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Review

Supporting Optimal Aging through the Innovative Use of Virtual Reality Technology

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Abstract: Although virtual reality (VR) technology has been implemented as a tool to address the health issues of older adults, its applicability to social connectedness is underrepresented in the literature, and less is known about its efficacy in this area in contributing to overall wellness and well-being in later life. Expanding the VR possibilities beyond traditional entertainment purposes holds considerable potential for the older adult market. Technological tools have been employed in the elder health care field for many years, and cutting-edge developments such as virtual and augmented reality have begun to be used to facilitate optimal wellness in aging. Such technological advances have the potential to significantly impact one of the most important issues that older people face: social isolation and loneliness. This paper will serve as an introductory exploration of what is currently known about the use of virtual reality technology with an older cohort.

Keywords: older adults; virtual reality; social isolation; wellness; healthy aging

1. Introduction

Population aging is a defining characteristic of the times in which we live. To take Canada as an example, in 2015, an estimated 16% of Canadians were at least 65 years old, and that number is expected to reach 20% of the population by 2024 [1]. Baby boomers (those born from 1946 to 1965) will reach retirement age over the next two decades; it is important to note that, globally, this a very diverse group traversing a wide age range that includes older people with varied characteristics, behaviours, and needs. This demographic change poses unique challenges and opportunities with respect to maintaining the costs for providing services and resources to this group.

Health care practitioners and corporate businesses, attempting to respond to the challenge, have found that the use of technology improves the well-being of older adults while reducing the costs in the long term. Elders' acceptance of innovative technologies in their everyday lives is thought to be a key factor of success for governments, technology providers, healthcare providers, and other major players in the lives of older adults [2].

One of the many stereotypes around aging is that seniors are resistant to new ideas and advances in technology. Although older adults are now widely understood to be an extremely diverse group and do not uniformly conform to technology-averse stereotypes [3], many older adults face unique obstacles to adopting new technologies. Not all older adults feel comfortable using technology, because they either do not trust it or do not understand how to use it. For many of the older adults who would like to engage with technology, barriers to using technology are associated with cost, design, and usability of the device or service [4]. There is also an important consideration for the universal accessibility of technologies. While design philosophies exist to ensure that technologies are designed for use by those with a wide range of abilities and disabilities, less attention has been given to the

challenge of overcoming socioeconomic or geopolitical barriers to technology use [5], which may impact internet access, digital literacy or language fluency.

As virtual reality (VR) technology becomes more common and less expensive, industry leaders and researchers involved in elder health are beginning to explore its potential uses with older adults. Programs are beginning to emerge that combine artificial intelligence and avatars to provide cost-effective, virtual interventions for older adults. VR technology has been increasingly used as a health promotion tool to assist with issues such as mobility and fall prevention. More recently, the technology is being explored to assess its applicability to social health. Mostaghel [2] suggests that the market of older adults is an excellent field of "disruptive innovation application", because their demand for new, easy to use, and affordable products and services has increased so exponentially. However, the majority of the available studies on older adults' use of technology build on observations, focus groups, and interviews, while both conceptual and empirical research are still scarce [2], suggesting that some types of research within this domain are in their infancy.

This mini-review explores the relatively new intersection of VR technology and aging with an emphasis on both its use for physical health purposes as well as for social engagement.

2. Selected Age-Related Applications of VR Technology

In news outlets and popular media channels, one can find countless examples of ways that innovative technologies, including the use of virtual and augmented reality, are being applied to support older adults. While these are exciting and interesting applications, for the purposes of this mini-review, published, peer-reviewed articles and/or studies were preferentially included. The authors primarily conducted this search using Google Scholar, using search terms that included multiple ways of describing older adults (e.g., "older adult", "senior", "elder"), "virtual reality" and "VR", "health and wellness", and "technologies to support healthy aging". There were no specific exclusion criteria for results or articles, though the focus was on adults over 65. Similarly, no specific health or chronic conditions were included or excluded. The authors had previously completed a similar literature review related to social isolation and aging in particular, and some of the inspiration for focusing on the potential of VR for social engagement came from that previous work. The authors note that, while it was easy to find news features, it was relatively difficult to find a substantive amount of formal literature in this area. This could be viewed as the emergence of a new area of interest, suggesting that these applications are likely to form the basis of many intriguing research endeavours in the near future. The authors do freely admit, however, that there may be other fields contributing work in this area that were not reviewed, as there was no explicit focus, for instance, on the more technical elements of VR and how that might impact its use.

