Cyberpsychology, Behavior, and Social Networking
Volume 26, Number 12, 2023

DOI: 10.1089/cyber.2023.0188

From 65 to 103, Older Adults Experience Virtual Reality Differently Depending on Their Age: Evidence from a Large-Scale Field Study in Nursing Homes and Assisted Living Facilities

Ryan C. Moore, MA, Jeffrey T. Hancock, PhD, and Jeremy N. Bailenson, PhD

Abstract

There is growing interest in applications of virtual reality (VR) to improve the lives of older adults, but the limited research on older adults and VR largely treats older adults as a monolith, ignoring the substantial differences across 65 to 100+ year olds that may affect their experience of VR. There are also few existing studies examining the experiences and challenges facing those who facilitate VR for older adults (e.g., caregiving staff). We address these limitations through two studies. In study 1, we explore variation *within* older adults' experiences with VR through a field study of VR use among a large ($N = 245$) and age-diverse ($M_{age} = 83.6$ years, $SD_{age} = 7.9$, range = 65–103 years) sample of nursing home and assisted living facility residents across 10 U.S. states. Age was negatively associated with the extent to which older adults enjoyed VR experiences. However, the negative relationship between age and older adults' attitudes toward VR was significantly less negative than the relationship between age and their attitudes toward other technologies (cell phones and voice assistants). In study 2, we surveyed caregiving staff ($N = 39$) who facilitated the VR experiences for older adult residents and found that the caregiving staff generally enjoyed the activity relative to other activities and felt it to be beneficial to their relationship with residents.

Keywords: older adults, virtual reality, VR, nursing homes, assisted living, caregivers, communication technology

In light of the global population growing older and advances in virtual reality (VR) technology, there is increasing interest in the application of VR technologies to support older adults.[1–3] Studies show that VR can improve older adults' well-being,[4,5] reduce feelings of social isolation,[6] improve memory[7] and balance,[8] and serve as a vehicle for physical rehabilitation.[9–11]

However, overall there has been limited research on older adults' use of VR.[12,13] Specifically, the extant literature on older adults and VR suffers from two limitations. First, most existing research is not equipped with large or age-diverse enough samples to examine differences in the use and effects of VR *within* the older adult population. Many studies focus on ''younger'' older adults—for example, in a scoping review of studies on VR health interventions for older adults, Carrol et al. found that the average age of participants was 67 years.[14] Studies also often conceive of older adults monolithically, comparing VR experiences among older adults with experiences among younger adults.[15–17]

This is problematic because there is substantial variation among older adults in terms of mobility, hearing, vision, memory, and physical health, which tend to decline as older adults age,[18,19] and may affect experiences with VR. For example, moderate and severe hearing loss is common in older adults age >75 years, particularly those >90 years.[20] The prevalence of severe visual impairment in older adults also increases rapidly with age.[21] These declines in the perceptual systems of older-older adults could negatively affect

Department of Communication, Stanford University, Stanford, California, USA.

their experience using VR, which depend on audio and visual modalities to create immersive experiences.[22,23]

Second, few studies examine the experiences of those who facilitate VR for older adults. In assisted living facilities, VR can be used for entertainment and health interventions. However, most applications in these contexts require caregiving staff to help administer the VR experience, and there is concern that doing so may be difficult[24,25] for workers already suffering from burnout.[26,27]

Unfortunately, only a handful of studies have solicited information from caregiving staff to learn more about their experience facilitating VR experiences for older adults[4,24,25,28] and these studies have been conducted at small scales across limited sites. Learning more about the benefits and challenges for caregiving staff of administering VR experiences is essential for improving our understanding about both the effects and scalability of VR for older adults.

In this article, we address these limitations through two studies. Study 1 is a large-scale field study of older adults' experiences using VR in 16 nursing homes and assisted living facilities spread across 10 U.S. states. Our sample of 245 older adult participants had an average age of 83.6 years (range = 65–103 years), allowing us to examine differences within the older adult population and making our study one of the largest and ''oldest'' studies of older adults and VR to date. Study 2 uses surveys to explore the experiences of caregiving staff ($N = 39$) who facilitated the VR experiences for the older adult residents, providing insight into the process and experience from caregivers' perspectives.

Study 1: Variation Within Older Adults' Responses to VR Experiences

Older-older adults might respond more negatively to VR than younger-older adults because their perceptual systems are less amenable to the benefits of immersive VR experiences. For instance, stereopsis, a major contributor to depth perception, tends to decline exponentially as older adults age.[29] Combined with declines in overall visual acuity,[21] this may inhibit older-older adults' ability to reach the same levels of immersion during a VR experience as younger-older adults.

Hearing loss that occurs with older age[20] may further undermine VR experiences. Wearing a head-mounted display could also be more physically difficult or uncomfortable for older-older adults, who are more likely than younger-older adults to have neck and shoulder pain.[30] These age-related mobility issues could also problematize VR experiences because a contributor to the effectiveness of VR simulations is the degree to which users rotate their heads side-to-side during use.[31]

Alternatively, older-older adults could respond similarly to VR as younger-older adults if the aforementioned deficits (e.g., worsened eyesight and hearing) do not exert a strong negative influence on the extent to which older-older adults enjoy and benefit from VR experiences. As there is not sufficient evidence to support a specific prediction, we ask the following research question:

RQ1: How do older adults of different ages respond to VR experiences?

