinate plane, from -180° to 180° in Yaw and -90° to 90° in Pitch. This projection is similar to a mercator map or equirectangular image distortion. The origin (0°, 0°) is the starting view, whereby the Yaw established when the VR software is first initialized and the Pitch is set at the horizon. The x-axis represents the horizon while the points at ±90° Pitch represent the poles of the virtual world.

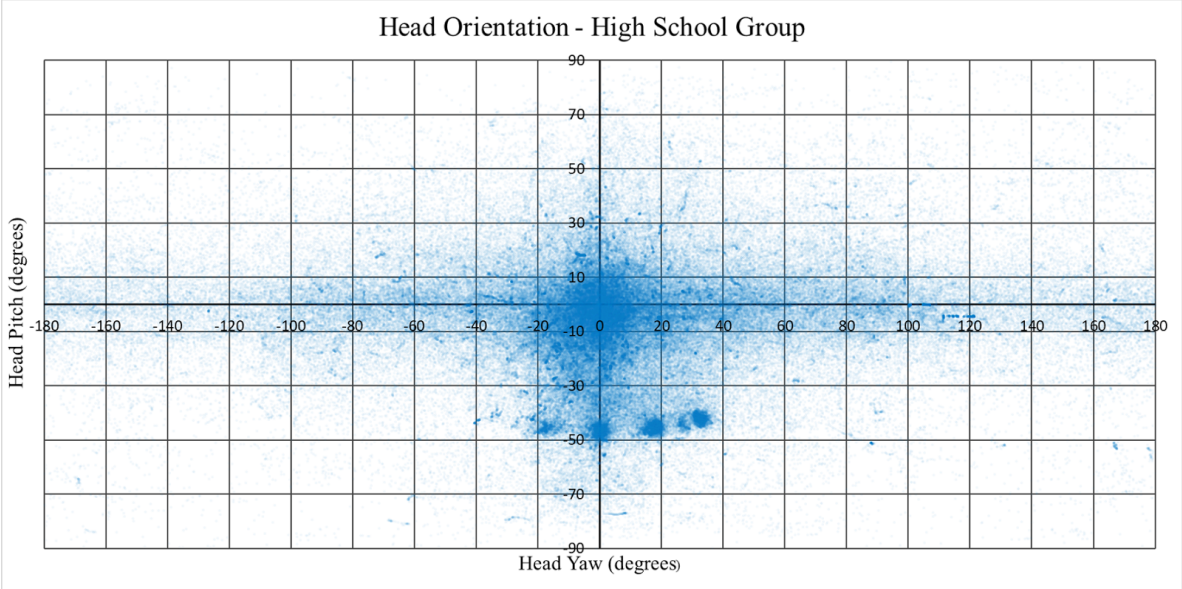


Figure 12: Gaze of High School Participants accumulated during all trials

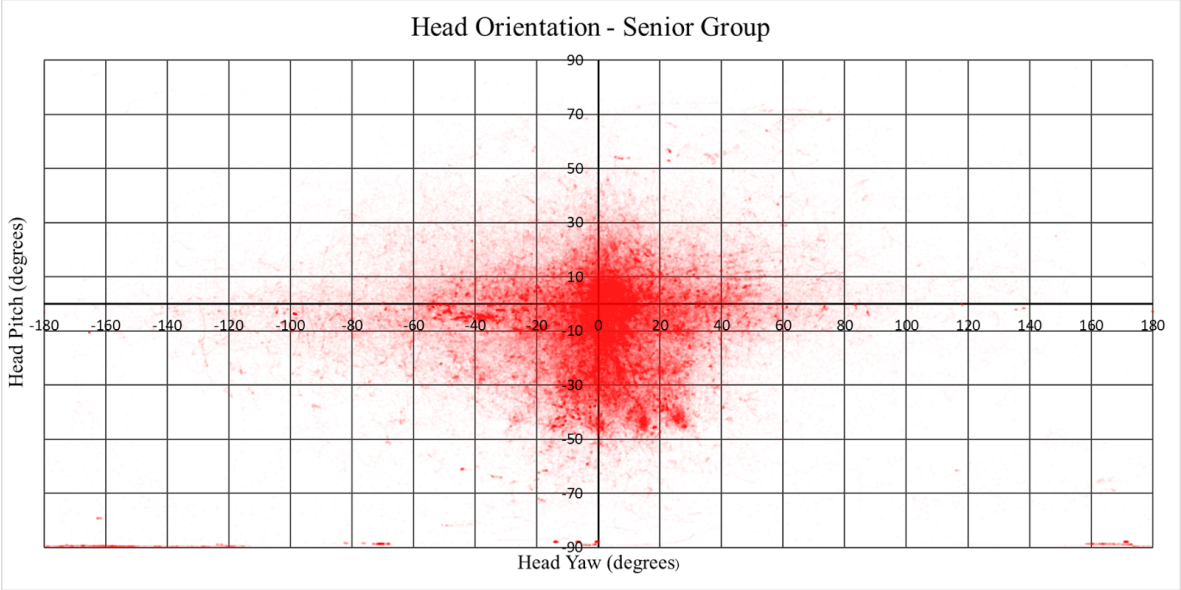


Figure 13: Gaze of Senior Participants accumulated during all trials

5. Discussion

5.1 Content Rating Analysis

While the rating of engagement is subjective as far as the individual user is concerned, the results of the Content-Specific Engagement Ratings filled out by participants from within the headset yield instances of clear interest and disinterest related to the 24 content pieces. As the focus of this study is on the reaction of the Senior Community members, this section is primarily concerned with the metrics of the Senior group in comparison to the High School group, not of both groups independently. *Figure 6* represents the average engagement ratings for each individual piece of content, and as such can be interpreted as a subjective scoring system related to the satisfaction produced by the corresponding content, as it pertains to the Senior demographic.

From *Figure 7*, it is evident that the Videos and Balloon-Popper experiences were most enjoyable for the High School and Senior Community groups respectively. It is likely that the Senior population has less experience playing interactive computer games, and almost none in VR, thus increasing the novelty of the Balloon-Popper game and yielding a higher sense of enjoyment. *Figure 8* shows a higher engagement rating for Video content in the High School group, likewise for Still images within the Senior Group. *Figure 9* indicates the majority of participants found the Still Images and the Balloon-Popper to be the least enjoyable, with slight dislike for the video content among the Senior population. *Figure 10* indicates that the Still Images were not nearly as engaging as the Videos, especially amongst the High School Group.

Figure 11 indicates that only 7 of the 25 participants in the High School Group had not tried VR prior to the experiment, while in the Senior Community, only one of the 27 participants had experienced it prior.

5.2 Orientation Analysis