2.1. Health Promotion

The use of VR through active video games is increasingly used as a complementary tool in health rehabilitation; the effectiveness and feasibility of virtual reality and gaming systems for use at home by older adults has been researched extensively [6]. Virtual reality applications can engage older adults in better health choices, and these platforms can be sources of both physical (e.g., virtual "cycling outdoors", for example [7]) and social activities.

The virtual modality creates environments that are responsive to the actions of the user, providing opportunities for repetitive, contextual practice, and feedback. Particularly when coupled with popular, commercially available gaming systems, the engaging nature of these activities can provide a motivating and enjoyable means of adhering to exercise and increasing physical activity (in the form of what is occasionally termed "exer-gaming"), both in health care settings and in the comfort and convenience of home [8]. A variety of health care practitioners use virtual reality technology to enhance patient treatments by using tools such as the Nintendo® Wii [9].

A major health concern for older adults is falling in the home, which has serious implications, including fear of leaving home, which significantly contributes to social isolation [10]. Mirelman,

Rochester, and Maidan [11] suggest that, while virtual reality devices used to be more commonly associated with video games, such technology can also be used to reduce the risks of falls in older adults. The virtual reality system in their study simulated the conditions and hazards that lead to older adults' falling, such that the study's participants could practice how to better avoid such hazards and receive feedback on their performance. Based on their observations, they concluded that a game-like approach based on virtual reality seemed to be able to engage subjects, motivate compliance, and reduce fall rates.

Virtual reality technology has recently been explored as a tool for neurorehabilitation to treat individuals with Parkinson's disease [12]. By practicing challenging skills in a safe environment, individuals experiencing impairments in balance and gait were able to safely negotiate a virtual environment. However, clinical utilization of VR for long periods of time may cause individuals with Parkinson's to experience simulator sickness due to sensory processing deterioration. This particular study concluded that limiting the use of immersive VR to 20 min did not induce simulator-related sickness, which could be a useful baseline "best practice" value for future rehabilitation-based applications with this population.

The technology has also been applied to practitioners working with cognitively impaired adults to detect navigational deficits [13]. Indeed, cognitive deficits are seen as potentially being addressed by a variety of technological VR programs. One study reported the use of a VR program that used a "virtual forest" theme with older adults with dementia. Moyle, Jones, and Dwan [14] looked at the impact of this program on participants' engagement, apathy, and mood, as well as the experiences of staff and families. All of the participants perceived the virtual forest to have a positive effect overall. However, those with earlier dementia became bored, while it seemed too confusing for those with late-stage dementia. While this study shows promise for the use of VR with individuals with dementia, it also suggests that in designing VR programs for this population, attention needs to be paid to how the interface can be as engaging as possible while not being confusing, and to taking steps to reduce fear and anxiety that may accompany this experience. More broadly, the success of the inclusion of VR in a diverse group of older adults in [11], which included individuals with Parkinson's and mild cognitive impairment, does demonstrate that it is possible to design programs of this sort that are suitable for a very heterogeneous group of participants.

2.2. Social Isolation and Loneliness

Social isolation and loneliness of older adults is a global issue and represents a known health risk. For example, in Canada, approximately 50% of people over the age of 80 report feeling lonely [15]; while living alone does not necessarily mean that a person is lonely, it can be a risk factor for loneliness or isolation. Both social isolation and loneliness are among risk factors that have negative effects on older adults' health. Social isolation is defined by having few social contacts or roles, whereas loneliness is the perceived lack of contacts and roles with others. Those who have lost their partner, have transportation issues, have poor health, have fewer family or friends, or who have limited contact with others are at risk of social isolation. Loneliness has been linked to poor cognitive functioning, impaired sleep and daytime dysfunction, impaired mental health, and even Alzheimer's disease [16]. Research has shown that loneliness can be as harmful to our health and quality of life as smoking 15 cigarettes a day [17], highlighting the importance of addressing this growing challenge among older adults.