If older adults respond differently to using VR depending on their age, this may simply reflect a general trend in older adults' perceptions of technology and not specifically responses to VR. Indeed, prior work has identified a positive correlation between age and general technology anxiety among older adults,[32] and found that older-older adults have lower levels of digital literacy than younger-older adults.[33,34] To understand whether any potential age differences in older adults' responses to VR are specific to VR or instead track with their perceptions of other technologies, we ask the following:

RQ2: How do older adults' responses to VR experiences compare to their perceptions of other technologies?

Study 1: Methods

We used MyndVR, who distribute VR headsets with connected Android tablets that control content through ''kiosk mode'' to assisted living facilities across the United States. The headsets used with MyndVR are the Pico G2, a standalone head-mounted display featuring $1{,}920 \times 2{,}160$ resolution per eye, 101° field of view, 75 Hz refresh rate, and three-degree-of-freedom head tracking (total weight = 472 g).

MyndVR content consists of a variety of 360° videos ranging from travel experiences to nature scenes and meditation (average video length: ~7 minutes). Residents could freely choose which of MyndVR's content they wanted to experience in the Pico G2. The facility's caregiving staff helped residents get the Pico G2 headset set up properly and assisted them in selecting 360° video content to experience.[a] Figure 1 contains photographs of examples of residents engaging in VR experiences using the Pico G2 and MyndVR.

The Android tablets were used in this study to administer a Qualtrics questionnaire to residents after their VR experience.[b] This survey was designed to be a short add-on to the VR experiences that residents engaged in. Residents provided informed consent before completing the survey and the research was approved by the Stanford University IRB. In total, 16 facilities across 10 U.S. states who had MyndVR systems participated.

Participants

Two hundred forty-five older adult residents completed our survey after a VR experience from June 2021 to January 2023. The survey asked residents about their reactions to the VR experience (see Measures section). The average age of resident participants was 83.6 years ($SD = 7.9$, range = 65–103; Fig. 2 illustrates the age distribution). Resident participants predominantly identified as white (91.9 percent) and female (72.8 percent), and their level of education was varied, with 47.2 percent having a bachelor's degree or greater.

Measures[c]

To answer RQ1, we measured resident participants' enjoyment of the VR experience[d] by asking them ''How much are you looking forward to using virtual reality again?'' (5-point scale; None at all–A great deal) and ''How likely would you be to recommend the use of virtual reality to friends and acquaintances?'' (5-point scale; Not at all likely–Extremely likely). These items appeared in prior research[5,35,36] and had good internal consistency (Cronbach's $\alpha = 0.87$).

FIG. 1. Photos of resident participants engaged in VR experiences. VR, virtual reality. Photos used with permission from Mynd Immersive.

In addition, we measured whether residents talked about their VR experience with others, as past study shows that VR experiences can serve as a basis for social interaction.[37,38] Specifically, we asked, ''Over the past week, how often did you talk to other people about your VR experience?'' with five answer options ranging from Never to Daily. To distinguish talking about VR from proclivities to talk in general, we also measured participants' socializing behaviors by asking how often they talked with the caregiving staff and with other people in general each week, and these two items had good reliability ($\alpha = 0.7$).

To answer RQ2, we asked resident participants questions about other familiar (cell phones) and novel (voice assistants) technologies to assess attitudes toward those technologies compared with VR.[39] After past research on technology acceptance among older adults,[40,41] we asked participants ''How useful do you think a (cell phone/home voice assistant) is?'' (5-point scale; Not useful at all–Extremely useful) and ''How well do you feel you are able to use a (cell phone/home voice assistant)?'' (5-point scale; Not well at all–Extremely well). These measures had good reliability ($\alpha_{\text{cell phone}} = 0.74$, $\alpha_{\text{voice assistant}} = 0.73$).

Study 1: Results

RQ1: How do older adults of different ages respond to VR experiences?

To answer RQ1, we first examined the relationship between resident participants' age and VR enjoyment. We

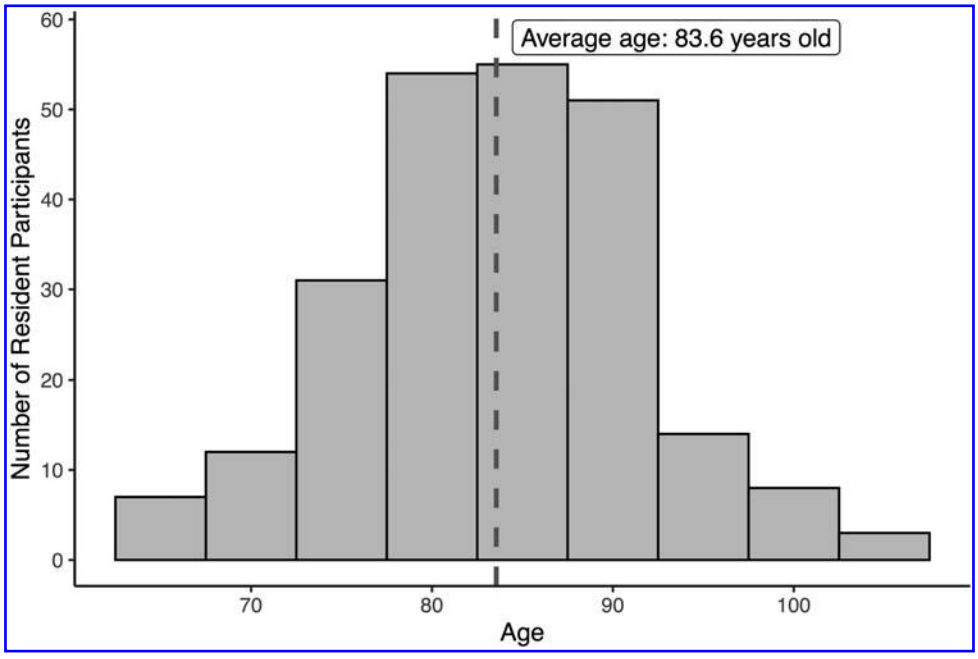

FIG. 2. Distribution of age among resident participants (study 1). Note: Histogram of age among resident participants in study 1. The *y*-axis is the number of participants contained within each bar of the distribution. The *x*-axis is age (in years). The *dashed line* represents the average age of the participants, 83.6 years.

