

Acceptance of Virtual Reality Games Among Older Adults Living in Long-Term Care Facilities: A Mixed-Methods Study

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DEDICATION

This dissertation is dedicated to Sarina, Nika, Hadis, Mahsa, Aida, Ghazaleh, Armita, and all the courageous girls and women in Iran whose strive for a brighter future has been an inspiration for me.

Preface

This research project was conducted with the approval of the University of Ottawa Research Ethics Board (H08-17-10). MH, the named doctoral candidate, participated in all aspects of the study, including conceptualization and design, data collection and analysis, findings interpretation, and manuscript drafting. MH was responsible for ensuring the integrity of the data and overseeing all aspects of the dissertation studies.

Dissertation Abstract

Background: Virtual reality (VR) offers potential for enhancing physical activity and engagement among older adults in long-term care (LTC) facilities. This addresses the need for health maintenance and independence. Yet, limited research exists on VR acceptance and its optimization for promoting physical activity. Older adults' VR gaming experiences and the social and contextual factors affecting acceptance are underexplored. This study aims to investigate these unique experiences to inform the design of inclusive VR technology in LTC, enhancing physical activity and well-being.

Objectives: My dissertation has two objectives: (1) to examine the individual and social factors that impact the acceptance of VR games among older adults in LTC facilities and (2) to explore LTC residents' experience with VR games and the meaning they associate with their gaming experience.

Methods: To reach these objectives I conducted two studies: (1) a scoping review of 5 articles to identify evidence on older adults' acceptance of physical activity VR games in LTC facilities, describe research designs used, define key acceptance concepts, and identify knowledge gaps for future research and (2) a mixed-methods study, including a series of gaming sessions with 20 older adults residing in a healthcare center followed by a composite questionnaire and semi-structured interviews with 15 older adults and 4 staff members.

Results: The scoping review identified a knowledge gap in VR acceptance among older adults in LTC. Varying acceptance levels and inconsistent concept definitions were found, emphasizing the need for an integrated approach combining qualitative and quantitative methods. Only one study used validated tools for assessing acceptance. The quantitative study involved VR gaming

sessions with 20 participants aged 65 and older, revealing significant positive correlations between perceived ease of use and Selective Optimization with compensation (SOC) strategies. No significant relationship was found between Technology Acceptance Model (TAM) and Future Time Perspective (FTP). Prior gaming experience led to higher SOC and socioemotional Selectivity (SST) scores, higher game self-efficacy, and increased hedonic motivation. Age and gender had no impact. Participants viewed VR as user-friendly and useful, with positive attitudes toward aging and physically demanding activities. The qualitative revealed themes related to enjoyment, physical activity, social connection, and individual preferences. Staff perspectives addressed relevance, personalization, training, and organizational barriers. The study highlighted the potential benefits of VR gaming for LTC residents, offering insights for technology development.

Conclusion: This study offered a comprehensive understanding of VR gaming acceptance among older adults in LTC settings, highlighting the significance of individual and social factors in technology acceptance. Personalized design, support, education, trust, and safety are crucial. Integrating social theories of aging is essential to understand older adults' needs and preferences. Implications for VR design include user-centered approaches, intuitive interfaces, customization, social interaction, and safety considerations. Addressing limitations and biases in future research can promote effective use of VR as a therapeutic tool for older adults in LTC.

Acknowledgements

I would like to express my heartfelt gratitude to all those who have supported me throughout my dissertation journey. First and foremost, I am deeply thankful to the participants of this study who generously shared their time and experiences, without whom this research would not have been possible.

Changing my research focus from technology in social sciences to technology in health sciences and aging was challenging. It brought frustrations and uncertainties, but the continuous support from my supervisors played a crucial role in overcoming these obstacles. Their belief in my abilities and guidance helped me navigate this new direction and pursue excellence in the field.

I extend my sincere appreciation to my supervisors, Dr. Jeffrey Jutai and Dr. Roanne Thomas. I appreciate Dr. Jutai's exceptional knowledge and expertise in the field. I am grateful for his continuous support, valuable insights, and the trust he placed in me, allowing me to make independent decisions and explore new paths in my research. Moreover, I am truly grateful for his understanding and support during the challenging times I faced throughout my Ph.D. journey.

I was fortunate to have had Dr. Thomas as my supervisor. Her unique blend of being a kind friend and a knowledgeable scholar created a nurturing environment that allowed me to thrive. Her guidance gave me the confidence and courage to step out of my comfort zone and explore new horizons.

I am also grateful to my thesis advisory committee members, Dr. Pilutti and Dr. Fallavollita, for their insightful feedback and contributions, which have enriched the scholarly rigour of this work.

I was fortunate to receive the Admission Scholarship, which has provided financial support for my studies. I would like to acknowledge the funding received through Dr. Jutai's research grants, which have been instrumental in facilitating the progress of this research.

I would also like to express my sincere appreciation to my friends in Canada and in Iran for their support and encouragement throughout this academic journey. Your friendship has been a source of strength and motivation for me.

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List of Abbreviations

LTC	Long-term Care
VR	Virtual Reality
PA	Physical Activity
TAM	Technology Acceptance Model
UTAUT	The Unified Theory of Acceptance and Use of Technology
STAM	The Senior Technology Acceptance Model
SOC	Selective Optimization with Compensation
SST	Socioemotional Selectivity Theory
FTP	Future Time Perspective
SoF	Summary of Findings

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CHAPTER 1: INTRODUCTION

This chapter aims to introduce the dissertation and describe the problem statement, the objectives, key concepts, and the gap in the knowledge related to the topic of this study. First, I discuss the problem and the dissertation's objectives, which are focused on identifying the factors that influence the acceptance of technology by older adults in LTC facilities. Second, I describe the conceptual framework that guided this study. Third, I summarize the current state of knowledge on technology acceptance among older adults in LTC, highlighting gaps in the literature, and justify the reasons for the dissertation. Finally, I outline the organization of the dissertation and describe the methodology.

Statement of the problem

As the proportion of older adults continues to increase relative to other age groups, there is an expected rise in the number of older individuals residing in LTC facilities (CCSMH, 2016). LTC facilities are residential settings that provide care and services to individuals who require assistance with activities of daily living due to chronic illness, physical or cognitive impairment, or other health conditions. In this context, the primary objective in the field of LTC is to maintain residents' functional abilities and social engagement. Physical activity has been shown to be effective in improving functional independence and reducing the risk of various health issues among older adults; however, older adults in LTC facilities typically exhibit lower levels of physical activity compared to those living in the community (Y. M. Chen, 2010) due to various factors, such as health conditions, environmental factors, and the availability of activities (Bender et al., 2021; McPhee et al., 2016; Park et al., 2012; Paterson & Warburton, 2010; United Nations, 2022; Weeks et al., 2008). In this study, sedentary behavior is defined as “activities that do not increase

energy expenditure substantially above the resting level”. Activities such as sitting, lying down, sleeping, and watching television are examples of sedentary behavior. In other words, in sedentary behavior, sitting is predominant. In contrast, physical activity includes activities that cause an increase in energy expenditure above the resting metabolic rate (1.0-1.5 metabolic equivalents) (Pate et al., 2008). Exercise, often used interchangeably with physical activity, specifically denotes planned, structured, and repetitive bodily movement with the aim of improving or maintaining physical fitness (Caspersen et al., 1985). While exercise primarily targets physical fitness, physical rehabilitation adopts a holistic approach to foster comprehensive well-being in individuals facing impairments or disabilities.

Promoting physical activity among LTC residents can be crucial in enhancing their quality of life and achieving LTC objectives. With the increasing population of older adults in LTC settings and the rising costs of providing care to this demographic, there is a growing need to prioritize the role of technology in supporting independence and preventing or reducing disabilities in aging. Technology has the potential to address staffing shortages and improve person-centred care delivery in LTC facilities (Chu et al., 2021). Recent studies have shown the potential of technology, specifically virtual reality (VR) exergaming, in increasing physical activity among older adults (Yen & Chiu, 2021). VR is a computer-generated environment that utilizes specialized hardware and software, such as goggles and controllers, to immerse users in a realistic experience, enabling communication through voice, gestures, and facial expressions, and engaging all senses for a fully immersive experience (Kipper, 2013).

The customizable VR environment allows tailoring games to players' functional and cognitive abilities, making exercise entertaining, engaging, and motivational. VR exergaming can also

reduce social isolation and increase social engagement by creating a virtual community, promoting performance sharing, and supporting multi-player activities (Zhang & Kaufman, 2017). Social resources have been shown to affect the health of older adults, acting as a physiological triggering mechanism, strengthening people's immune systems, and buffering stress (Muckenhuber et al., 2013; Rostila, 2011); however, several barriers prevent implementation of VR in LTC setting, including a lack of awareness, accessibility, and technology acceptance among caregivers and residents (Benjamin et al., 2014).

In a broader context, the successful integration of VR technology in LTC facilities extends beyond addressing immediate concerns related to physical activity. It sets a precedent for innovative and person-centred approaches in older adults' care, potentially changing the way that health and well-being among older adults in LTC settings are promoted. This shift not only enhances the quality of life for residents but also contributes to the ongoing conversations on the role of technology in shaping the future of older adults' care.

Objectives

Technology has the potential to improve the quality of life for older adults; however, it is unclear whether older adults living in LTC settings will accept it (Renaud & Biljon, 2008). If older adults do not accept technology, they may not benefit from the potential improvements that technology can provide, including improved quality of life and access to services (Yen & Chiu, 2021). It is important to understand how VR technology can be tailored to the unique needs and preferences of older adults in institutionalized settings, and determine how age-related factors, such as cognitive decline and sensory impairments, might impact the use and acceptance of VR technology by this population.

Using theories of aging and technology acceptance models might help to identify factors that influence the adoption and sustained use of VR technology among residents of LTC but the applicability of these models to older adults in LTC settings has not been well-researched. Investigating the potential of these theories and models for explaining the use of VR technology can help to inform the design and implementation of interventions aimed at promoting physical activity and improving the quality of life in this population.

My dissertation consists of two research projects aimed at bridging the gap in research on the acceptance of VR physical activity technology among older adults in the context of LTC facilities: a scoping review and a mixed methods study. The scoping review aims to map the research and find the key concepts in the literature and to identify the methods and designs used for studying VR acceptance among older adults. Using the Arksey and O'Malley framework (2005), I drew the research data from published and unpublished journal articles in relevant electronic databases and supplementary sources for published articles and unpublished trials. Informed by the findings of the scoping review about the gaps in the literature, key concepts, and methodologies used for studying technology acceptance, I used a ***fully mixed sequential equal status design*** (Leech & Onwuegbuzie, 2009) to identify the important factors that affect VR exergames acceptance by older adults and explore the experiences of older adults with VR exergames. I conducted a set of gaming sessions followed by close-ended questionnaires to investigate the factors associated with technology acceptance (Quantitative Phase) and semi-structured interviews to explore participants' interaction with VR exergames and their unique experience on exercise with VR to validate results of questionnaires (Qualitative Phase). The analysis is

sequential as the quantitative phase was conducted before the qualitative phase and is equal because both methods are given equal weight.

Conducting these two studies, I pursued two objectives:

1- Identify the key factors influencing the acceptance of technology among older adults, focusing on individual and social factors. This objective aimed to understand how factors such as age, health status, prior experience with technology, and social support impact the acceptance of VR games among older adults in LTC facilities. Identifying these factors facilitates the development of interventions and strategies that meet the needs and preferences of older adults regarding VR exergames.

