Don't Forget Our Presence: Exploring VR for Older Adults

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ABSTRACT

Virtual reality (VR) as a technology has been around for decades, but the modern era of VR started with the commercial release of the Oculus Rift headset in 2016. The intervening years have seen significant growth in the technology and its application. Lowered barriers to entry (e.g., system cost, no longer requiring a powerful gaming computer) and a pandemic have resulted in a substantial increase in the use of VR in the workplace and at home. During this period, the older adult population, those 65 and older, is also experiencing rapid growth. While the benefits of older adults using VR are numerous (e.g., socialization, rehabilitation, well-being), recent studies show that only a fraction of the older adult population has used VR. We conducted a study investigating accessibility barriers older adults may face when interacting with VR hardware and applications and what benefits they believed VR could provide. Our participants expressed that current VR technology does not support the needs and abilities of older adults, but if it did, they believed VR would benefit the population, demonstrating the need to create VR hardware and applications to support older adults.

Keywords: Virtual reality, VR, accessibility, older adults.

Index Terms: Human-centered computing → Accessibility → Empirical studies in accessibility—Virtual Reality

1 INTRODUCTION

Virtual reality (VR) technology allows users to become immersed in digital environments that range from replicated reality to entirely imaginary. This technology is used in training [17], education [23], social interactions [6, 7], rehabilitation [26], exercise [16], and gaming [13]. While still considered an emerging technology [30], VR usage has grown significantly since the Oculus Rift and HTC Vive VR systems were released in 2016 [43]. Affordability [9], an increase in available content [42], exposure [32], and the COVID-19 pandemic [31] have all contributed to the increased market growth of VR systems. VR during the pandemic showcased the technology's ability to virtually connect workers, friends, and family while providing entertainment and distraction during the stay-at-home mandates. Using VR to connect with friends and family during the pandemic [24] shows the potential for VR to positively impact older adults, especially those with age-related disabilities, who may find it difficult to leave their residences and interact with people regularly [8] or are homebound [46].

Researchers estimated that in 2020, over 50 million Americans were 65 and older [27]. This population is expected to increase to approximately 98 million by 2060 [27]. This growing population also has the highest percentage of people with disabilities (35.2%), more than double the percentage of all other age groups combined [25]. A ramification of this higher rate of disabilities, specifically for cognitive and mobility disabilities, is a higher chance of becoming homebound [46]. Homebound older adults have an increased susceptibility to social isolation, lack of medical care, diminished quality of life, and a higher mortality rate [3, 46].

While the older adult population is growing, it is not using VR technology, which research suggests could prove beneficial [4, 39]. Recent studies found that the majority of older adults (55+) are not interested in VR [22], and only six percent of this population has used VR [5]. If VR can benefit older adults, why are they not using or interested in it? We argue that one reason is VR accessibility.

We conducted a research study using semi-structured interviews, focus groups, and performance tasks with ten older adults, with and without self-reported disabilities, who had never previously used VR. While participants had different needs and abilities, we found many similarities in their interaction with the VR hardware and applications, revealing potential VR accessibility barriers for older adults. Additionally, they expressed that if accessible, VR could provide many benefits for older adults.

2 RELATED WORK

2.1 VR Hardware and Accessibility

Off-the-shelf VR hardware primarily consists of a head-mounted display (HMD) and two handheld controllers. The HMD houses the visual displays and speakers and uses a head strap to mount it in front of the user's eyes, while the controllers house vibration motors, batteries, and physical inputs (e.g., joysticks and buttons). With all the equipment and inputs in specialized VR hardware, it is unsurprising that many people find VR inaccessible [10].

While people with disabilities may wish to experience VR, many expect it will never be possible [2, 31]. However, there are some encouraging trends in accessible VR hardware. Most of today's HMDs have adjustable lenses to set interpupillary distance and include spacers to provide distance between the eyes and lenses for people who wear glasses [30]. Additionally, voice commands have been added, providing multimodal interaction methods [44]. Researchers are exploring different hardware options for people with disabilities to access VR, including a virtual white cane [38, 47], an HMD strap modification for individuals using a Cochlear implant [18], and wheelchair motion platforms [11, 37]. These examples reflect Wobbrock et al.'s opinion that the onus of accessibility rests on the technology, not the user [45].