estimated a linear regression where the dependent variable (DV) was VR enjoyment and the independent variables (IVs) were age,[e] level of education, gender, and race. We obtained a negative and significant coefficient on age ($\beta = -0.021$, SE = 0.010, $p < 0.05$), indicating that older age was associated with significantly less enjoyment of the VR experience, controlling for participants' level of education, gender, and race. As visualized in Figure 3, the level of VR enjoyment declines from a value of 4.07 for our youngest participant (65 years) to 3.26 for our oldest participant (103 years), a nearly 20 percent decrease.

We also examined whether there were age differences in the frequency at which residents reported socializing about VR experiences. Consistent with past research,[42] a linear regression where general talking frequency was the DV and age, education, gender, and race were IVs revealed a significant positive association between age and frequency of talking per week ($\beta = 0.017$, SE = 0.008, $p < 0.05$), indicating that older-older adults were more likely to talk with others. However, an ordinal logistic regression where frequency of talking *about VR* was the DV revealed that age was not significantly associated with the likelihood of talking about VR ($\beta = -0.014$, SE = 0.018, $p = 0.44$). Thus, although older-older adults talked more in general, they were not more likely to talk about VR.

RQ2: How do older adults' responses to VR experiences compare with their perceptions of other technologies?

We compared age differences in participants' attitudes toward VR (a composite index of the VR-specific questions from RQ1) with their attitudes toward cell phones and voice assistants. Linear regressions where these attitudes were the DVs and age, education, gender, and race were the IVs revealed that age was negatively associated with attitudes toward VR ($\beta = -0.018$, SE = 0.009, $p < 0.05$), cell phones ($\beta = -0.033$, SE = 0.009, $p < 0.001$), and voice assistants ($\beta = -0.034$, SE = 0.011, $p < 0.01$). We statistically compared these three regression slopes[43,44] to examine whether the strength of the negative relationship between age and technology attitudes varied by technology.[45–47]

To compare VR attitudes with attitudes toward cell phones, we fit a linear regression where the 5-point VR and cell phone attitude indices were the DV and the IV of interest was the interaction between age and a binary variable indicating whether a response represented a participant's rating for VR (1) or for cell phones (0). Education, gender, and race were included as controls, as were random effects for participants to account for nonindependence.

A positive interaction term ($\beta = 0.024$, SE = 0.012, $p < 0.05$) indicated that the relationship between age and VR attitudes was significantly less negative than the relationship between age and cell phone attitudes. Estimating this model for VR and voice assistant attitudes also produced a positive interaction ($\beta = 0.028$, SE = 0.013, $p < 0.05$), indicating that the relationship between age and VR attitudes was significantly less negative than the relationship between age and voice assistant attitudes.

These results are displayed in Figure 4. Although the relationship between age and older adults' attitudes toward all three technologies is negative, the slope of the relationship between age and VR attitudes is significantly less steep than the relationships between age and cell phone and voice assistant attitudes. Although there are significant age differences in older adults' attitudes toward VR, these age differences are less dramatic than age differences in attitudes toward other technologies.[f]

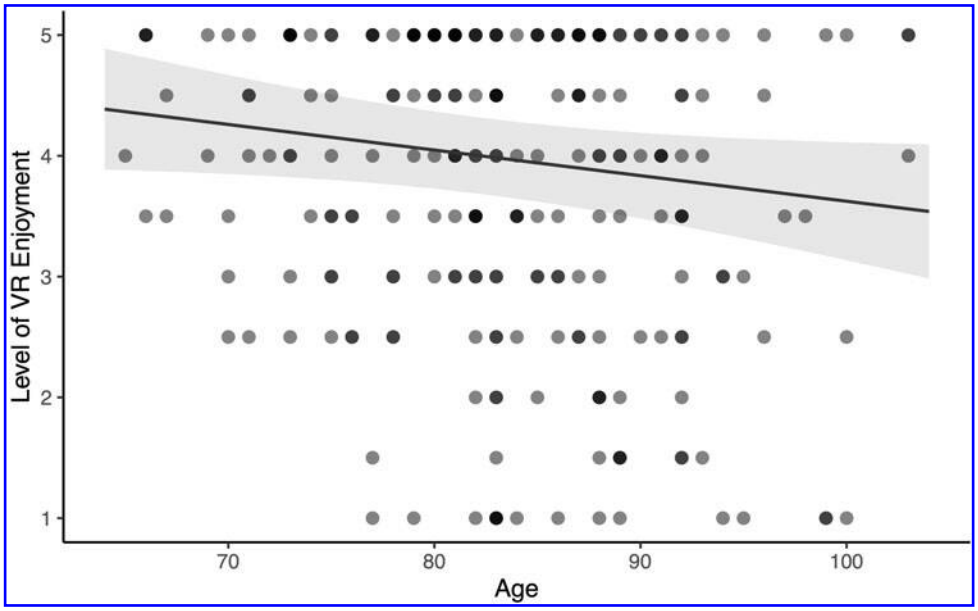

FIG. 3. Association between age and enjoyment of the VR experience (study 1). Note: Marginal effects plot from a regression model in which VR enjoyment was the DV and age, level of education, gender, and race were IVs. The *y*-axis is the estimated level of VR enjoyment, which is an index comprising the likelihood that resident participants would recommend doing VR to others and the extent to which they are looking forward to doing it again (Cronbach's $\alpha = 0.87$). The *x*-axis is age (in years). The *line* represents the estimated level of VR enjoyment at each value of age in the study 1 sample (65–103 years). The shaded region is 95 percent confidence intervals. Points are underlying data. DV, dependent variable; IV, independent variable.