In addition to the apparent benefits for physical health, social engagement also appears to have a positive influence on various aspects of mental health, including both cognitive functioning and affective mental health [18]. Intense feelings of emptiness, loneliness, abandonment, and forlornness, suggest [19], are linked to an insufficient quality or quantity of an individual's network of social relationships. It is therefore vital to propose solutions to minimize the impact of social isolation and loneliness among older adults.

Technology has the potential to bridge gaps across physical and social distance in times of crisis, such as the hesitation to interact in times of grief, loneliness, or declining health or mobility [10].

Virtual humans (VHs) can now be created to provide an older adult living on her/his own and perhaps vulnerable to loneliness with a customized 3D personal-care assistant.

Innovative programs are continuing to be introduced: O'Brian, Smith, and Beck [20] conducted research that examined the use of a program called "Second Life", an immersive, realistic 3-D online environment, in the lives of older adults who are susceptible to social isolation and loneliness. Second Life is a world that users can explore to find areas and people of interest. Users of Second Life create avatars of themselves, which can then explore this virtual world and interact with other users in the world. Second Life users can attend courses or virtual dance parties, go virtual shopping, or create their own areas. Such environments potentially offer isolated older adults a venue for increased social interaction.

Three main themes emerged from their research: in general, participants were optimistic about the idea of forming completely new social relationships in a virtual world. However, when asked about the value they gained from relationships they formed online, responses were mixed. While a few were able to form new online relationships that were seen as positive, most of the strongest relationships were formed with other human participants who they met in person during the study. Obstacles centered around social discomfort, including "the participants' own personalities, difficulty finding other avatars, language differences, lack of face-to-face interaction, rejection by other avatars, and discomfort with inappropriate sexual interactions" [20] (p. 178). The authors [20] noted that, if the participants' identified obstacles could be addressed, then their social discomfort would be minimized and the technology would be more appealing. These concerns, in addition to the philosophical question of how valuable or appropriate it is to cultivate virtual relationships instead of in-person ones, will undoubtedly be addressed as this field grows and older adults increasingly turn to online or virtual platforms to support their social engagement goals. While engagement with avatars may help to alleviate loneliness, or even boredom, it may not be the best approach to reducing social isolation in this population.

Another unique social engagement tool is the GeriJoy virtual care companion (www.gerijoy.com), which is operated around the clock by GeriJoy representatives who work remotely. A virtual "talking" dog or cat on a tablet screen interacts and converses with an older adult. The pet "wakes up" when the screen is touched, and starts chatting. When asked a question, the virtual companion (pet) responds immediately, as the human helper can look up an answer on the Internet. Daily conversations and events are kept on a written log, which the family can access through a secure Web site. Again, while these tools may be able to help alleviate boredom, they are certainly not a replacement for true human (or even animal) interaction; exploring the balance between nurturing supportive virtual relationships and maintaining meaningful in-person ones will be of fundamental importance as machine learning and artificial intelligence allow virtual companions to take on more and more human-like characteristics.

3. Discussion

It is clear that virtual reality technology is being increasingly adapted to meet the social needs of older people as well as its more traditional uses in addressing physical health issues such as failing mobility. Baecker, Moffatt, and Massimi [10] suggest that virtual reality programs can be especially effective when older adults emotionally isolate themselves from those around them. O'Brien, Smith and Beck [20], in exploring how older adults responded to a virtual world and its social opportunities, concluded that if their identified obstacles could be addressed, then social discomfort could be minimized and the technology made more appealing to this age cohort. Future research, then, might focus on how to make VR technology more useable, flexible, and attractive to serve a variety of older users. Schulz et al. [21] raise an important caveat to this approach, however, in reminding those working in gerontology and related fields not to underestimate the importance of leveraging interdisciplinary work to drive technology development. It is not enough to use a primarily biomedical research model to assess the efficacy of an intervention, but rather, questions relating to uptake,

adoption, and abandonment of technologies are equally important, alongside a better understanding of how to prevent the undermining of motivation and autonomy by using technology [21]. Little research on technology and older adults "closes the loop" in this way, and as these technologies become more integrated into our lives, this question will surely grow in importance and relevance for developers and users alike.