2.2 Advances in Accessible Application Development

A 2012 collaborative effort created a game accessibility guidelines website, providing a reference for creating inclusive games [15]. The website provides options for developing video games to support different disabilities. While only one specifically addresses VR, many guidelines are device-agnostic.

Accessibility features for VR are beginning to emerge. Zhao et al. created a Unity Toolkit to increase VR environments' usability for people with low vision [48], while Gluck and Brinkley explored leveraging auditory and haptic feedback to allow people who are blind to explore a virtual environment [19, 20].

While neither of these advances explicitly targets older adults using VR, each presents potential application implementation strategies to increase VR accessibility for older adults. Mott et al.'s research argues that now is the time to implement accessible VR, as VR technology is still impressionable [30].

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2.3 Older Adults and VR

Researchers have been studying the benefits of VR for older adults for decades, with many early studies focused on clinical research [21, 28]. Grealy et al. integrated VR with a rehabilitation exercise program, which improved cognitive rehabilitation after a traumatic brain injury [21]. More recently, researchers have shifted their focus toward exploring VR for socialization [12] and cognition [26]. Appel et al. explored how older adults with cognitive, sensory, or mobility impairments would benefit from experiencing VR [4]. Their participants reported increased energy and decreased anxiety and stress. However, the authors noted a need to address how VR can be optimized for populations like older adults with disabilities.

As mentioned previously, over one-third of older adults have a disability [25], with mobility being the most reported difficulty, followed by hearing, cognition, and vision [1]. Therefore, we must understand and address older adults' needs regarding VR technology because it can positively impact older adults' well-being. These studies show the benefits of VR technology, but older adults may miss out due to a lack of accommodations.

2.4 Impact of Related Work on the Present Study

While research on accessible VR hardware and applications for older adults has begun, it is limited. Most research on VR for older adults is focused on VR's benefits rather than exploring accessibility. This work seeks to fill that gap by understanding the accessibility barriers older adults experience while interacting with VR hardware and applications.

This study aimed to answer the following research questions:

RQ1: What challenges do older adults face when interacting with VR hardware?

RQ2: What challenges do older adults face when interacting with VR applications?

RQ3: What do older adults perceive as the benefits of using VR?

3 METHODOLOGY

We conducted performance assessment tasks, semi-structured interviews, and focus groups with older adult participants to understand their thoughts, opinions, and usage of VR system hardware and applications. The study sought to understand the challenges and potential benefits for older adults when using VR.

3.1 Participant Recruitment

Emails were sent to potential participants through a third-party affiliate associated with the facility where the participants live. Interested individuals emailed or called for more information or scheduling. Those 65 or older who had never used VR previously and who do not easily experience motion sickness (to limit potential falls and injuries) were invited to participate.

The Institutional Review Board of the authors' university approved the study. Participants provided informed consent on the day of the scheduled session. Participants were compensated with a $50 prepaid gift card for participating in the individual session and another for attending a focus group.

3.2 Description of Participants

We recruited and interviewed ten older adult participants (2 female, 8 male, mean age of 84.5 years, range = 71 to 92 years old) over six days at a retirement community in northwestern South Carolina. Nine of the ten participants (2 female, 7 male, mean age of 84.3 years, range = 71 to 92 years old) participated in one of two focus groups conducted after the individual interviews. (P4 could not attend a focus group due to a medical emergency on the day the sessions were scheduled.) Table 1 summarizes participant demographic information.

Table 1. Participant demographic information.

ID	Age	Gender	Focus Group Session	Self-reported Impairment(s)
P1	71	M	2	Getting older
P2	88	M	1	Auditory
P3	81	M	2	--
P4	86	M	--	--
P5	90	F	1	Auditory, cognitive, and mobility
P6	90	M	2	Auditory and visual
P7	80	M	1	Auditory
P8	92	M	1	--
P9	83	F	1	Auditory and visual
P10	84	M	2	Mobility

3.3 Apparatus and Materials

We used a Meta Quest 2 VR system to conduct this study due to its availability and lack of cords. Three VR applications were installed on the device. The selection process required applications to have a comfort level rating of moderate or lower and a four-star or higher user rating with over 2,000 ratings. This process left many VR applications available for this study. *Vacation Simulator* [33] was selected based on its inclusion of multiple accessibility features [40]. *The Climb* [14] was selected to explore mobility limitations discussed by Mott et al. [31]. Finally, *Rec Room* [35] was selected based on being a cross-platform application that allows connecting with friends and family without a VR system.