2- Explore the interaction between residents of LTC and VR games. This objective aims to understand how LTC residents engage with VR games, the benefits and challenges they experience, social connections, and how VR technology can improve their health and well-being. By exploring the interaction between residents of LTC and VR games, the study aimed to develop recommendations for designing and implementing VR exergames that can effectively enhance the health and wellness of older adults in LTC facilities.

Guiding Conceptual Framework

Positioning The Research: A Pragmatic Paradigm

In the rapidly advancing field of rehabilitation sciences, the incorporation of technology has opened up new ways for innovative interventions. Among these technological innovations, VR games have emerged as a highly promising tool for enhancing the well-being and overall quality of life among older adults. However, the acceptance of VR games within this context remain underexplored. By adopting a pragmatism paradigm, this research aims to explore the factors

that influence the acceptance of VR games among LTC residents, utilizing a mixed-methods design to gain a comprehensive and nuanced understanding of this phenomenon.

Pragmatism, as a philosophical framework, emphasizes the practical consequences of ideas and focuses on the real-world implications of research. Rooted in the social sciences, the application of pragmatism provides a holistic lens to explore complex phenomena and generate knowledge that informs practical interventions (Creswell & Plano Clark, 2011).

The application of pragmatism recognizes that knowledge is not static but evolves through an ongoing process of inquiry and experimentation. This paradigm acknowledges the complexity and multifaceted nature of the research topic, understanding that a singular perspective or methodology may not capture the full essence of the phenomenon being studied (Yvonne Feilzer, 2010).

The ontological assumptions underlying this dissertation highlight a perspective that emphasizes the practical and context-dependent nature of reality (Morgan, 2007). It acknowledges that reality is not fixed or universally defined, but rather shaped by the specific contexts and circumstances in which individuals operate. This ontological stance recognizes that older adults may experience VR differently based on their unique social, cultural, and environmental contexts. Pragmatism acknowledges that reality is not an abstract and fixed entity but is constructed through human experiences and interactions within specific contexts. In alignment with this ontological stance, my epistemological perspective recognizes the importance of integrating multiple perspectives and methodologies in understanding the acceptance of VR games among LTC residents. The mixed-methods design employed in this study reflects the pragmatic approach to knowledge generation by combining qualitative and quantitative methods. The qualitative

component allows for an exploration of the subjective experiences, perceptions, and attitudes of LTC residents towards VR games, while the quantitative component provides measurable data on acceptance levels and identifies factors influencing acceptance. This blending of approaches ensures a comprehensive and nuanced understanding of the phenomenon and promotes the practical application of research findings. The alignment between the pragmatism paradigm, mixed-methods design, and ontological assumptions enables a holistic exploration of the factors influencing acceptance and supports the development of evidence-based practices in the field of rehabilitation sciences.

In terms of methodology, I recognize employing a mixed-methods design, enables me to combine the strengths of qualitative and quantitative approaches, thereby addressing the research question from multiple angles (Johnson & Onwuegbuzie, 2007). The qualitative component was aimed to enable an in-depth exploration of the subjective experiences, perceptions, and attitudes of LTC residents towards VR games. Through interviews, participants had the opportunity to express their thoughts and emotions, providing rich insights into the acceptance or resistance towards this emerging technology. On the other hand, the quantitative component employed questionnaires to gather data on a larger scale. This approach allows for the measurement of acceptance levels, identification of specific factors that influence acceptance, and the quantification of trends or patterns within the LTC resident population. By blending these two approaches, a more comprehensive understanding of the complex interplay of factors influencing acceptance of VR games in LTC settings is achieved.

The mixed-methods design employed in this study offers the advantage of triangulation, where the integration of qualitative and quantitative data provides a deeper and more holistic

understanding of the research topic. By combining narratives and numbers, this approach enhances the validity, reliability, and generalizability of the findings. The insights gained through qualitative data complements and enrich the quantitative results, allowing for a delicate exploration of the social, psychological, and contextual factors influencing acceptance. Within the pragmatism paradigm, this research aims to bridge the gap between theoretical concepts and practical application, exploring the acceptance of VR games among LTC residents.

Theoretical framework

Advancing a role for VR games in enhancing the health and wellness of older adults living in LTC requires a research approach that understands the factors influencing their acceptance of technology within a conceptual framework that integrates theories of aging and technology. To address this need, I employed a theoretical framework that integrates the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), the Senior Technology Acceptance Model (STAM), the Socioemotional Selectivity Theory (SST), and Selection, Optimization, and Compensation (SOC) theory, which allows for a comprehensive understanding of the various factors that impact the acceptance of VR games among older adults in LTC facilities.

The multiple theories that I integrated into my framework (TAM, UTAUT, STAM, SST, and SOC) are all relevant to understanding technology acceptance and aging, and they each provide a different perspective on the various factors that influence the acceptance of VR games among older adults in LTC facilities, especially, the role of social and emotional factors.

In recent years, there has been an attempt to understand the factors associated with the design of technologies and user acceptance in older adults' aging process and life worlds. However,

there is still a research gap in technology acceptance by older adults, as most studies have focused on technology acceptance and adoption from a disciplinary perspective rather than aging. This lack of bridging between technology acceptance models and theories of aging reinforces the division between aging scholars and technology scholars. This division impedes the development of theories of aging and technology. Many technology projects assume that older adults are not interested in or familiar with technology, which is a result of the failure of aging scholars to describe aging with technology and the framing of acceptability problems because of older people's technology skepticism (Peine & Neven, 2020; Renaud & Biljon, 2008; Peine & Neven, 2019).

Technology Acceptance

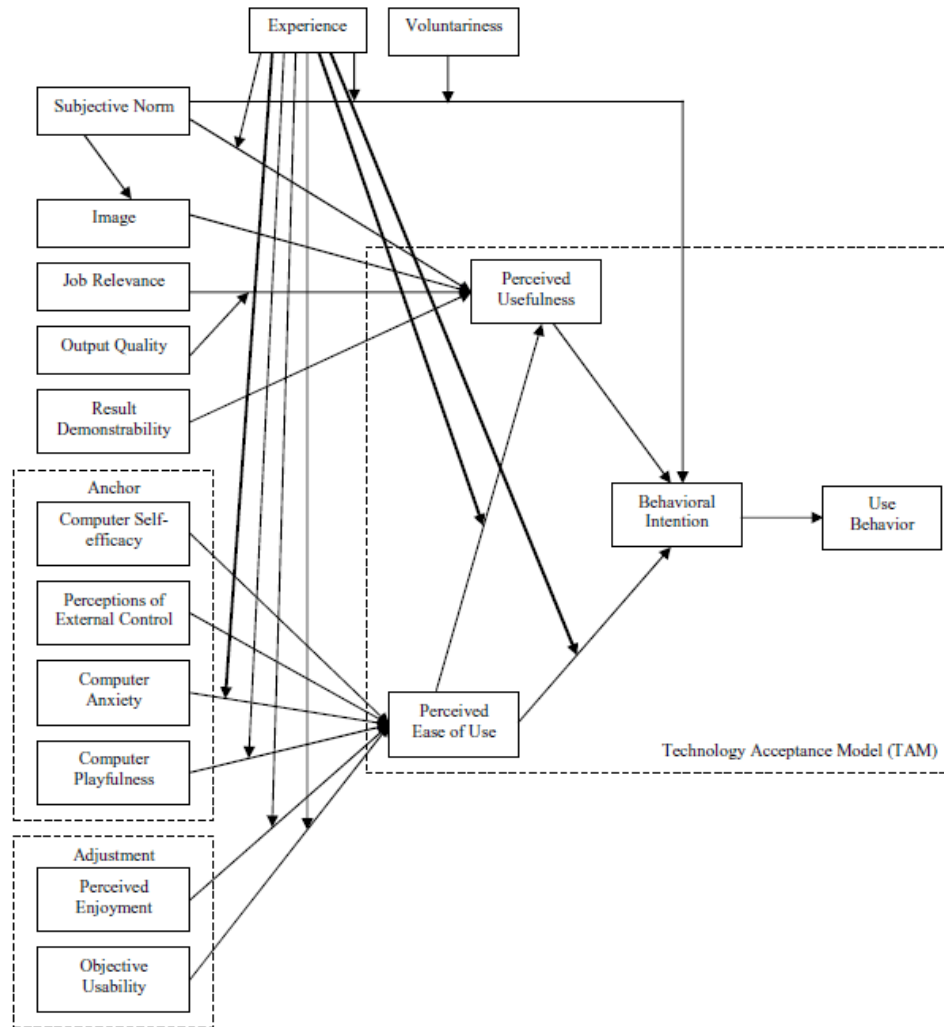
The literature has extensively investigated the concept of technology acceptance, offering various definitions and conceptualizations. A widely accepted definition characterizes technology acceptance as an individual's attitude towards technology, which can be influenced by various factors, as defined by Renaud and Biljon (2008). This attitude can be considered a precursor to the technology adoption stage, indicating the likelihood of adoption, according to Jia, Lu, and Wajda (2015). Conversely, technology adoption is a process that encompasses the stages an individual or organization goes through, from becoming aware of technology and its potential benefits to fully utilize it in their daily operations (Renaud & Biljon, 2008). This process is often depicted as a journey that starts with awareness and culminates in full integration and utilization of the technology. Notably, technology acceptance and adoption are closely intertwined, with technology acceptance frequently serving as a prerequisite for adoption. Hence, understanding

and influencing the factors that affect technology acceptance is crucial for successfully adopting and implementing new technologies within organizations and society.

The Technology Acceptance Model (TAM)

The study of technology acceptance has been guided by several proposed models. TAM (Figure 1.1) has emerged as a fundamental framework for examining this phenomenon. TAM suggests that users' attitudes towards technology, which in turn determine their intention to use and computer acceptance behaviour, are shaped by perceived usefulness (i.e., the degree to which using a specific application system will enhance job performance) and perceived ease of use (i.e., the subjective likelihood that using technology will require minimal effort) (Davis et al., 1989). Although originally developed to model computer acceptance within an organizational context, TAM has since been applied in studying technology acceptance among older individuals (Gschwind et al., 2014; Morán et al., 2015; Roberts et al., 2019).

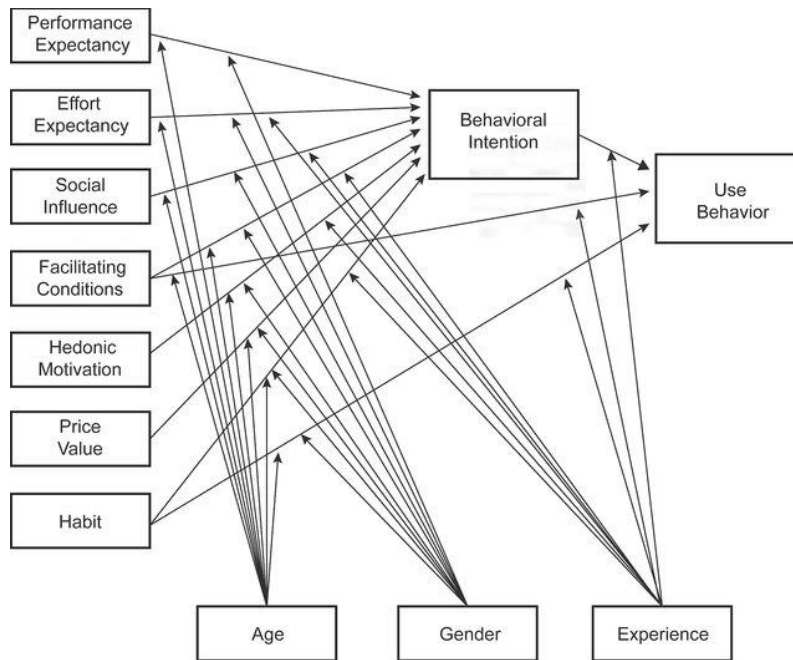
Figure 1.1 *Technology Acceptance Model (TAM)*



The Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh and colleagues formulated UTAUT (Figure 1.2) to examine technology acceptance and use in a consumer context. UTAUT integrates eight dominant theories and models and consists of seven core determinants of intention and usage and up to four moderate determinants. These determinants include performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit as direct determinants, and gender, age, and experience as key moderators, all of which play a significant role in user acceptance and usage behaviour (Venkatesh et al., 2003; Venkatesh, Thong, & Xu, 2012).