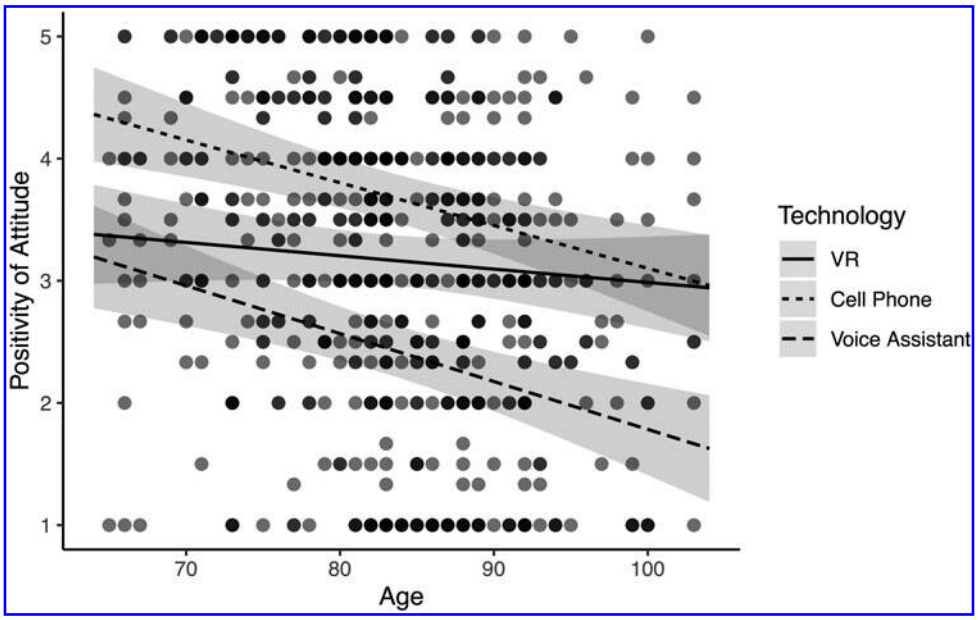

FIG. 4. Association between age and attitudes toward different technologies (study 1). Note: Marginal effects plot from a regression model in which participants' attitudes toward three different technologies (VR, cell phones, and voice assistants) were the DV and the key IV of interest was an interaction between age and a variable indicating whether an attitude was for VR, cell phones, or voice assistants (level of education, gender, and race were also included as IVs). The *y*-axis is the estimated positivity of participants' attitudes toward each technology (see Study 1: Methods section for details on the variables comprising these indices). The *x*-axis is age (in years). Each line represents the estimated attitude toward the technologies at each value of age in the sample (65–103 years). The *solid line* represents attitudes toward VR, the *densely dashed line* represents attitudes toward cell phones, and the *dashed line* represents attitudes toward voice assistants. *Shaded* regions are 95 percent confidence intervals. Points are underlying data.

Study 2: Caregiving Staff's Experiences Administering VR for Older Adults

In nursing homes and assisted living facilities, VR experiences are typically facilitated by facility caregiving staff, although little research has examined their experiences administering VR for older adults. Waycott et al. conducted interviews with 11 caregivers in nursing homes that offer VR, finding that although many saw great potential, residents sometimes felt physical discomfort due to the headset or that it induced nausea and disorientation, and that it was difficult to provide care while residents were in VR without disrupting the experience.[25]

Thach et al. interviewed 10 staff in nursing homes and identified similar pros and cons.[24] Although valuable, these prior studies were conducted at small scales across limited sites, and it remains a question as to how caregiving staff feel regarding their administration of VR experiences. Thus, we pose RQ3, which we explore in study 2:

> RQ3: How do caregiving staff who administer VR experiences for older adults feel about the experience?

Study 2: Methods

To answer RQ3, we surveyed the caregiving staff who helped facilitate residents' VR experiences in study 1. After resident participants from study 1 finished their VR experiences and the corresponding survey, the caregiving staff had the opportunity to take a separate survey to understand their experiences administering VR for the residents. This caregiver survey was administered on the Android tablet that was connected to the Pico G2 VR headset and took ~5 minutes to complete. Caregivers' survey responses makeup study 2.

Participants

Thirty-nine caregiving staff completed our caregiver survey a total of 66 times, with some caregivers completing the survey multiple times as they facilitated VR experiences for different residents. Caregivers provided informed consent before completing the survey.

Measures

We asked the caregiving staff two close-ended questions: ''Compared to other activities, how much more or less do you enjoy interacting with the resident while doing the VR activity?'' (7-point scale; Much less–Much more) and ''How beneficial do you think doing the VR activity with the resident is to your relationship with them? (5-point scale; Not beneficial at all–Extremely beneficial). We also asked an open-ended question to learn more about the resident's interactions with the caregivers during the experience: ''Briefly describe what the resident talked to you about regarding their VR experience.''

Study 2: Results

RQ3: How do caregiving staff who administer VR experiences for older adults feel about the experience?