Over 7.2 million data points representing participant head orientation were collected, 2.4 million of which are shown in *Figures 12* and *13* after filtering. Orientation data was collected in a constant stream of values, however this study is concerned specifically with this data during the time which participants were experiencing new content, thus data points which were not recorded during the content trials themselves have been omitted. Note that the five dots present in both graphs near -45° Pitch represent the head orientation when participants looked down at the on-screen survey to rate the content on engagement. As shown by *Figures 12* and *13* respectively, the High School and Senior Community groups exhibit differing head movement over the course of the trials, namely in the spread of participants head movement beyond the 20° mark from the center position. This may be attributed to older participants' inability to angle their heads as much as a younger demographic. Additionally worth noting is the difference in the dispersion of data between the two groups; the High School group has a much more regular density over the period of its rotation, while the Senior population has a rather large cluster of values concentrated within 50° of the origin; again likely due to decreased mobility or decreased interest in the content surrounding the Senior group.

6. Conclusion

6.1 Application

Application of this study includes the consideration of this data when designing and selecting VR experiences for use in Senior Assisted Living Communities or in the older demographic as a whole. From this study, the response of participants shows a marked variance depending not only on age, but also on fascination, energy, and interest in the content being shown. Already, content including the “Haiti After The Storm” documentary and the image of an “Uru Home” stand out with exceptionally high ratings from the older demographic.

6.2 Future Research

Future analysis of this same data may reveal more of a personal story behind the data; as each individual had their device undergo recording, it is possible to reconstruct the behavior of each participant on a timescale. This would allow a case-by-case analysis of participant behavior, speculation of their thought processes, and a wider look into the way each demographic thinks about the environment they are in. Furthermore, given that the hardware and software frameworks exist to conduct this study on a small scale, this framework could be expanded to handle more simultaneous participants for a larger sample size, or perhaps become integrated within an existing product as to reduce the time spent exclusively in a research trial.

While the scope of this study is relatively small, its implications extend beyond that of the Senior Assisted Living Community. Potential for VR to act as an analgesic in the clinical setting is strong. A content framework similar to the one designed for this experiment could be

used in a hospital's pre-surgical waiting rooms, to relieve patient anxiety and provide a sense of comfort in an otherwise stressful environment.

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