Figure 1.2 *The Unified Theory of Acceptance and Use of Technology (UTAUT)*

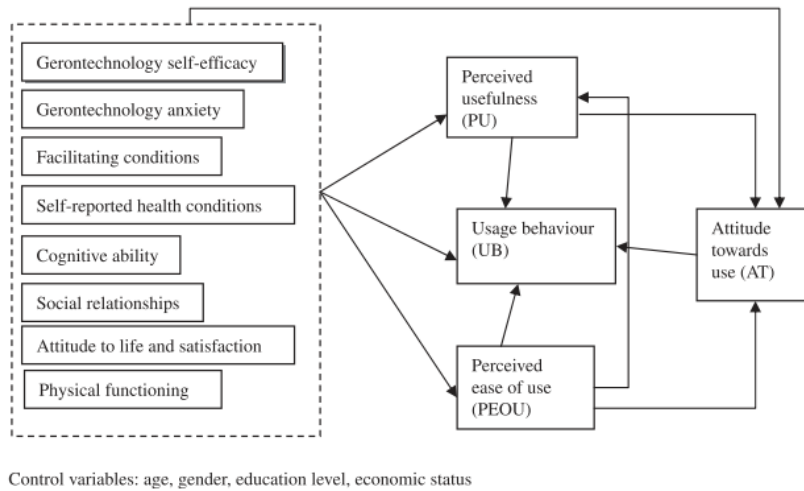


The Senior Technology Acceptance Model (STAM)

STAM is a TAM-based model specifically formulated to understand the acceptance of gerontechnology by older adults (Figure 1.3). STAM goes beyond TAM's organizational and business context and incorporates predictive factors of both TAM and UTAUT (K. Chen & Chan, 2014). STAM considers individual characteristics, such as physical and cognitive functioning, health status, technology anxiety, and self-efficacy, as technology acceptance determinants. According to STAM, perceived usefulness (PU) and perceived ease of use (PEOU) jointly determine attitude toward (AT) technology use behaviour, which in turn influences technology use behaviour. Chen and colleagues predicted that individual attributes (such as age, gender, education, gerontechnology self-efficacy and anxiety, health and ability characteristics, and facilitating conditions) and attitudinal factors (PEOU, PU, AT) predict technology use by older adults. Their survey found that individual attributes are better predictors of gerontechnology

usage behaviour (UB) than the traditionally used attitudinal factors of usefulness and ease of use (Czaja et al., 2016).

Figure 1.3 *The Senior Technology Acceptance Model (STAM)*



Social Theories of Aging

Social theories of aging examine how social factors and cultural practices influence the aging process and its outcomes. These theories emphasize that aging is not solely determined by biological factors, but rather shaped by the social, cultural, and environmental contexts in which individuals live. They highlight selectivity of resource investment and compensation of failure and loss and the significance of social relationships, societal norms, and cultural values in shaping individuals' health, well-being, and overall experience of aging (Baltes et al., 1999). We employed two social theories of aging in our theoretical framework to explore the social determinants of VR acceptance by LTC residents.

The Selective Optimization with Compensation (SOC) theory

SOC, developed by Baltes et al. (1999), centers on the awareness of losses and gains and resource decline in older adults due to aging. According to this theory, seniors choose goals that are more

important or achievable, optimize their performance to maximize gains and compensate for unattained goals to maintain their functioning (Cleveland & Agbeke, 2019; Schulz et al., 2015a). Seniors are advised to choose and optimize their best abilities and most intact functions while compensating for declines and losses to enhance their health and well-being. For example, a visually-impaired senior who enjoys singing can allocate more time and effort to singing, such as by joining a new choir, while reducing the time spent on reading. In the SOC framework, social resources play a crucial role in maintaining the well-being of older adults.

Socioemotional Selectivity Theory (SST)

SST, proposed by Laura L. Carstensen (1995), is a lifespan theory that explains how personal goals and behaviours change with age. One of the key concepts in SST is the future time perspective (FTP), which refers to an individual's perception of time and how much time is left. According to SST, younger individuals perceive the future as more distant than older adults. Therefore, younger people tend to value future-oriented investments and focus on goals related to knowledge acquisition, career planning, and establishing new social relationships that can potentially pay off. In contrast, older adults prioritize current and emotionally significant relationships and goals related to emotional regulation. They tend to spend time with individuals with whom they share positive relationships that enhance their positive emotional experiences and psychological well-being (Carstensen, Fung, & Charles, 2003).

I operationalized the theoretical framework by translating abstract concepts and constructs from the theories into tangible variables, measures, and questions that I could use in my research. Using these theories, my dissertation aims to investigate the factors that affect the acceptance of VR games by older adults living in LTC facilities. This research approach considers the

technological and social factors that influence technology acceptance by older adults. Specifically, TAM provides a foundation for examining the attitudes and behaviours of technology users. At the same time, UTAUT and STAM extend the TAM to include additional variables and contextual factors that influence technology acceptance and use, such as social influence and habit. Moreover, the SOC theory and SST provide insight into the resource management and goal prioritization strategies used by older adults, which are essential for understanding how VR games can be effectively integrated into their lives. Situated acceptance complements these theories by emphasizing that technology acceptance is context-dependent, shaped by the specific conditions, needs, and social dynamics of the environment in which it is introduced (Bobillier Chaumon, 2021).

By adopting an integrated theoretical framework, this research can contribute to addressing the gap in technology and aging. The proposed framework provides a comprehensive understanding of the factors influencing the acceptance of VR games among older adults living in LTC facilities. This can help design effective interventions and programs that promote the use of VR games to enhance the health and well-being of older adults. Moreover, this research approach can contribute to the development of theoretical models that incorporate technological and social factors in understanding older adults' acceptance and use of technology, thereby filling the gap in the current technology acceptance models.

Review of Literature

Current State of Knowledge

Technology and aging emerged as a new research area in the late 1980s. This development can be attributed to rapidly growing technology, extended life expectancy and increasing costs of

caring for older adults (Pruchno, 2019). Researchers in this area aimed to use the potential of technology to enhance older adults' quality of life and independence. However, the efforts to address the factors influencing the relationship between older adults and technology resulted in little literature (Schulz et al., 2015) with a significant research gap in exploring the underlying factors influencing acceptance within this context.

To address this gap, researchers have investigated the efficacy and acceptance of VR interventions among older adults, as well as the factors influencing acceptance of technology using social theories of aging as a theoretical framework. In this section I provide a brief review of two distinct, yet interconnected areas of research. The first encompasses studies that specifically focus on investigating the efficacy and acceptance of VR interventions among older adults. The second strand of research draws upon social theories of aging as a theoretical framework to explore the underlying factors that influence the acceptance of VR among older adults.

Efficacy and Acceptance of VR Interventions

The reviewed studies in the field of VR interventions for older adults encompassed various interventions and outcome measures. One area of focus was the impact of VR systems on the emotional and social well-being of older adults. Lin et al. (2018) conducted a two-week intervention involving a VR system to examine its effects on emotional and social well-being among older adults residing in assisted living communities. The study found that the use of the VR application to review travel-related content provided significant benefits compared to the control condition, suggesting that VR technology has the potential to enhance the emotional and social well-being of older adults. In terms of physical activity and well-being, Dwivedi et al. (2018)

studied the use of a VR-based 9-square matrix aerobic exercise program specifically designed for older adults. Their research aimed to explore the effectiveness of VR technology in engaging older adults in physical activity and promoting overall physical well-being. Similarly, Eisapour et al. (2020) focused on older adults living with dementia and investigated the applicability of exercise delivery via VR-based games. The research employed a participatory design approach, involving the active involvement of the target population in the design and evaluation process of the VR games. The study sought to explore the potential benefits and effectiveness of VR-based interventions in enhancing physical activity levels and overall engagement in this population.

In addition to examining the impact of VR interventions, researchers have also explored the acceptance of VR technology among older adults. Burdea et al. (2015) developed a subjective evaluation questionnaire to measure the acceptance of the BrightBrainer serious game, which led to a significant improvement in the Montreal Cognitive Assessment (MoCA) test scores of the participants. Huygelier et al. (2019) created attitude, enjoyment, and confidence/anxiety scales, finding high acceptance of VR natural landscapes using Head-Mounted Display VR (HMD-VR) technology.

Laver et al. (2011) utilized a discrete choice experiment methodology to gauge the preferences and acceptance of the Nintendo Wii Fit as a form of physical activity among older adults. The study revealed that the Wii Fit was indeed acceptable and appealing to older people.

Chau et al. (2021) assessed the feasibility, acceptability, and efficacy of VR training among older adults and people with disabilities. Their single-arm pre-post study design involved VR training interventions, and outcomes were measured before and after the training. The findings

demonstrated that VR training was feasible and well-received among both older adults and people with disabilities.

While the studies mentioned above provide valuable insights, there is still a need to explore the theoretical underpinnings that can inform the implementation of VR technology in a meaningful way. These studies sought to determine whether VR is a viable and engaging tool for this population and contributed to the growing understanding of the potential benefits and effectiveness of VR interventions for older adults, shedding light on various aspects such as emotional well-being, social engagement, physical activity, cognitive improvement, and overall acceptance and feasibility of VR technology in this population. However, as VR technology continues to advance, it becomes increasingly important to explore the theoretical underpinnings that can inform and guide its implementation in a meaningful way.

Technology and Social Theories of Aging

As theoretical perspectives on lifespan development, SOC and SST have been used by researchers to explain older adults' approach to various aspects of late life, such as leisure activities (e.g., Burnett-Wolle & Godbey, 2007) and challenges of independence in aging-in-place (Kelly, Fausset, Rogers, & Fisk, 2014). Nonetheless, there has been little research based on SOC and SST within the context of applying new technologies. Technology acceptance models have been used to assess technology usage by older adults; however, due to the absence of aging-related factors, their ability to explain technology acceptance by older adults is arguable.

Recent studies have made efforts to address these gaps by integrating social theories of aging and technology acceptance models. An exemplar of this approach is Nimrod's study, which employed social theories of aging as the theoretical framework for examining technology use

among older adults (Nimrod, 2020). In her study, Nimrod examined the impact of ICT on older adults' subjective well-being (SWB), utilizing SOC, and sought to answer inquiries such as "How do older adults employ ICT through SOC processes?" and "In what ways do these ICT use to assist in maintaining their subjective wellbeing and involvement in valued activities?" by conducting focus groups with grandmothers who use ICT. Nimrod observed that older adults had employed various ICT strategies that could be classified under SOC, such as selective and restricted usage of ICT to prevent diversion from important activities as a selection strategy and using technology to support activities of daily life (ADL) such as online appointments, shopping, and communication management as optimizing strategies. She acknowledged using social media and educational resources available on the Internet as compensating strategies for age-related losses (e.g., retirement, spouse loss, and physical constraints) and general obstacles (e.g., physical distance from loved ones, lack of knowledge or skills). Despite many participants with varying backgrounds, Nimrod's findings lack generalizability to older men and other forms of technology that impact SWB other than the Internet.