Overwhelmingly, caregiving staff enjoyed doing VR with residents more than other activities (81 percent of responses indicated they enjoyed doing the VR activity with residents

more than other activities) (Fig. 5A). The responses also indicated that caregiving staff felt the VR activity was beneficial to their relationship with the resident, with more than half of responses indicating it was very beneficial (Fig. 5B).[g]

The caregiving staff's open-ended responses highlighted the positive experiences that residents had using VR. One caregiver wrote, ''The resident and I discussed her time spent traveling in Europe. She recognized several of the sights in the VR videos and enjoyed seeing them again'' whereas another wrote, ''The resident said she enjoyed watching the videos, especially the animal videos. She talked about the animals she used to have as a child.''

These quotes display elements of reminiscence therapy, an intervention in which memories of past experiences and events are stimulated to improve memory and well-being.[28,48] There were also, however, several responses that raised issues the residents had (e.g., ''She doesn't like things on her head so she wanted to remove the headset after only watching two videos''; ''She stated the headset made her nose and forehead sweaty'').

General Discussion

Contributions and implications

Study 1 revealed that age was negatively associated with the enjoyment of VR among older adults. Although prior study has demonstrated that older adults generally enjoy VR,[3,49] our analysis *within* an age-diverse older adult sample reveals that enjoyment declines with age. Importantly, however, attitudes toward other technologies became more negative across the older adult lifespan than did attitudes toward VR. Taken together, these findings reaffirm calls from other scholars for more research on heterogeneity in the use of and attitudes toward digital technologies within the growing and diverse older adult population.[33,34,50]

Although many of the applications of VR for older adults require facilitation by a caregiver, only a small handful of studies examine caregivers' perspectives.[4,24,25,28] Our findings from study 2 indicate that caregiving staff generally enjoyed the VR activities relative to other activities they do with residents, and found it to be beneficial for their relationships with residents. Administering VR activities in the field may be quite feasible but challenges persist, such as those related to discomfort wearing head-mounted displays.

Limitations and future directions

We did not pinpoint the mechanisms responsible for differences in older adults' experiences with VR and this is an important priority for future research. Our study's internal validity could also be improved. Although the external validity of our study was relatively high in that we studied older adult users of VR systems in the field, this came at the expense of the control we had in the study. Conducting research in the field, with older adult participants, under the parameters of the COVID-19 restrictions placed on facilities at the time of data collection meant that our ability to collect data was limited.

We avoided certain research designs (e.g., recruiting a control group, measuring resident's attitudes and feelings before the VR experience, and observing multiple VR experiences to track resident and caregiving staff experiences over time as VR activities become less novel for residents) to limit the burden placed on the staff and facilities in our study. Future study on the questions we examine should leverage more controlled research designs to obtain a more precise and holistic understanding of older adults' experiences with VR.

Notes

a. As participants were also free to select the VR content they wanted to view, not all resident participants were exposed to the same content, which is a by-product of the naturalistic setting of our study that introduces some noise into our measurements of residents' experiences.
b. Resident participants filled out their survey themselves on the Android tablet and we designed the surveys in Qualtrics in a way that would make that easier for them to do (large font, large answer response options). In some instances (14 percent of trials in study 1), the caregiving staff member had to help the resident complete the survey on the tablet due to, for example, issues selecting options on the touchscreen. Re-running the models specified in the Study 1: Results section including a control variable for whether or not residents received assistance from caregiving staff in completing the survey did not change any of our substantive conclusions.
c. We wanted to keep the surveys as unobtrusive as possible, so our surveys were kept relatively short, and were designed and tested to be completed in $\sim$5–10 minutes. For the full questionnaires, see the Supplementary Information.
d. In study 1, our survey questions asked about participants' experience with ''virtual reality,'' but participants may have been thinking of VR in general, the Pico G2 specifically, or MyndVR's suite of 360° videos specifically when answering questions about VR. In future studies that afford more control and time to researchers, time should be spent explaining and defining these different hardware and software components that make up the VR medium to participants to minimize differences between participants in what they are thinking of when answering questions about ''virtual reality.''
e. We modeled age as a continuous variable in our analyses. There is a growing consensus in studies examining age and its relation to health outcomes and interventions to model age as a continuous variable rather than binning it into different categories (e.g., young-old, middle-old, and oldest-old) as it leads to models with more explanatory power (see van Walraven and Hart[51] for an early example) and, indeed, studies examining psychological processes across the lifespan and within older adults typically model age as a continuous variable.[52–57]
f. Attitudes toward VR were measured with different questions than attitudes toward cell phones and voice assistants, although all attitudes were measured on the same scale. This was because resident participants had just completed a VR experience and were thus asked questions about their reactions to that experience, whereas the questions about cell phones and voice