3.4 Interview Procedure

Our interview procedure was designed to understand the thoughts and opinions of older adults with no prior VR experience. Sessions lasted two hours, and each session's procedure was identical. Sessions began with reading the informed consent document and media release form; each participant then signed the documents.

We applied two approaches to gather feedback from our older adult participants. First, after watching a video on the setup process, we asked them to complete four specific performance assessment tasks [34] related to the Meta Quest 2 setup process [49]. Participants were asked to adjust the HMD lenses and strap and set the floor height and the guardian system. Then, participants were asked to open the battery compartment, as this was not included in the video. After completing the tasks, participants took part in a semi-structured interview about the tasks and the setup process.

Second, we used a visual media elicitation approach [29] by having participants experience three different genres of VR applications: Game (*Vacation Simulator*), experience (*The Climb*), and social (*Rec Room*). Participants were asked to spend 20 minutes in each application with a break between applications, during which semi-structured questions were asked about their overall experience and what difficulties, if any, they encountered.

Each session ended with a short semi-structured interview to understand their overall VR experience, perceived benefits of older adults using VR, and interest in experiencing VR again.

3.5 Focus Group Procedure

Our focus group procedure was designed to gather additional thoughts and opinions of our older adult participants after they had used VR for the first time and were able to reflect on the experience. Focus group sessions lasted one hour, and a semi-structured interview process was used for each focus group. The questions for the focus groups were derived from an analysis of the responses to the individual sessions. Participants were asked to discuss their experience with using VR for the first time, requirements to make the VR hardware and applications accessible, benefits for VR usage by older adults, preferred VR applications for older adults, and any final thoughts about the process or technology.

3.6 Data Capture and Transcription

Each session was audio and video recorded using a GoPro video camera. Before analysis, the recordings were transcribed verbatim by transcriptionists at Rev.com [36]. Transcripts were then verified against the original video recordings and prepared for analysis.

3.7 Analysis

Analysis was conducted on each session's transcript by entering them into the qualitative data analysis program MAXQDA [41]. Before analysis, two researchers familiarized themselves with the data and worked together to develop an a priori codebook. The researchers worked independently to code the transcripts. A third researcher reviewed the coded transcripts, settled discrepancies, and created a finalized version.

4 RESULTS

4.1 Performance Assessment

We assessed success on the five setup tasks described in Section 3.4. Success was measured on a three-point scale for each task: ability to complete the task successfully (2), ability to complete the task successfully with assistance (1), and inability to complete that task altogether (0). The results can be seen in Figure 1.

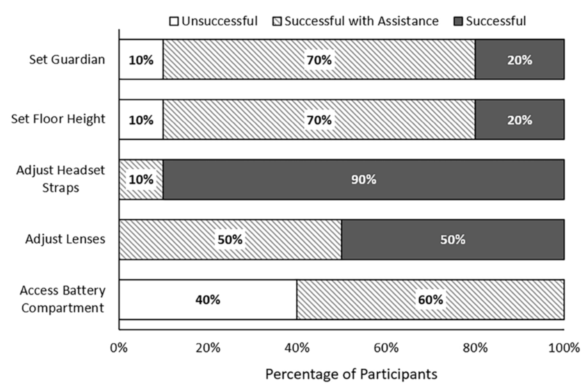

Figure 1: Bar chart representing participants' success in completing the five performance assessment tasks.

Nine participants successfully, some with additional coaching, completed the four VR system setup tasks. P1 described the process as being *"just a little bit foreign."* P1 and P9 remarked that they needed assistance to complete the four tasks. While all participants watched the same modified instructional video [49], additional help was required by half of our participants to complete the four VR system setup performance tasks. Seven participants required assistance setting the floor height and guardian assessment tasks. All participants successfully adjusted the lenses and the HMD straps tasks, but half required assistance adjusting the lenses. Adjusting the HMD straps was the most successful task, with nine participants completing it without additional help. P10 felt the need for coaching was due to the presentation being too fast. P4 felt that *"There was an awful lot of information they were throwing at you."*

However, accessing the battery compartment in the Touch controllers was the least successful performance assessment task presented to our participants. No participant could complete the task without assistance, and four participants were unsuccessful even after demonstrating the process. P6, P8, and P9 reported that accessing the battery was the most challenging task. *"Well, I had trouble, um, I don't know whether my thumb is not strong enough to slide it down… I couldn't figure out how to open it."* (P5). P4 stated that the controller needed more information on where the compartment was and how it opened. *"As far as the battery, I think you could have some type of, uh, graphic there that'll be able to locate how to, you know, it's gonna slide out like, other things, give you a little arrow or something like that."* P5, P8, and P9 agreed that rechargeable controllers could simplify this process.