Like Nimrod's work, Chu et al. (2019) investigated the acceptance rates of two assistive robots among community-dwelling older adults. They compared the preferences for service-oriented robots with human characteristics versus companion-oriented robots with animal qualities. Their hypotheses were generated based on the SOC and SST frameworks, with the main goal of older adults being to maintain their independence and everyday competence. The researchers used drawings, interviews, and questionnaires to assess participants' expectations and preferences. However, their study had limitations since participants were not exposed to the robots they aimed to compare and were not informed about all the robots' functions and abilities. The

researchers modified the information about each robot to limit the differences and comparability limitations. Moreover, the participants were relatively healthy, active, wealthy, and educated; thus, their study findings are not readily generalizable to other populations.

On the other hand, Fang et al. (2018) investigated the relationship between ICT use and psychological well-being (PWB) in older adults, considering the roles of age, frailty, and social connectedness. Drawing on SST and SOC, they posited that older adults prioritize maintaining meaningful social relationships, and ICT tools that facilitate this can promote PWB. They also suggested that older adults are more likely to benefit from ICT compensations due to frailty, such as mobility impairments that limit in-person visits, shopping, and appointments. The study involved telephone interviews with people aged 50 and above, with results indicating a positive association between ICT use and PWB among older adults aged 75 and older. However, their study was limited to assessing Internet and smartphone use, which may not be generalizable to other types of technology. The study also did not investigate the actual uses of these technologies and did not gather information on all the sociodemographic factors that may impact ICT use among older adults.

Like Fang's work, Sims et al. (2017) investigated the impact of ICT use on well-being among the oldest-old, utilizing SST to propose that social goals have a greater impact on well-being than informational goals in this population. The study was conducted through a survey of individuals aged 80 and above, and the results indicated that the relationship between ICT use and psychological well-being was mediated by social motivations. In contrast, the relationship between ICT use and physical well-being was mediated by informational motivations. However, the study had several limitations, including a lack of clear definition of the physical and

psychological well-being variables and covariates and a failure to assess participants' prior technology skills. Additionally, the researchers took a broad approach to ICT use among older adults, which limits the ability to draw causal relationships between technology use and well-being. Furthermore, as the study was conducted solely among individuals aged 80 and above, the SST-based findings may not be generalizable to younger older adults. Therefore, further research is needed to clarify the causal relationship between technology use and well-being across a broader range of age groups.

In contrast to Sims's study, Meekes and colleagues (2017) employed TAM and Self-Determination Theory to investigate the factors influencing motivation to use the exergame. They used a mixed-methods approach that included interviews and a TAM questionnaire developed by Davis (1989) to assess the participants' motivation to use the exergame. In their study, the researchers utilized the eight elements of game enjoyment defined by Sweetser and Wyeth. The results showed that most participants found the exergame enjoyable. The main motivational factors for exergame participation among older adults in assisted living facilities were enjoyment, social interaction, and perceived health benefits. The participants reported that they enjoyed playing the exergame, which motivated them to participate regularly. They also highlighted the social interaction aspect of exergaming, which provided opportunities for socializing and connecting with others in the facility. However, the study has limitations since it was conducted in an assisted living facility, and the findings might not be generalizable to other settings.

Additionally, Nawaz et al. (2014) utilized the UTAUT to evaluate the experience of exergames among healthy older adults and their technological preferences for balance training. The researchers also investigated the essential factors for older adults in exergames. The team

collected data using the card-ranking method, system usability scale (SUS), and semi-structured interviews after the participants played the games. They discovered that participants valued the level of difficulty, advancement in the game, and instructions in languages other than English for exercising. Despite the researchers' exploration of the user experience of exergames and their preferences, they noted that the UTAUT lacks explicit constructs for measuring older adults' intrinsic motivation and characteristics affecting their preferences and expectations from exergames. Furthermore, this model did not account for enjoyment and flow as significant factors in exergaming.

Similarly, Mitzner et al. (2010) applied UTAUT to examine the predictors of mid-term and long-term adoption of a computer system designed for older adults by conducting 18 focus groups with community-dwelling older adults. They highlighted that older adults' characteristics differ significantly from those of younger adults regarding abilities, health, attitudes and experience with technology. However, the inclusion criteria were limited, which restricted the generalizability of the results to other populations. Furthermore, UTAUT was not designed to address within-group heterogeneity of older adults regarding technology adoption purposes. Mitzner et al. emphasized the importance of presenting predictors for older adults and the need for testing technology acceptance models for specific senior technologies.

On the other hand, Chen and Chan (2014) aimed to understand the acceptance of gerontechnology by older adults by surveying older adults recruited from local elderly service centers. They used individual attributes and TAM-based attitudinal factors as predictors of technology use by older adults. They found that individual attributes were better predictors of gerontechnology usage behaviour than conventional attitudinal factors. However, their study's

general approach to technology and specific population limits the generalizability of the results. Furthermore, the predictors presented by STAM may affect technology acceptance differently in different cultures. For instance, social relationships may affect technology acceptance differently in collective and individualistic cultures.

It is noticeable that a limited amount of research focuses on the acceptance and use of technology among older adults using social theories of aging and technology acceptance models. Most studies that have been reviewed concentrate on the use of ICT, such as the Internet and smartphones, by older adults who live in the community. Therefore, their results may not apply to more recent technologies, such as VR and their use in LTC facilities. The studies reviewed are also limited in that they lack explicit constructs for measuring older adults' intrinsic motivation and their characteristics to examine technology acceptance, have a restricted and homogeneous population, fail to address cultural factors, do not study the acceptance of a particular technology, do not mention the specific uses of technology, and have a general approach to wellbeing variables. These quality issues highlight the need for further studies that address the overlooked influential factors, as the current models are limited in addressing the effects of social factors.

In summary, advances in our understanding of factors affecting technology acceptance by older adults living in LTC facilities require research with a more robust and comprehensive theoretical foundation. This foundation should incorporate insights from the theories and models reviewed above.

Methodology

The literature review highlights the inadequacy of current models in addressing social factors that influence the acceptance of technology among older adults, emphasizing the need for further studies to address the neglected influential factors. To bridge this gap, this dissertation aims to investigate the acceptance of VR technology among residents of LTC facilities through two distinct activities:

1. A scoping review to explore the determinants of VR acceptance among this population.

The existing literature on aging and technology acceptance is limited, with few studies specifically exploring the application of VR physical activity games for older individuals. Moreover, a comprehensive review of LTC residents' attitudes toward VR games is lacking, resulting in a knowledge gap regarding how older adults living in LTC engage with VR technology and the factors influencing their acceptance. Additionally, previous studies on technology acceptance among older adults have presented varied definitions of relevant concepts that require integration and unification. Given these factors, this portion of my dissertation adopts an exploratory approach aiming to provide a comprehensive overview of the current knowledge on VR games, including factors influencing acceptance among older adults, while also identifying gaps in the existing literature (Peters, 2016). To achieve these objectives, I conducted a scoping review, synthesizing the findings from published research studies that have examined the acceptance of VR interventions in promoting the physical and cognitive health of older adults living in LTC.

2. A mixed-methods study to fill the existing knowledge gap on factors that affect VR acceptance and to investigate the link between emotion-related goals and the use of VR games.

Mixed-method research has emerged as a methodological approach that addresses the unexpected conflicting results between quantitative and qualitative methods by adopting an integrative approach that combines numeric and narrative data and analyses, operating within the pragmatism paradigm (Tashakkori & Teddlie, 2009). Mixed-method research employs this integrative approach across various aspects of the research process, including the formulation of research questions, selection of research methods, data collection, and analysis. By utilizing this design, I aimed to achieve a more comprehensive and in-depth understanding of the research problem at hand, surpassing the limitations of relying solely on quantitative or qualitative methods (Creswell & Plano Clark, 2011). Considering the research objectives and the nature of the research problem, the mixed-methods design was chosen as the most appropriate approach for capturing a holistic view of the phenomenon under investigation and addressing the research questions in a comprehensive manner.

In the context of technology and aging, mixed-methods study is particularly valuable for understanding the interaction between older adults and technology, overcoming digital disparities, addressing sociodemographic characteristics, and examining the lived experiences and challenges of older adults. To effectively integrate technology into the environment of older adults, and to foster collaborative efforts among key stakeholders such as consumers, designers, scientists, and producers, it is necessary to employ a combination of research methods in diverse real-world settings rather than confining research to laboratory settings (Östlund et al., 2015). Furthermore, it is important to note that the field of aging and technology is still in its early stages of development (Hughes et al., 2017), and the use of collaborative research methods contributes to a deeper understanding of this field.

This dissertation includes two studies (Table 1.1) to address the following research questions and hypotheses:

1. To identify the available types of evidence regarding the acceptance of VR technology by older adults in the literature.
2. To describe the research designs associated with the available evidence, including the use of validated acceptance questionnaires, concerning VR technology acceptance by older adults.
3. To define the key concepts associated with older adults' acceptance of VR technology.
4. To identify and analyze knowledge gaps in older adults' acceptance of VR technology.
5. To investigate the participants' experience of VR exergames and the meaning they attach to their participation.
6. To determine the factors that influence the participants' experience of VR exergames and how these factors affect their experience.
7. To examine the correlation between individual acceptance of VR exergames and the use of selection, optimization, and compensation strategies when accounting for age covariate, in accordance with SOC theory (Hypothesis 1).
8. To explore the association between individual acceptance of VR exergames and future time perspective in accordance with SST theory (Hypothesis 2).

Table 1.1- *Dissertation’s studies*

Study	Objective	Research Question(s)	Design
I	To identify types of evidence, research designs, validated acceptance questionnaires, key concepts related to VR acceptance, and knowledge gaps in this area among older adults.	1, 2, 3, 4	Scoping review
II	To identify the factors affecting the acceptance of VR games among older adults living in LTC	5, 6, 7, 8	Mixed-methods study

Dissertation Organization

This dissertation is organized in an article-based format and consists of 5 chapters to explore the acceptance of VR technology among older adults living in assistive living settings. Chapter 1 discusses the theoretical conceptualizations that guide my research. Subsequently, it features a brief review of the literature pertaining to my dissertation’s topic. This section explains relevant definitions and provides an overview of key research studies that have contributed to informing

my dissertation. Additionally, this first chapter outlines the methodologies employed in the respective studies. Chapter 2 presents a scoping review, the first manuscript of VR technology acceptance in assistive living settings and represents the first manuscript of this dissertation. The findings of this scoping review reveal a compelling requirement for the increased utilization of validated acceptance questionnaires in VR research and emphasize the importance of investigating individual, environmental, and age-related factors to gain a holistic understanding of technology acceptance. Chapter 3, the second manuscript of this dissertation, investigates the factors associated with the acceptance of VR games among older adults living in LTC, with a particular emphasis on identifying social and individual factors that have been overlooked in existing technology acceptance models. Chapter 4 investigates how participants experience VR exergames and the meaning they associate with their participation and explores the factors that influence the participant's experience in VR exergames. This chapter represents the third manuscript of this dissertation. Chapter 5 provides an integrated discussion to present the findings from all three studies and discusses implications for the rehabilitation sciences. **Table 1.2** depicts the organization of the dissertation and the associated manuscript.