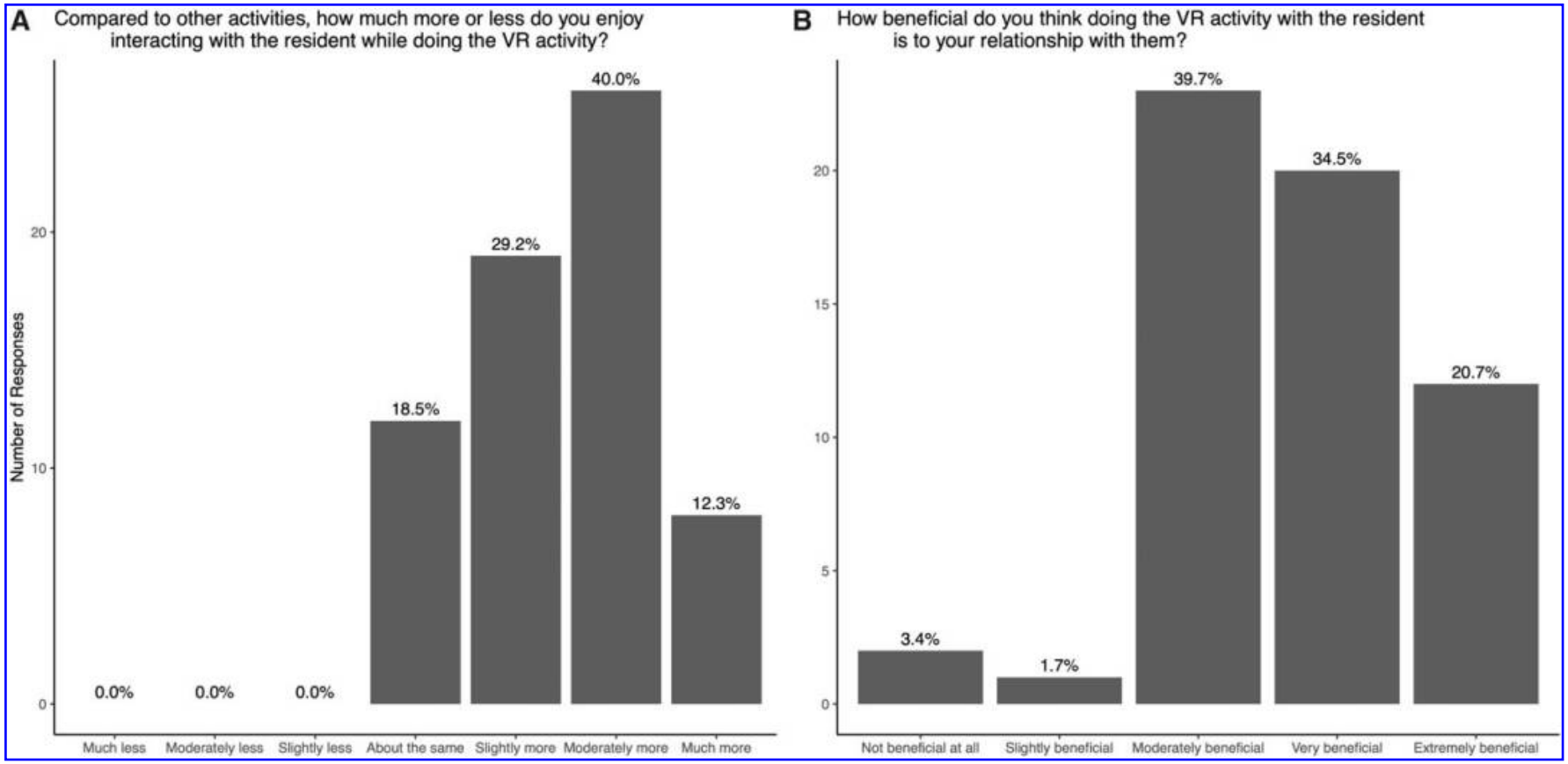

FIG. 5. Responses to close-ended questions from caregiving staff participants (study 2). Note: The distribution of caregiving staff's responses to the close-ended questions, ''Compared to other activities, how much more or less do you enjoy interacting with the resident while doing the VR activity?'' **(A)** and ''How beneficial do you think doing the VR activity with the resident is to your relationship with them?'' **(B)**. The possible response options are on the *x*-axis, and the number of responses each response received is on the *y*-axis. Percentages appear above each bar to indicate what percentage of the total responses each response option received.

assistants were asked more abstractly, as participants had not just finished using those technologies and potentially had never used them. Prior study comparing the relationships between an IV and different constructs has relied on measures of those constructs comprising different questions.[45–47] Still, future study should attempt to measure attitudes toward different technologies ideally in an environment where they have time to allow participants to use each of the technologies during the study to facilitate better comparability between attitudes.

g. We asked resident participants in study 1 questions about the impact of the VR experiences on their relationship with the caregiving staff that mirrored those that we asked to caregiving staff, specifically ''How much more or less do you enjoy interacting with the activities staff while doing your VR activity compared to while doing other activities?'' and ''How beneficial do you think doing the VR activity is for your relationship with the activities staff?'' Residents' responses to these questions indicated that a little less than half (46 percent) of residents enjoyed doing the VR activity with caregiving staff more than other activities and many of the remaining residents (44 percent) enjoyed doing the VR activity with caregivers as much as doing other activities (Supplementary Fig. S1A). Nearly half (47 percent) of residents felt that the VR activity was very or extremely beneficial to their relationship with the caregiving staff, with many of the remaining residents (42 percent) indicating that they thought the VR activity was moderately beneficial to their relationship with caregiving staff (Supplementary Fig. S1B). Taken together with the results from the caregiver survey, these responses suggest that the VR activity may be mutually beneficial for the relationship between older adult residents and their caregiving staff.

Acknowledgements

The authors would like to thank MyndVR, especially Ted Werth, as well as the staff and residents of the facilities who participated in our study for making this research possible. We also thank Talia Weiss for early work on this project and collaboration.

Author Disclosure Statement

No competing financial interests exist.

Funding Information

Ryan Moore is supported by a Stanford Interdisciplinary Graduate Fellowship.