Mitzner et al. [4] also concur that further research is required to improve issues of cost, design, and usability of VR devices. Design is a critical factor: the needs of this population differ dramatically from those of Millennials or middle-aged adults, especially in terms of audition, vision, and mobility. An older adult with a chronic condition such as arthritis, who may also have limited vision, is unlikely to enjoy and regularly use any device that has a complicated interface and tiny, hard-to-press buttons. Goodall et al. [22] add that, at a time when the population is aging and there is an increasing use of the Internet to deliver services and information, there is little research on the effects of ethnicity, migration, socio-economic status, education, or gender of older people on the use of innovative technologies. It is also interesting to note that many of the studies about VR and aging are based out of retirement and long-term care homes, in and of themselves pre-selecting individuals of a certain socioeconomic and/or geopolitical status. As described in [5], language abilities, access to the Internet, accommodations for disabilities, and digital literacy are not always considered (or taken into account) when designing technologies; in this context, individuals who live in a retirement or long-term care home that can afford, and is able to implement, a VR-based program may differ in some of these important ways from the general population of older adults, skewing the results of work in this area and underestimating the impact of poor design elements.

Finally, it would be worthwhile to consider the importance of older adults' attitudes towards technology in general and to VR in particular. There is a very complex relationship between the media's portrayal of older technology users and the way they (older technology users) view themselves in comparison to younger users and to their peers [23], which might impact how developers or service providers "pitch" the value of VR-based platforms. Findings that demonstrate that older adults' attitudes towards interventions that include VR are strongly related to their experience [24] suggest an important role for user testing to maximize the user experience for a wide range of potential older users. Even with effective user testing, the quality of a tech-based experience, no matter how engaging or positive, will never be the same as an interaction with a real life human; it is the high-tech vs. high-touch question [25], asking if and how technology might replace (or support) traditional care paradigms. The perceptions and attitudes of both the end users and the developers/providers of technology-based experiences will have to contend with this question as the field progresses.

4. Conclusions

In this world of rapid technological advances, as well as a burgeoning elder population, it appears that service providers, health practitioners, social entrepreneurs, and tech developers might do well to look to expanding VR possibilities beyond traditional entertainment purposes to engage the older adult market. Such technological advances appear to hold the potential to significantly impact one of the most important issues that older people face (social isolation and loneliness), while also playing an important role in helping older adults to maintain their overall health and well-being. The authors present the following specific recommendations based on this review that may help move this area of work forward:

- Designers should be mindful of the abilities and attitudes of their target market prior to designing VR narratives and/or platforms. Individuals with mild cognitive impairment living in retirement homes will need different design and use considerations compared to healthy, community-dwelling older adults. This is not to say that multiple target groups cannot be served by the same virtual environment(s), but outcomes will be maximized if designers are able to truly consider the unique needs of older adults.

- Researchers must consider the broader factors impacting the use of the technologies that they are developing; does the design assume, or require, a particular level of digital literacy? Is the technology prohibitively expensive for use with the general public? How can the implementation of the technology itself circumvent the variety of socioeconomic and geopolitical factors that impact an older adult's engagement with a new device/platform?
- How does the end goal of the technological narrative align with the end goal from a health and wellness perspective? Cultivating virtual friendships while abandoning real-life ones is not a sustainable or healthy solution for socially isolated or lonely older adults. This issue requires a holistic, interdisciplinary approach to the integration of technological solutions into the daily lives of older adults whereby gerontologists, developers, service providers, and researchers in many other disciplines should collaborate to design the most effective, engaging, and appropriate technologies.

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