Table 1.2 *Organization of Dissertation*

Chapter	Title	Objective	Method
1	Introduction	Discusses the theoretical research conceptualizations. Provide a brief review of the literature. Explains relevant definitions. Provide an overview of key research studies. Outline the methodology.	N/A
2	Scoping Review (Manuscript 1)	Map the research and find the key concepts in the literature. Identify the methods and designs used for studying VR acceptance among older adults.	Scoping Review

3	VR gaming study (Manuscript 2)	Explore the factors associated with the acceptance of VR games among older adults living in LTC.	Quantitative questionnaire-based study
4	Older Adults' Individual Experience (Manuscript 3)	Investigate how participants experience VR exergames and the factors associated with their acceptance of the game.	Qualitative interpretive-description study
5	Integrated Discussion	Integrate the findings from three studies and provide an overall discussion with research and educational implications.	Descriptive synthesis

CHAPTER 2: SCOPING REVIEW (STUDY 1)

This manuscript is a scoping review of studies on the acceptance of VR technology for older adults residing in LTC facilities. Despite the potential of VR games to provide cognitive and physical stimulation, social interaction, and entertainment to LTC residents, the acceptance and use of VR games among LTC residents have not been thoroughly investigated. This scoping review aimed to examine the existing literature on the acceptance of VR games among LTC facility residents and provide insights into the factors that influence their adoption and usage. By identifying the evidence on older adults' acceptance of PA VR games in LTC facilities, describing research designs used, defining key acceptance concepts, and identifying knowledge gaps, this scoping review aimed to inform the other components of my dissertation. It highlighted the gap in the literature on technology acceptance for older adults. It demonstrated the importance of using qualitative and quantitative methods and validated acceptance measure tools to gain a comprehensive understanding of technology acceptance, as well as the need to study individual, environmental, and age-related factors. These findings provided an overview of the existing literature and the research gaps and helped to create the research questions for the following studies associated with my dissertation.

This manuscript was submitted to the journal *Disability and Rehabilitation: Assistive Technology* and is currently under review. This journal's aims align perfectly with my research on physical activity and the well-being of residents in LTC facilities. The journal's indexing in renowned databases like CINAHL, PubMed/MEDLINE, Scopus, and PsycINFO ensures visibility to researchers, practitioners, and policymakers. Its multidisciplinary and international audience

offer an excellent opportunity for my research to reach a broad range of professionals and researchers, fostering meaningful discussions in the field of assistive technology.

Manuscript 1: Acceptance of Physical Activity Virtual Reality Games by Residents of Long-term Care Facilities: A Scoping Review

Abstract

Purpose: Our study aimed to investigate the factors associated with the acceptance of virtual reality (VR) games among older adults living in LTC, with a particular emphasis on identifying social and individual factors that have been overlooked in existing technology acceptance models.

Materials and Methods: We conducted VR gaming sessions, followed by a composite questionnaire to explore the factors associated with the acceptance of VR games among residents of LTC with a focus on technology acceptance models (TAM) and social factors derived from Selective Optimization with Compensation (SOC) theory and Socioemotional Selectivity Theory (SST).

Results: We studied 20 older adults aged 65 and older. Participants were moderately sedentary, with the majority of them having prior gaming experience. Participants with prior gaming experience had higher mean scores in most SOC theory and SST subscales, except for elective selection. Participants perceived the technology as useful and easy to use, with no heightened gaming-related anxiety. Significant correlations were found between perceived ease of use and selection strategies and between attitudes towards gaming and elective selection strategies. No significant score differences were observed between male and female participants.

Conclusion: The positive correlation between VR acceptance and using SOC strategies suggests a positive response to straightforward experiences. Our study highlights VR exergaming's potential benefits for encouraging LTC residents' engagement in valued activities and pursuing goals.

Moreover, social theories of aging can inform technology acceptance and guide the design and marketing of VR exergames to better suit older adults' needs and preferences in LTC.

Keywords: Virtual Reality, Older Adults, Technology acceptance models, Social theories of aging, Selective optimization with compensation, socioemotional selectivity.

Introduction

With the population aging, the proportion of older adults is increasing relative to other age groups. The number of older adults residing in long-term care (LTC) facilities is expected to increase accordingly. A health objective for LTC should be maintaining residents' functional abilities (Bender et al., 2021) and social engagement (Park et al., 2012). Physical activity has been proven to be effective in improving functional independence (Paterson & Warburton, 2010) and decreasing the risk of developing major cardiovascular and metabolic diseases, falls, obesity, cognitive impairments, and muscular weakness in healthy and frail older adults (McPhee et al., 2016). However, residents of LTC demonstrate lower levels of physical activity compared to older adults living in the community (Weeks et al., 2008). Various factors contribute to this difference, including health conditions, environmental factors, and the number and kind of activities available for older adults living in these two settings.

While technology has the potential to address challenges such as staffing shortages and enhance the delivery of person-centred care in LTC facilities to improve residents' function and quality of life, there are barriers to implementing technology in these settings. These barriers include lack of awareness about available technologies for older adults, accessibility and lack of universal design, and acceptance of technology among caregivers and residents (Tak et al., 2010). Therefore, it is imperative to conduct further research on technology implementation in LTC facilities to better understand and address these barriers and promote its successful integration in the long-term care sector.

The potential of technology as a strategy for improving physical activity among older adults has been shown in recent studies (Peng et al., 2011) in different forms of exercise, such as video or

virtual reality (VR) games (Skjæret et al., 2016). The customizable virtual environment of VR exergaming allows a game to be tailored to players' functional and cognitive abilities, facilitating physical activity and improving health outcomes (Munoz et al., 2022). The immersive and interactive VR environment can provide an entertaining, engaging, and motivational way of exercising for those who are not able to participate in regular exercise; it can also reduce social isolation and increase social engagement among residents of LTC by creating a virtual community (Munoz et al., 2022). Social resources have been shown to affect the health of older adults (Muckenhuber et al., 2013) by acting as a physiological triggering mechanism, strengthening people's immune systems to fight disease and buffer stress (Rostila, 2011). Playing virtual games allows for performance sharing and joint participation. It can be used to promote socialization through supporting multi-player activities so that the users, as a part of the virtual community, can cooperate and compete (Lunardini et al., 2017).

A recent study revealed that people of different ages and various levels of ability could enjoy the same VR games (Chau et al., 2021). The use of VR for digital gameplay holds promise for encouraging the physical activity of older residents of long-term care facilities (Chu et al., 2022; Zhang & Kaufman, 2016), but we know very little about what factors influence their acceptance of and engagement with this technology. Currently, available VR interventions do not consider residents' interests and needs (Chu et al., 2022), and there does not appear to be a universally accepted definition of technology acceptance.

Our scoping review aimed to comprehensively map the literature on the acceptance of PA VR games by older adults living in LTC settings (Munn et al., 2018). The objectives of the review were fourfold: (1) to identify the types of evidence available on older adults' acceptance of PA VR

games in LTC facilities, (2) to describe the research designs used in these studies, including the utilization of validated acceptance questionnaires, (3) to define key concepts related to the acceptance of VR games, and (4) to identify knowledge gaps and propose areas for further research. Through this review, we synthesized findings from published research studies investigating the acceptance of video games, including VR, as interventions for promoting older adults' physical and cognitive health.

Materials and Methods

Study Inclusion/Exclusion Criteria

Research data were collected from published and unpublished journal articles between January 1st, 2000, and May 31st, 2023 (Thomas, 2012). Various approaches to technology acceptance by older adults were considered, including experimental and descriptive studies with qualitative, quantitative, and mixed-methods approaches. Eligibility criteria were applied to select relevant publications, including articles written or translated into English. The PICO framework (participants, intervention, comparison, and outcome) (Schardt et al., 2007) was utilized to develop the inclusion criteria, focusing on participants, intervention, and outcome.

The inclusion criteria for the studies were as follows: participants aged 65 and older living in long-term care facilities, using video games (including VR games) as the intervention for physical activity, and evaluating participants' acceptance or attitudes towards the PA VR games as a study outcome. The games used in the studies were required to have a user interface or devices such as joysticks, VR headsets, or controllers. The evaluation of acceptance or attitudes focused on the participants' perception and response to the VR games. **Table 2.1** depicts the inclusion and exclusion criteria.

Table 2.1 *Inclusion and exclusion criteria for reviewed articles*

PICO	Inclusion criteria	Exclusion criteria
Population	Enrolled participants aged 65 and older living in long-term care facilities	Enrolled participants younger than 65 and focused on community-dwelling older adults
Intervention	Used video games, including VR games, for physical activity as the intervention	Used video games or PA VR games as the intervention
Comparison	N/A	N/A
Outcome	Evaluated the acceptance or attitudes of participants about the PA VR games as a study outcome	Studies that focused on other aspects of PA VR games (i.e., effectiveness and feasibility) did not report findings on the acceptance or attitudes of participants.

Articles that were published before the start date or after the end date, did not have an English full text, did not use video games or PA VR games as the intervention, recruited participants younger than 65, and focused on community-dwelling older adults were excluded. Book chapters, technical reports, commentaries, posters, study protocols, conference papers, policy reviews, and study protocols were also excluded.

To ensure a comprehensive review of the literature, we expanded the scope to include studies on PA VR that specifically targeted older adults residing in LTC facilities. In the context of this review, LTC facilities encompass a range of care settings known by different terms in Canada, such as nursing homes, continuing care facilities, and residential care homes (CIHI, 2021). By adopting this inclusive definition, we aimed to capture a diverse range of studies conducted within these care settings and enhance the breadth of our findings. These studies provided valuable insights into how VR technology can be used to improve the lives of older adults in caring facilities and helped to ensure that our review was inclusive of the needs and perspectives of this important population. Additionally, we included the studies designed to examine the acceptance of non-gamified VR contents that provide physical exercise through entertainment in LTC facilities to understand the potential uses of VR technology for older adults.

Search Strategy

To identify the most relevant databases and concepts for searching VR technology acceptance by older adults, a search was conducted in the Cochrane Library for reviews that focused on similar topics. Key concepts such as "older adults," "virtual reality," "long-term care," and "technology acceptance" were used in the search. The appendices of the identified reviews matched these concepts and were then examined to determine the most frequently utilized databases. This process helped identify the appropriate databases and develop search strategies for each database.

A comprehensive search strategy ([Appendix](#)) was formulated with the collaboration of a health information specialist at the University of Ottawa. The search strategy was developed for each concept and was then translated for each database using specific truncations, operators, and field codes.

The key concepts were searched in the following electronic databases for published studies: Medline (Ovid), Embase (Ovid), CINAHL (EBSCO), Scopus, Cochran Library, Sociological abstracts (ProQuest), Web of Science, PsycINFO, ERIC, And Database of Abstracts of Reviews of Effects (DARE). We searched the International Standard Randomised Controlled Trials Number (ISRCTN) registry and the National Institutes of Health Clinical Trials Database for unpublished trials. Databases were searched for title, abstract, and author keywords. Medical Subject Headings (MeSH) were searched for in the databases and were used in the final search. Given the limited literature on acceptance of virtual reality among older adults, each database was searched twice, once with the VR concept and without the technology acceptance concept, and once with the technology acceptance concept and without the VR concept. This combination of terms was used

to search the title, abstract, and keyword fields. Filters offered by the University of Alberta (Campbell, 2021) were used to retrieve studies on the main concepts, including Geriatrics and exercise for CINAHL, MEDLINE, and Embase. An example of the electronic search for MEDLINE is depicted in **Table 2.2**.