Supplementary Material

Supplementary Information
Supplementary Figure S1

References

1. Seifert A, Schlomann A. The use of virtual and augmented reality by older adults: Potentials and challenges. Front Virtual Real 2021;2:639718.
2. Tuena C, Pedroli E, Trimarchi PD, et al. Usability issues of clinical and research applications of virtual reality in older people: A systematic review. Front Hum Neurosci 2020;14:93.
3. Barsasella D, Malwade S, Chang CC, et al. Opinions Regarding Virtual Reality among Older People in Taiwan; 2023 [cited August 2, 2023]. pp. 165–171. Available from: https://www.scitepress.org/Link.aspx?doi=10.5220/0009425801650171 [Last accessed: November 6, 2023].
4. Afifi T, Collins N, Rand K, et al. Using virtual reality to improve the quality of life of older adults with cognitive impairments and their family members who live at a distance. Health Commun 2022;38(9):1904–1915.
5. Lin CX, Lee C, Lally D, et al. Impact of Virtual Reality (VR) Experience on Older Adults' Well-Being. In: Human Aspects of IT for the Aged Population Applications in Health, Assistance, and Entertainment. (Zhou J, Salvendy G. eds.) Springer International Publishing: Cham; 2018. pp. 89–100. [Lecture Notes in Computer Science].
6. Baker S, Waycott J, Robertson E, et al. Evaluating the use of interactive virtual reality technology with older adults living in residential aged care. Inf Process Manage 20201; 57(3):102105.
7. Man DWK, Chung JCC, Lee GYY. Evaluation of a virtual reality-based memory training programme for Hong Kong Chinese older adults with questionable dementia: A pilot study. Int J Geriatr Psychiatry 2012;27(5):513–520.
8. Duque G, Boersma D, Loza-Diaz G, et al. Effects of balance training using a virtual-reality system in older fallers. Clin Interv Aging 2013;8:257–263.
9. Campelo AM, Hashim JA, Weisberg A, et al. Virtual Rehabilitation in the Elderly: Benefits, Issues, and Considerations. In: 2017 International Conference on Virtual Rehabilitation (ICVR), Montreal, QC, Canada; 2017; pp. 1–2.
10. Ortet CP, Veloso AI, Vale Costa L. Cycling through 360° virtual reality tourism for senior citizens: Empirical analysis of an assistive technology. Sensors (Basel) 2022;22(16):6169.
11. Campo-Prieto P, Cancela JM, Rodríguez-Fuentes G. Immersive virtual reality as physical therapy in older adults: Present or future (systematic review). Virtual Reality 2021;25(3):801–817.
12. Brown JA. An exploration of virtual reality use and application among older adult populations. Gerontol Geriatr Med 2019;5:2333721419885287.
13. Lee LN, Kim MJ, Hwang WJ. Potential of augmented reality and virtual reality technologies to promote well-being in older adults. Appl Sci 2019;9(17):3556.
14. Carroll J, Hopper L, Farrelly AM, et al. A scoping review of augmented/virtual reality health and wellbeing interventions for older adults: Redefining immersive virtual reality. Front Virtual Reality 2021;2:655338.
15. Hassandra M, Galanis E, Hatzigeorgiadis A, et al. A virtual reality app for physical and cognitive training of older people with mild cognitive impairment: Mixed methods feasibility study. JMIR Serious Games 2021;9(1):e24170.
16. Liu Q, Wang Y, Tang Q, et al. Do you feel the same as I do? Differences in virtual reality technology experience and acceptance between elderly adults and college students. Front Psychol 2020;11:573673.
17. Liu Q, Wang Y, Yao MZ, et al. The effects of viewing an uplifting 360-degree video on emotional well-being among elderly adults and college students under immersive virtual reality and smartphone conditions. Cyberpsychol Behav Soc Netw 2020;23(3):157–164.