4.2 Accessibility Barriers

4.2.1 VR Hardware

All ten participants reported experiencing difficulty with the VR hardware. The most mentioned area of difficulty was the Touch controllers, specifically the buttons. P6 clarified their difficulty with the controllers, stating, *"I'm not used to a controller. I don't play games."* Five participants (P1, P2, P8-P10) requested simplified controllers. When participants were asked how to simplify the controllers, P8 inquired, *"Do you need five buttons?"* and P9 responded, *"The fewer buttons, the better."* Three participants requested having only one button (P3, P8, P9). P5 and P10 only wanted two buttons, while only one participant wanted three (P2). The button confusion negatively affected the experience for some participants. *"I was too focused on what the buttons do to enjoy it. It was hard."* (P8).

Participants also found the HMD challenging. *"Well… when I first got it on, I didn't realize where it had to be on the face, and I had it too far out. And so, I think that a little of the difficulty was getting it adjusted for ultimately what you should be looking at."* (P4). P7 had initial difficulties, finding *"It was too tight, to begin with,"* and P9 reported, *"I never did get it on really very well."*

Two participants with self-reported disabilities conveyed that the HMD was not fully accessible. While the Meta Quest 2 had the eyeglass spacers installed, P9 stated it was *"A little difficult with glasses. The glasses kind of dig in."* P6 is deaf in his left ear and has a Cochlear implant. He found that the HMD strap interfered with his hearing device. *"Well, only for people like me out of, for me to be able to use it properly, I got to hear. I got to be able to work around that hearing device."*

4.2.2 VR Applications

Participants described experiencing problems while interacting with the VR applications. Seven participants had trouble hearing and understanding the tutorial voice in the applications. *"You know, I had a big problem hearing. And I, uh, I couldn't hear some of the instructions."* (P7). Problems hearing were echoed by P2, P6, P8, P9, and P10, even though the Meta Quest 2's volume was at maximum. P5 had trouble understanding the in-application voices. *"I could hear them, but I didn't understand what she was saying. She spoke too fast."* P2, P9, and P10 also reported needing a slower voice. The *"ability to slow down the speech would've helped a lot… and a deeper voice female… I don't know if it's just my ears, but, uh, there's a lot of, a lot of seniors that can't hear the higher frequency, and especially if it's being spoken very fast… it's a double whammy."* (P10).

Nine participants requested additional instruction or training on the controllers and buttons related to the different VR applications. *"I think maybe a little… an initial tutorial. Just a little bit more about the uh, what you had to do with the controllers to uh, to manipulate the hands."* (P4). P2 reiterated the request for tutorials.

Rather than more tutorials, P10 wanted additional training. *"Maybe the developers could develop an expanded training package, where you'll have one holds, maybe a fifteen-minute segment of nothing but using this, this finger and shooting at targets, you know, tailored to this one button. Instead of going ahead and looking at the whole thing at one time. And here's what your thumb'll do for you, and you sit there and, and practice."*

Instead of the instruction coming from the application itself, eight participants prefer one-on-one instruction, at least while they are beginning. *"Probably personal instruction to start with."* (P2). P9 found coaching beneficial. *"Well, it was hard. But once you explained how to do it, that was helpful. I'm very glad you were coaching me."* P2 felt that pre-planning was needed. *"Maybe more ahead of time, talking about – and what we needed to do."*

Two participants mentioned the inconsistencies between applications and how the controllers and the buttons were used to interact with the virtual environment. P2 stated that *"with the different controls, it makes it hard to decide which one to use, and when and where."* These variations in controls led to a discussion of standardization. *"Buttons require standardization across the industry, and that's tough to do."* (P10).