Table 2.2 Search strategy and Subject headings (MeSH) for MEDLINE

Medline	Search Strategies	Subject Headings
Seniors	exp Geriatrics/ or exp Aged/ or Health Services for the Aged/ or Senior Centers/ or (elders or elderly or geriatric* or "gerontolog* old age" or (seniors not "high school") or (older adj3 (adult* or person* or people or man or men or woman or women)) or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old" or supercentenarian*).mp. (3497388)	Aged/ aging/"Aged, 80 and over"
LTC	(longterm care adj3 (home* OR facilit* OR residen*)).ti,ab,kf. OR (long-term care adj3 (home* OR facilit* OR residen*)).ti,ab,kf. OR (nursing adj3 (home* OR residen* OR care OR facility*)).ti,ab,kf. OR (senior adj3 (home* OR facilit* OR residen*)).ti,ab,kf. OR (assistive living adj3 (facilit* OR home* Or communit*)).ti,ab,kf. OR (skilled nursing adj3 (home* OR facilit* OR residen*)).ti,ab,kf.	Long-term care
VR	(virtual or virtuality or VR).tw. ((simulated or augmented or mediated) adj3 (reality or world* or environment*)).ti,ab,kf. Or computer simulation/ OR (computer simulation).ti,ab,kf. OR (videogame* OR ((video OR computer OR electronic OR online OR simulat* OR role playing) adj3 gam*)).ti,ab,kf. OR (immerse* OR spatial presence).ti,ab,kf.	Video games/ Computer simulation/ Virtual reality/
Acceptance	exp Attitude to Computers/ Technology accept*.ti,ab,kf. Attitude to computer.ti,ab,kf. Attitude to technology.ti,ab,kf.	Attitudes to computers

An additional hand search was performed on the reference lists through the included articles. Additionally, key journals in aging and technology were sought for relevant studies.

Study Selection, Review, and Assessment

The lead author performed the search twice and imported all search results into the Covidence systematic review management tool. VR effectiveness and feasibility studies were excluded at the first screening unless they involved information about participants' acceptance and/or attitudes towards the PA VR intervention in the abstract. The full-text review was performed for the articles included in the abstract and title screening. All the excluded articles at the full-text

review level were identified by the specific exclusion reasons recommended within Covidence or created by the researchers.

Data Extraction

We imported all search results into the Excel workbook. A Summary of Findings (SoF) table was designed in Excel to extract and synthesize the data. The following variables were extracted from included articles:

- 1- Author(s), year of publication or submission (for unpublished studies), country,
- 2- The type of article (original study, review)
- 3- Design, research questions, conceptual/theoretical framework
- 4- Population and setting
- 5- Intervention, comparison, outcomes, findings
- 6- Limitations of the study.

Two researchers (MH and JJ) formulated two separate tables to guarantee the best analysis, including variables to address the study's main questions and objectives. The tables were compared and combined, and discrepancies were resolved via discussion until a consensus was reached and MH extracted data. Both Excel and Covidence were used to report the results of this review. After combining two SoF tables, the following variables were finalized to be sought to extract data from included articles: title, author, year, country, the type of article (original study, review), design, research questions, conceptual/theoretical framework, population and setting, intervention, comparison, outcomes, findings, and limitations.

Synthesis of Results

The SoF variables were aimed at addressing the review's main questions regarding the design, methods and theories used. We also searched the articles for the definition of acceptance to provide a better understanding of the main concepts in the literature. We ensured that all variables were documented in sufficient detail to provide a meaningful response to each question and be able to be replicated by other researchers (Arksey & O'Malley, 2005).

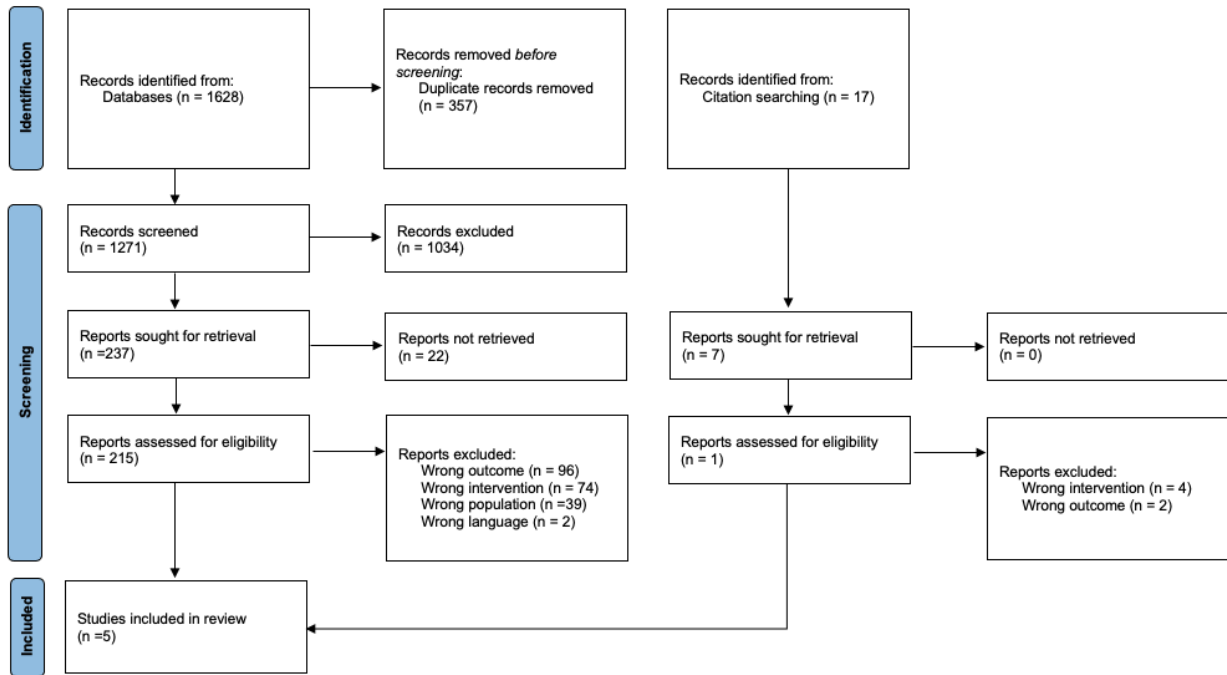
A combination of methods was used to map the findings. The screening process was reported through a flowchart, and the review results were summarized quantitatively through numeric counts and tables. In addition, key concepts were discussed qualitatively, utilizing a narrative synthesis of the literature reviewed.

Results

The initial search resulted in 1628 titles. Duplicates were identified and removed by Covidence (n = 357), and the remaining results (n = 1271) were screened by one of the authors based on titles and abstracts. After the initial title and abstract screening phase, 1034 articles were excluded. A total of 237 articles were identified as eligible for full-text screening. After the full-text screening, 233 articles were excluded as the full-text articles were not available (n=22), they did not assess acceptance and/or attitudes towards technology (wrong outcome, n= 96), did not study video games or VR (wrong intervention, n= 74), did not include people aged 65 and older residing in LTC (wrong population, n= 39), did not include an English full-text (wrong language, n= 2). Four titles were identified and screened. Screening records identified through citation searching (n= 4) resulted in one eligible article. All in all, five articles were included in the review

in combination with database search results. The flow chart of the article selection process is depicted in **Figure 2.1**.

Figure 2.1 Flow diagram of the article selection process (Page et al., 2020)



Type of Evidence

To address the first objective of our review, we explored the type of evidence available in the literature on technology acceptance studies. Both descriptive and analytical methods were used in the studies. One study used descriptive methods (Meekes & Stanmore, 2017), and four articles used analytical methods (Burdea et al., 2015; Chau et al., 2021; Huygelier et al., 2019; Laver et al., 2011). Descriptive methods describe the factors influencing technology acceptance, while analytical methods enable exploring relationships between variables and developing predictive models.

Type of Design

The second objective of this review was to identify the types of research designs associated with VR acceptance evidence. The only descriptive study used a mixed-methods design (Meekes & Stanmore, 2017) to determine the factors influencing older adults' motivation to use exergames. The four studies that used analytical methods adopted interventional and observational approaches to exploring technology acceptance. Four analytical articles used interventional methods, including two randomized controlled trials (Huygelier et al., 2019; Laver et al., 2011) and one uncontrolled trial (Chau et al., 2021) and one observational study was cross-sectional (Burdea et al., 2015b).

Definition of Key Concepts and Conceptual Framework:

One of the objectives of this scoping review was to identify the definitions of key concepts related to acceptance. However, the reviewed studies lacked clear definitions and a shared vocabulary for key concepts related to acceptance, limiting comparability across studies. Only one study explicitly identified effective factors on VR acceptance

Out of the reviewed articles, only two studies incorporated theoretical frameworks such as the Technology Acceptance Model (TAM) and Self-Determination Theory (Meekes & Stanmore, 2017) and the Unified Technology Acceptance and Use Theory (UTAUT) (Huygelier et al., 2019). These frameworks can provide a foundation for understanding acceptance factors and guiding future research.

Knowledge Gaps

We identified some gaps and limitations in the literature we reviewed to achieve our last objective. Firstly, there was inconsistency in defining key concepts related to VR acceptance. Only two studies used technology acceptance models, while others lacked clear definitions or frameworks for assessing acceptance. Secondly, contextual factors were inadequately addressed in the studies, focusing primarily on individual-level factors and a lack of consideration for the physical and social environment of LTC facilities. Lastly, gender-based analysis was largely absent, failing to explore men and women's unique perspectives and experiences.

Participants Characteristics

The selected studies included a variety of participants with different health conditions. Two articles recruited older adults with physical disabilities (Chau et al., 2021; Laver et al., 2011), one with dementia (Burdea et al., 2015), and two studies did not mention older adults' health status (Huygelier et al., 2019; Meekes & Stanmore, 2017). In most studies, researchers recruited small samples. The smallest sample had 10 (Burdea et al., 2015), and the largest had 135 participants (Chau et al., 2021). Across all studies, the number of female participants was greater than male participants. Among the articles that reported their sample size and gender, from 248 participants, 168 (67.7%) were female, and 80 participants (32.3%) were male. Participants' ages ranged from 55 to 94. All recruited participants were residents of assisted living facilities, and one study recruited both community-dwelling and residents of LTC (Chau, 2021). **Table 2.3** summarizes the samples' characteristics.

Table 2.3 *Participants' characteristics for reviewed articles*

Author (Year)	Population	Sample size	Age	Gender	Setting
Laver et al. (2011)	Patients of a geriatric rehabilitation unit (not specified)	21	65 and older	3 male, 18 female	Geriatric rehabilitation unit at repatriation general hospital
Burdea et al. (2015)	Dementia	10	55-73	7 male, 3 female	Skilled nursing facilities
Meekes et al. (2017)	Physically and cognitively healthy	12	59-91	6 male, 6 female	Assistive living facilities
Huygelier et al. (2019)	With adequate vision and hearing	76	57-94	38 male, 38 female	Nursing homes
Chau et al. 2021	Patients with physical or cognitive disabilities	135	Mean 62	68 male, 103 female	23 Residential care settings and community settings

Interventions and Acceptance Outcomes

The VR interventions employed in the selected studies varied, with four studies using gamified interventions (Chau 2021, Meekes 2017, Burdea 2015, Laver 2011) and one study using VR natural landscape (Huygelier et al., 2019). Different methods were used to measure acceptance outcomes. Burdea et al. (2015) developed a subjective evaluation questionnaire, significantly improving participants' acceptance of the serious game. Huygelier et al. (2019) developed attitude, enjoyment, and confidence/anxiety scales to measure acceptance of the Head-Mounted Display VR (HMD-VR) technology. Meekes et al. (2017) employed the Technology Acceptance Model (TAM) questionnaire to assess motivation to use exergames. Laver et al. (2011) used a Discrete Choice Experiment (DCE) to measure the acceptability of Wii Fit. Chau et al. (2021) analyzed participants' comments to determine acceptance rates of VR games. Most studies reported positive acceptance outcomes, though their evidence levels varied. Higher-level studies, such as RCTs, indicated low acceptance of technology, while lower-level studies showed high acceptance. It is important to interpret the findings of lower-level studies with caution and support them with higher-level studies for more robust conclusions. Intervention characteristics and acceptance outcomes are depicted in **Table 2.4**.