18. Carstensen LL, Gross JJ, Fung HH. The social context of emotional experience. Annu Rev Gerontol Geriatr 1998;17: 325–352.
19. Jaul E, Barron J. Age-related diseases and clinical and public health implications for the 85 years old and over population. Front Public Health 2017;5:335
20. Li S, Ye H, Chen A, et al. Characteristics of hearing loss in elderly outpatients over 60 years of age: An annual cross-sectional study. Acta Otolaryngol 2021;141(8):762–767.
21. Evans JR, Fletcher AE, Wormald RPL, et al. Prevalence of visual impairment in people aged 75 years and older in Britain: results from the MRC trial of assessment and management of older people in the community. Br J Ophthalmol 2002;86(7):795–800.
22. Sanchez-Vives MV, Slater M. From presence to consciousness through virtual reality. Nat Rev Neurosci 2005; 6(4):332–339.
23. Cummings JJ, Bailenson JN. How immersive is enough? A meta-analysis of the effect of immersive technology on user presence. Media Psychology 2016;19(2):272–309.
24. Thach KS, Lederman R, Waycott J. Guidelines for Developing the VR Program in Residential Aged Care: A Preliminary Study from Staff Members' Perspective. In: Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA'21). Association for Computing Machinery: New York, NY; 2021; pp. 1–6.
25. Waycott J, Kelly RM, Baker S, et al. The Role of Staff in Facilitating Immersive Virtual Reality for Enrichment in Aged Care: An Ethic of Care Perspective. In: Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI'22). Association for Computing Machinery: New York, NY; 2022; pp. 1–17.
26. Cocco E, Gatti M, de Mendonça Lima CA, Camus V. A comparative study of stress and burnout among staff caregivers in nursing homes and acute geriatric wards. Int J Geriatr Psychiatry 2003;18(1):78–85.
27. Kandelman N, Mazars T, Levy A. Risk factors for burnout among caregivers working in nursing homes. J Clin Nurs 2018;27(1–2):e147–e153.
28. Brimelow RE, Dawe B, Dissanayaka N. Preliminary research: Virtual reality in residential aged care to reduce apathy and improve mood. Cyberpsychol Behav Soc Netw 2019;23(3):165–170.
29. Haegerstrom-Portnoy G, Schneck M, Brabyn J, et al. Changes in vision function over time in an older population: The SKI study. Invest Ophthalmol Vis Sci 2002; 43(13):4717.
30. Cassou B, Derriennic F, Monfort C, et al. Chronic neck and shoulder pain, age, and working conditions: Longitudinal results from a large random sample in France. Occup Environ Med 2002;59(8):537–544.
31. Herrera F, Bailenson JN. Virtual reality perspective-taking at scale: Effect of avatar representation, choice, and head movement on prosocial behaviors. New Media Soc 2021; 23(8):2189–2209.
32. Ellis RD, Allaire JC. Modeling computer interest in older adults: The role of age, education, computer knowledge, and computer anxiety. Hum Factors 1999;41(3):345–355.
33. Hargittai E, Piper AM, Morris MR. From internet access to internet skills: Digital inequality among older adults. Univ Access Inf Soc 2019;18(4):881–890.
34. Hargittai E, Dobransky K. Old dogs, new clicks: Digital inequality in skills and uses among older adults. Can J Commun 2017;42(2):3176.
35. Afifi T, Collins NL, Rand K, et al. Testing the feasibility of virtual reality with older adults with cognitive impairments and their family members who live at a distance. Innov Aging 2021;5(2):igab014.
36. Fiocco AJ, Millett G, D'Amico D, et al. Virtual tourism for older adults living in residential care: A mixed-methods study. PLoS One 2021;16(5):e0250761.
37. Abeele VV, Schraepen B, Huygelier H, et al. Immersive virtual reality for older adults: Empirically grounded design guidelines. ACM Trans Access Comput 2021;14(3):14:1–14:30.
38. Bailenson J. Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do. W.W. Norton & Company: NY, New York; 2018.
39. Kakulla B. AARP. 2023 Tech Trends: No End in Sight for Age 50+ Market Growth; 2023 [cited March 24, 2023]. Available from: https://www.aarp.org/research/topics/technology/info-2023/2023-technology-trends-older-adults.html [Last accessed: November 6, 2023].
40. Tyler M, De George-Walker L, Simic V. Motivation matters: Older adults and information communication technologies. Stud Educ Adults 2020;52(2):175–194.
41. Orso V, Nascimben G, Gullà F, et al. Introducing Wearables in the Kitchen: An Assessment of User Acceptance in Younger and Older Adults. In: Universal Access in Human–Computer Interaction Human and Technological Environments. (Antona M, Stephanidis C. eds.) Springer International Publishing: Cham; 2017; pp. 579–592. [Lecture Notes in Computer Science].
42. Cornwell B, Laumann EO, Schumm LP. The social connectedness of older adults: A national profile. Am Sociol Rev 2008;73(2):185–203.
43. Clogg CC, Petkova E, Haritou A. Statistical methods for comparing regression coefficients between models. Am J Sociol 1995;100(5):1261–1293.
44. Zarnoch SJ. Testing Hypotheses for Differences Between Linear Regression Lines. U.S. Department of Agriculture; 2009 [cited March 28, 2023]. Available from: https://www.fs.usda.gov/research/treesearch/33218 [Last accessed: November 6, 2023].
45. Abdelaaty L, Steele LG. Explaining attitudes toward refugees and immigrants in Europe. Polit Stud (Oxf) 2022; 70(1):110–130.
46. Henkens B, Verleye K, Larivière B. The smarter, the better?! Customer well-being, engagement, and perceptions in smart service systems. Int J Res Mark 2021;38(2):425–447.
47. Selzam S, Ritchie SJ, Pingault JB, et al. Comparing within- and between-family polygenic score prediction. Am J Hum Genet 2019;105(2):351–363.
48. Woods B, O'Philbin L, Farrell EM, et al. Reminiscence therapy for dementia. Cochrane Database Syst Rev 2018; 2018(3):CD001120.
49. Huygelier H, Schraepen B, van Ee R, et al. Acceptance of immersive head-mounted virtual reality in older adults. Sci Rep 2019;9(1):4519.
50. van Boekel LC, Peek ST, Luijkx KG. Diversity in older adults' use of the internet: Identifying subgroups through latent class analysis. J Med Internet Res 2017;19(5):e6853.
51. van Walraven C, Hart RG. Leave 'em alone—Why continuous variables should be analyzed as such. Neuroepidemiology 2008;30(3):138–139.

52. Carstensen LL, Shavit YZ, Barnes JT. Age advantages in emotional experience persist even under threat from the COVID-19 pandemic. Psychol Sci 2020;31(11):1374–1385.
53. Pasupathi M, Carstensen LL. Age and emotional experience during mutual reminiscing. Psychol Aging 2003; 18(3):430–442.
54. Scheibe S, Mata R, Carstensen LL. Age differences in affective forecasting and experienced emotion surrounding the 2008 US presidential election. Cogn Emot 2011;25(6): 1029–1044.
55. Shavit YZ, Chi K, Carstensen LL. Age and time horizons are associated with preferences for helping colleagues. Work Aging Retire 2023;9(3):280–290.
56. Steen-Baker AA, Ng S, Payne BR, et al. The effects of context on processing words during sentence reading among adults varying in age and literacy skill. Psychol Aging 2017;32(5):460–472.
57. Wieck C, Kunzmann U, Scheibe S. Empathy at work: The role of age and emotional job demands. Psychol Aging 2021;36(1):36–48.

Address correspondence to:
Ryan C. Moore
Department of Communication
Stanford University
450 Jane Stanford Way
Building 120
Stanford, CA 94305-6104
USA

E-mail: rymoore@stanford.edu