4.3 Benefits

When participants were asked about the potential benefits of older adults using VR, P5 stated, *"You know what I hear more than anything else here… is the expression, I am so bored."* To alleviate that boredom, nine participants stated that being able to travel in VR would be beneficial (P2-P10), four stated they would like to be able to connect with others (P3, P6, P9, P10), and three expressed a desire to do hobbies (P3, P7, P8). *"Well, I think that you know there is one thing and we are always thinking of as older adults. More activities and different activities, and this would certainly be something different for us."* (P6).

The benefits of travel applications were discussed the most by our participants. *"I liked… that there'd be a travel VR edition. I know that's years down the road, but that you could travel to Yosemite, you could travel to Paris, through the VR, through the virtual experience. And you may be able to do some of that now, but I just really, I really liked that suggestion of travel for, especially this day and age where travel is, maybe restricted for, for health reasons or other reasons. Mine would be financial."* (P7). P8 also expressed the benefit of traveling in VR. *"But the travels that you were talking about. Being there. Experiencing it. Hearing it. Seeing it. Feeling it. That would be a great experience."*

Four participants focused on socializing. *"I would enjoy having one of these where I can look around and see other people."* (P10). P9 said connecting with friends and family would be nice and that social VR could be used to make new friends. *"I think that'd be great. It would be fun if you could connect with uh, you know, other people and then set up a little game time and that sort of thing. That would be really entertaining."* (P4).

P5 stated that VR could provide benefits in terms of mental health. *"I thought it was, um, very stimulating to the brain and would be very entertaining to elderly people. It would open up new avenues for them to participate in."* (P7). P3 echoed this, stating, *"I was doing something that I hadn't done, so, I mean, that was kinda intriguing."* VR could also allow older adults to participate in activities that may no longer be physically possible. *"I would think an older adult would appreciate being able to accomplish a lot of things they're, that physically they couldn't otherwise."* (P7)

5 Discussion

The results of our study suggest that older adults may find VR hardware and applications inaccessible even with video assistance and in-application tutorials. These findings assisted in answering our research questions.

For RQ1, participants reported experiencing multiple accessibility barriers when interacting with the VR HMD and controllers, including the head strap interfering with an implanted hearing device, complicated and confusing controllers, and the inability to open the handheld controller's battery compartment. For RQ2, the VR applications also presented accessibility barriers. These barriers include inconsistent interaction between applications, inability to hear or understand verbal instructions, unclear what to do upon starting an application, and a lack of ability to repeat or rewind dialog. Finally, for RQ4, participants stated that VR could benefit older adults by reducing boredom, allowing for engagement in activities in which they can no longer participate, and traveling without financial outlay or health concerns.

While our research attempted to explore both the physical and software accessibility barriers, it is essential to note that there are potentially additional accessibility barriers that our research could not uncover. Participants only had a limited time interacting with the VR hardware and applications, and the progress made in each application varied between participants. For example, in *The Climb* [14], four of the ten participants reached the first checkpoint in the training module, while others could not advance past the first few handholds. Future work will be required to uncover additional accessibility barriers for older adults to use VR.

6 Conclusion

This study explored the accessibility of VR systems for older adults. Our semi-structured interviews with ten participants interacting with VR for the first time found that 1) older adults may experience challenges with the HMD straps and the Touch controllers when interacting with VR hardware, 2) inconsistent interactions, lack of audio controls, and lack of clarity when starting a new application led to challenges using the VR applications, and 3) older adults can benefit from VR in many ways, ranging from travel, socialization, and taking part in activities they are no longer physically able to accomplish. These findings can be synthesized to show that our older adult participants experienced VR accessibility barriers concerning the design of VR hardware and the experience of interacting with VR applications. However, they expressed that VR can benefit older adults in general if designed to accommodate their needs and abilities. Thus, this demonstrates the importance of designers and developers creating VR hardware and applications that are accessible based on the abilities of the user rather than requiring the user to adapt to the technology [45].

VR should be accessible to all people, no matter their ability. Studying accessible VR for older adults benefits all people with disabilities due to their increased probability of having a variety of disabilities. Although the research and development of accessible VR may be slow, if we take the point of view of P9, we will get there in the end: *"I don't feel like I have a real good handle on how it all works. But at least I know a little more about it than I did at nine o'clock."*

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