Table 2.4 *Intervention characteristics and acceptance outcomes for reviewed articles*

Author (Year)	Technology	Design	Outcome	Measures	Approach to Studying VR	Main Findings
Laver et al. (2011)	Nintendo Wii Fit	RCT	Low acceptability of the Nintendo Wii Fit as a therapeutic tool	Discrete Choice Experiment (DCE) Questionnaire developed by researchers	Acceptance of VR	Participants preferred traditional therapy programs over programs using the Wii Fit.
Burdea et al. (2015)	BrightBrainer serious game ¹	Observational Cross-sectional	A high level of acceptance of technology	A subjective evaluation paper questionnaire developed by researchers	Acceptance of VR	Using the BrightBrainer™ system led to a significant improvement in the MoCA test scores of the participants.
Meekes et al. (2017)	MIRA Exergame ²	Mixed-Methods Design	Participants' motivation to use exergame	TAM questionnaire, observation & GameFlow model ³	Effective factors on acceptance	The exergames were enjoyable for most of the participants. Confidence and social interaction were important in participation in exergames
Huygelier et al. (2019)	Perfect application (VR natural landscapes)	RCT	Change in attitudes toward VR technology from neutral to positive	A questionnaire developed by researchers	Acceptance of VR	High levels of acceptance towards HMD-VR technology.
Chau et al. (2021)	14 immersive VR games	Uncontrolled Trial	Feasibility, acceptability, and efficacy	Participants' comments and feedback	Acceptance of VR	VR multipurpose training was feasible and acceptable for older adults and people with disabilities.

Limitations to the Reviewed Studies

There are some common limitations and challenges across the reviewed studies on VR acceptance by older adults. First, sample sizes were often small, limiting the generalizability of the findings. Laver et al. (2011) and Burdea et al. (2015) both had small sample sizes, which may affect their results' statistical power and representativeness. Second, some studies lacked a control group, as seen in the study by Chau et al. (2021) and Burdea et al. (2015), making it challenging to draw definitive conclusions about the effectiveness of VR interventions. Additionally, the lack of standardized game progression in the study by Chau et al. (2021) raises

¹ An integrative cognitive therapy system for rehabilitation simulations

² An evidence-based exercise that uses Microsoft Kinect, an off-the-shelf 3D camera motion tracking device that can track the user's movements from a distance (Meekes & Stanmore, 2017)

³ A model to evaluate games with respect to player enjoyment (Sweetser & Wyeth, 2005)

concerns about the consistency and comparability of the results. Another limitation was the inadequate description of the scales or measures used to assess technology acceptance, as observed in Huygelier et al.'s (2019) study. This lack of clarity in measurement methods hinders the understanding of how acceptance was precisely evaluated and questions the reliability and validity of the findings.

Furthermore, Meekes et al. (2017) had a small sample size. They did not clearly specify the order of different stages in their data collection process, potentially affecting the generalizability and interpretation of their results. These shared limitations should be acknowledged when interpreting the findings across the studies.

Discussion

Our review provides evidence regarding older adults' acceptance of PA VR games in dependent settings (four studies) and dependent and independent settings (one study). We mapped the evidence and highlighted the participants' characteristics, methods, and theoretical frameworks used to study acceptance by older adults. Most included studies used an analytical design, especially RCT, to address the research questions. One study synthesized qualitative data to capture participants' attitudes toward the VR intervention. We identified two main approaches to study acceptance applied by included papers: the dominant approach was assessing the acceptance of technology, and the other was investigating the acceptance determinants. The studies that followed the first approach used a variety of scales and tools to determine to what extent participants accepted the VR interventions. The second approach was taken by one study (Meekes et al., 2017), which utilized constructs from validated TAM questionnaires to measure the acceptance of the VR intervention. This is surprising because TAM questionnaires are widely

used in this field to measure acceptance of many other forms of technology and are designed to measure how users perceive and evaluate new technologies. The fact that VR research for older adults may not extensively utilize validated technology acceptance tools leads us to interpret findings cautiously.

The reviewed studies indicate that VR technology has the potential to be well-accepted and beneficial as a therapeutic tool and exergame for older adults. While one study reported lower acceptance of a specific VR exergame, most of the reviewed studies showed positive attitudes towards VR technology among older adults, supporting its value in promoting engagement, cognitive and physical stimulation, and social interaction (Burdea et al., 2009; Chau et al., 2017). These findings suggest that VR can be a valuable addition to the care and well-being of older adults in various settings, including long-term care facilities.

The sample size varied significantly across the studies, with Burdea et al. having 10 participants and Chau et al. having 135 participants. The larger sample sizes in studies may provide more robust and generalizable findings than those with smaller ones. However, despite the different sample sizes, most of the findings were consistent, which adds more credibility to the overall findings of the research on VR acceptance by older adults.

It is worth noting that among the five reviewed studies, Laver et al. (2011) found that older adults preferred traditional therapy programs over programs using the Wii Fit as a therapeutic tool. However, this study evaluated a specific technology (Wii Fit) rather than a broader range of VR exergames. It used a Discrete Choice Experiment (DCE) questionnaire that allowed participants to compare and choose between different therapy options. Moreover, this study was conducted over a decade ago, and since then, advancements in VR technology and a wider range of VR

exergames have emerged. In contrast, the other studies reviewed in this analysis demonstrated generally positive attitudes and acceptance towards VR technology among older adults, indicating the potential of VR as a therapeutic tool and exergame for this population. These findings highlight the potential benefits of VR technology for older adults while acknowledging the need for further research to explore the acceptance and effectiveness of different VR interventions in diverse contexts. However, the reviewed studies have identified certain limitations, some of which are listed below:

Inconsistent definition of key concepts

Clarifying the definition of key concepts in VR acceptance literature is one of the objectives of this review. Although all included papers were designed to investigate the acceptance of VR interventions among their senior participants, only two used technology acceptance models in their theoretical framework. Others did not define technology acceptance or describe the factors they considered when assessing acceptance. Further, the study by Chau (2021), which relied solely on analyzing qualitative feedback to assess acceptance instead of traditional technology acceptance assessment tools, did not clearly define the investigated concepts. The absence of a definition of key concepts using TAM constructs could be due to the limited knowledge of technology acceptance models, lacked familiarity with the relevant literature, or considering other theoretical frameworks that researchers believed were more appropriate for their research.

Defining key concepts of technology acceptance in literature is an important part of the research process. It not only helps establish a shared vocabulary among researchers in the field, facilitating communication and collaboration but also aids in identifying gaps in the literature and areas

requiring further research. Moreover, a clear definition of key concepts enables researchers to make their findings more accessible to a broader audience, including practitioners and policymakers who may not possess a background in the field. This promotes the translation of research findings into practical applications and policies that can have a positive impact on society. By determining and operationalizing key concepts, researchers can foster a shared understanding among stakeholders, leading to more consistent, comparable research findings and the development of effective interventions. Additionally, clearly defined key concepts contribute to the reliability and validity of research findings, enhancing the overall quality of studies in technology acceptance.

Lack of information about the effects of contextual factors

Despite the importance of contextual factors in determining the acceptance of technology by residents of LTC facilities, the included studies failed to address these factors adequately. To truly understand and enhance residents' acceptance of technology in LTC facilities, it is crucial to consider the full range of factors that can influence residents' attitudes and behaviours, including the physical and social environment of the LTCs, as well as the availability and accessibility of technology. These studies focused on the presence of acceptance or individual-level factors, such as age, cognitive ability, or education (Huygelier et al., 2019) or enjoyment (Meekes et al., 2017), while contextual factors may play a key role in the acceptance of technology by residents of LTC. LTC officials may not be aware of available technology products or how to interact with them. Due to staffing shortages, providing technology for individuals with different abilities can be challenging (Tak et al., 2010). The lack of addressing contextual factors in studies focusing on technology acceptance among LTC residents can lead to an incomplete understanding. It may

result in recommendations or interventions that are not effective. Huygelier et al. studied the extent to which global cognitive status, years of official education, and computer proficiency mediated the association between age and attitudes towards technology but did not find a mediating effect for these factors on the attitudes of their participants towards technology, which means that while these factors may be positively correlated with older adults' attitude towards technology, they do not play a direct role in shaping or influencing those attitudes. Instead, other factors such as access to technology, personal experience, support availability, and individual preferences are likely to impact older adults' attitudes towards technology significantly.

Absence of Gender-based Analysis

It is essential to consider the unique perspectives and experiences of men and women when exploring technology acceptance for residents of LTC facilities. This can include considering their different preferences for technology and addressing specific concerns that women or men may have about technology use. Two out of five articles (Laver et al., 2011 & Chau et al., 2021) recruited significantly larger groups of female participants (103 and 18 female versus 68 and 3 male); however, they did not consider gender-based analysis that explains the difference in the number of participants and the factors that might affect the acceptance rate among female and male participants.

Strengths and Limitations of the Review

Firstly, conducting a comprehensive search was challenging due to the limited literature on VR physical activity games among older adults. We employed a rigorous search strategy, combining

multiple databases and conducting two separate searches to gather relevant information. Secondly, the focus on LTC facilities may result in an under-representation of other technologies and perspectives of community-dwelling older adults. The findings may not generalize to other populations and technologies used by older adults. Finally, the inclusion of only English peer-reviewed articles may have excluded valuable information from non-English sources and grey literature, potentially impacting the comprehensiveness and generalizability of the findings.

The Implications for Rehabilitation

The implications of our study for rehabilitation can be summarized as follows:

Enhancing engagement: We suggest that PA VR games can improve engagement among LTC residents. By providing a novel approach to rehabilitation, PA VR games have the potential to increase motivation and participation, leading to improved outcomes.

Promoting physical and cognitive stimulation: VR games offer opportunities for both physical and cognitive stimulation. By integrating these games into rehabilitation programs, we can provide a more engaging and interactive experience for individuals undergoing rehabilitation. This can contribute to motor skills development, balance training, cognitive function, and overall well-being.

Addressing barriers to rehabilitation: Traditional rehabilitation approaches may face various barriers, such as lack of interest, adherence issues, or limited resources. The use of VR games can help overcome some of these barriers by offering a more enjoyable and accessible rehabilitation experience. This is particularly beneficial for individuals with mobility limitations or those residing in LTC facilities.

In summary, our study highlights the potential of incorporating VR games into rehabilitation settings. By implementing these findings, we can improve the acceptance and efficiency of rehabilitation practices, leading to better rehabilitation outcomes for individuals.

Recommendations for Future Study

An integrated approach combining qualitative and quantitative methods is recommended to improve research on technology acceptance among older adults. Traditional research designs may not capture the individual narratives and experiences that influence acceptance. By adopting an integrated approach, researchers can identify factors influencing acceptance, including individual, environmental, and age-related factors.

Detailed descriptions of interventions studied in VR research are recommended to better understand the specific elements contributing to technology acceptance and enables researchers to identify the components that influence acceptance.

Researchers should utilize technology acceptance models and social theories of aging to bridge the knowledge gap and ensure research findings translate into practical applications. These frameworks help identify factors influencing acceptance and enable the design of tailored interventions for older adults.

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Declaration of Interest Statement

The authors declare that they have no competing interests related to the publication of this manuscript. There are no financial or personal relationships that could potentially bias the interpretation or presentation of the research findings. This ensures the transparency and objectivity of the study, allowing for an unbiased evaluation and discussion of the results.

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Appendix- Search Strategy

Medline	Search strategies	Subject Heading
Seniors	exp Geriatrics/ or exp Aged/ or Health Services for the Aged/ or Senior Centers/ or (elders or elderly or geriatric* or "gerontolog* old age" or (seniors not "high school") or (older adj3 (adult*or person* or people or man or men or woman or women)) or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old" or supercentenarian*).mp. (Campbell, 2021)	Aged/ aging/ "Aged, 80 and over"
LTC	(longterm care adj3 (home* OR facilit* OR residen*)).ti,ab,kf. OR (long-term care adj3 (home* OR facilit* OR residen*)).ti,ab,kf. OR (nursing adj3 (home* OR residen* OR care OR facility*)).ti,ab,kf. OR (senior adj3 (home* OR facilit* OR residen*)).ti,ab,kf. OR (assistive living adj3 (facilit* OR home* Or communit*)).ti,ab,kf. OR (skilled nursing adj3 (home* OR facilit* OR residen*)).ti,ab,kf.	Long-term care
VR	(virtual or virtuality or VR).tw. ((simulated or augmented or mediated) adj3 (reality or world* or environment*)).ti,ab,kf. Or computer simulation/ OR (computer simulation).ti,ab,kf. OR (videogame* OR ((video OR computer OR electronic OR online OR simulat* OR role playing) adj3 gam*)).ti,ab,kf. OR (immerse* OR spatial presence).ti,ab,kf.	Video games/ Computer simulation/ Virtual reality/
Acceptance	exp Attitude to Computers/ Technology accept*.ti,ab,kf. Attitude to computer.ti,ab,kf. Attitude to technology.ti,ab,kf.	Attitudes to computers

CINAHL	Search strategies	Subject Heading
Seniors	(MH "Geriatrics") or (MH "Aged, Hospitalized") or (MH "Aged+") or (MH "Senior Centers") or (MH "Gerontologic Care") or (MH "Geriatricians") OR (MH "Gerontologic Nursing+") OR (MH "Health Services for the Aged") or ("aging in place" or elders or elderly or geriatric* or gerontolog* or gerodontic* or old age or (seniors not "high school") or "senior citizen*" or (older N3 (patient* or adult* or person* or people or man or men or woman or women)) or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old") (Campbell, 2021)	Aged/ aging/ "Aged, 80 and over"
LTC	AB ("nursing" N3 ("home*" or "care home* residen*" or "care facilit*" or "residn*")) or ("senior" N3 ("home*" or "residen*" or "facilit*")) or ("assistive living" N3 ("facilit*" or "home*" or "communit*")) or ("skilled nursing" N3 ("facilit*" or "home*" or "residen*" or "care home*")) or ("longterm" N3 ("care" or "care home*" or "facilit*" or "residen*")) or ("long-term" N3 ("care" or "home*" or "facilit*" or "residen*")) or ("retirement" N3 ("facilit*" or "home*" or "residen*")) or ("residential" N3 ("care home" or "home" or "facilit*")) or TI ("nursing" N3 ("home*" or "care home* residen*" or "care facilit*" or "residn*")) or ("senior" N3 ("home*" or "residen*" or "facilit*")) or ("assistive living" N3 ("facilit*" or "home*" or "communit*")) or ("skilled nursing" N3 ("facilit*" or "home*" or "residen*" or "care home*")) or ("longterm" N3 ("care" or "care home*" or "facilit*" or "residen*")) or ("long-term" N3 ("care" or "home*" or "facilit*" or "residen*")) or ("retirement" N3 ("facilit*" or "home*" or "residen*")) or ("residential" N3 ("care home" or "home" or "facilit*"))	Long term care/ Age specific care/
VR	(MH "simulation") or (MH "computer simulation") or (MH "virtual reality") or (virtual* OR VR OR simulat* OR cai OR "computer assisted") OR AB (virtual* OR VR OR simulat* OR cai OR "computer assisted")	Video games/ Computer simulation/ Virtual reality/
Acceptance	("Technolog*" N3 ("accept*" or "adher*" or "use*")) ("Attitude" to N3 ("computer" or "technolog*"))	Attitudes to computers/

Embase	Search strategies	Subject Heading
Seniors	exp geriatrics/ or aged/ or aged hospital patient/ or exp elderly care/ or frail elderly/ or gerontology/ or institutionalized elderly/ or very elderly/ or ("aging in place" or elders or elderly or geriatric* or gerodonic* or gerontol* or old age or (seniors not "high school") or (older adj3 (adult* or person* or people or man or men or woman or women)) or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old" or supercentenarian*).mp. (Campbell, 2021)	Aged/ aging/ "Aged, 80 and over"
LTC	(longterm care adj3 (home* OR facilit* OR residen*).ti,ab,kf. OR (long-term care adj3 (home* OR facilit* OR residen*).ti,ab,kf. OR (nursing adj3 (home* OR residen* OR care OR facility*).ti,ab,kf. OR (senior adj3 (home* OR facilit* OR residen*).ti,ab,kf. OR (assistive living adj3 (facilit* OR home* Or communit*).ti,ab,kf. OR (skilled nursing adj3 (home* OR facilit* OR residen*).ti,ab,kf.	Long term care/ Age specific care/
VR	(virtual or virtuality or VR).tw. ((simulated or augmented or mediated) adj3 (reality or world* or environment*).ti,ab,kf. Or computer simulation/ OR (computer simulation).ti,ab,kf. OR (videogame* OR ((video OR computer OR electronic OR online OR simulat* OR role playing) adj3 gam*).ti,ab,kf. OR (immerse* OR spatial presence).ti,ab,kf.	Video games/ Computer simulation/ Virtual reality/
Acceptance	Technology accept*.ti,ab,kf. Attitude to computer.ti,ab,kf.	Attitudes to computers/

Scopus	Search strategies
Seniors	"aging in place" or "elders" or "elderly" or "geriatric*" or "gerontolog*" or "gerodontic*" or "old age" or "seniors not high school" or "senior citizen*" or "older patient*" or "adult*" or "person*" or "people" or "man" or "men" or "woman" or "women"
LTC	"nursing home*" or "care home residen*" or "care facilit*" or "residn*" or "senior home*" or "senior residen*" or "senior facilit*" or "assistive living facilit*" or "assistive living home*" or "assistive living communit*" or "skilled nursing facilit*" or "skilled nursing home*" or "skilled nursing residen*" or "skilled nursing care home*" or "longterm care" or "longterm care home*" or "longterm facilit*" or "longterm residen*" or "long-term care" or "long-term home*" or "long-term facilit*" or "long-term residen" or "retirement facilit*" or "retirement home*" or "retirement residen*" or "residential care home" or "residential home" or "residential facilit*"
VR	"virtual reality" or "VR" or "augmented reality" or "AR" or "simulated reality" or "virtual environment*" or "vr environment*" or "augmented environment*" or "AR environment*" or "simulated environment*" or "videogame*" or "role playing game*"
Acceptance	"Technology accept*" or "technology adher*" or "technology use" or "Attitude to computer" or "attitude to technolog*"

Cochrane Library	Search strategies	Subject Heading
Seniors	(aging in place) or (elders) or (elderly) or (geriatric*) or (gerodontic*) or (gerontol*) or (old age) or (seniors not high school) or (older adult*) or (older person*) or (older people) or (older man) or (older men) or (older woman) or (older women) or (centenarian*) or (nonagenarian*) or (octogenarian*) or (septuagenarian*) or (decrepit) or (tottering) or (overaged) or (oldest old) or (supercentenarian*)	Aged
LTC	(nursing home*) or (care home residen*) or (care facilit*) or (residn*) or (senior home*) or (senior residen*) or (senior facilit*) or (assistive living facilit*) or (assistive living home*) or (assistive living communit*) or (skilled nursing facilit*) or (skilled nursing home*) or (skilled nursing residen*) or (skilled nursing care home*) or (longterm care) or (longterm care home*) or (longterm facilit*) or (longterm residen*) or (long-term care) or (long-term home*) or (long-term facilit*) or (long-term residen) or (retirement facilit*) or (retirement home*) or (retirement residen*) or (residential care home) or (residential home) or (residential facilit*)	Long term care/
VR	(virtual reality) or (VR) or (augmented reality) or (AR) or (simulated reality) or (virtual environment*) or (vr environment*) or (augmented environment*) or (AR environment*) or (simulated environment*) or (videogame*) or (role playing game*)	Exergaming/ Virtual reality/
Acceptance	(Technology accept*) or (technology adher*) or (technology use) or (Attitude to computer) or (attitude to technolog*)	Attitudes to computers/

ProQuest	Search strategies	Subject Heading
Seniors	(aging in place) or (elders) or (elderly) or (geriatric*) or (gerodontic*) or (gerontol*) or (old age) or (seniors not high school) or (older adult*) or (older person*) or (older people) or (older man) or (older men) or (older woman) or (older women) or (centenarian*) or (nonagenarian*) or (octogenarian*) or (septuagenarian*) or (decrepit) or (tottering) or (overaged) or (oldest old) or (supercentenarian*)	Aged
LTC	(nursing home*) or (care home residen*) or (care facilit*) or (residn*) or (senior home*) or (senior residen*) or (senior facilit*) or (assistive living facilit*) or (assistive living home*) or (assistive living communit*) or (skilled nursing facilit*) or (skilled nursing home*) or (skilled nursing residen*) or (skilled nursing care home*) or (longterm care) or (longterm care home*) or (longterm facilit*) or (longterm residen*) or (long-term care) or (long-term home*) or (long-term facilit*) or (long-term residen) or (retirement facilit*) or (retirement home*) or (retirement residen*) or (residential care home) or (residential home) or (residential facilit*)	Long term care/
VR	(virtual reality) or (VR) or (augmented reality) or (AR) or (simulated reality) or (virtual environment*) or (vr environment*) or (augmented environment*) or (AR environment*) or (simulated environment*) or (videogame*) or (role playing game*)	Exergaming/ Virtual reality/
Acceptance	(Technology accept*) or (technology adher*) or (technology use) or (Attitude to computer) or (attitude to technolog*)	Attitudes to computers/

Web of Science	Search strategies
Seniors	(elders or elderly or geriatric* or "gerontolog* old age" or (seniors not high school) or (older NEAR/3 (adult*or person* or people or man or men or woman or women)) or (centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or oldest old or supercentenarian*).
LTC	(longterm care NEAR/3 (home* OR facilit* OR residen*)) OR (long-term care NEAR/3 (home* OR facilit* OR residen*)) OR (nursing NEAR/3 (home* OR residen* OR care OR facility*)) OR (senior NEAR/3 (home* OR facilit* OR residen*)) OR (assistive living NEAR/3 (facilit* OR home* Or communit*)) OR (skilled nursing NEAR/3 (home* OR facilit* OR residen*))
VR	(virtual or virtuality or VR)((simulated or augmented or mediated) NEAR/3 (reality or world* or environment*)) OR computer simulation/ OR (computer simulation) OR (videogame* OR ((video OR computer OR electronic OR online OR simulat* OR role playing) NEAR/3 gam*)) OR (immerse* OR spatial presence)
Acceptance	Attitude to Computers Technology accept* Attitude to computer Attitude to technology

psycINFO	Search strategies
Seniors	<p>geriatrics/ or exp "aged (attitudes toward)"/ or exp aging/ or geriatric assessment/ or geriatric psychotherapy/ or gerontology/ or exp geropsychology/ or late life depression/ or exp elder care/ or elder abuse/ or (elders or elderly or geriatric* or gerontolog* or gerodontic* or old age or oldest age* or (seniors not "high school") or (older adj3 (adult* or people or person or persons or man or men or woman or women)) or oldest patient* or "old old" or "very old" or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or "late* life" or overaged or "oldest old" or supercentenarian*).mp.</p> <p>(elders or elderly or geriatric* or "gerontolog* old age" or (seniors not high school) or (older adj3 (adult* or person* or people or man or men or woman or women)) or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or oldest old or supercentenarian*).</p>
LTC	<p>(longterm care adj3 (home* OR facilit* OR residen*)) OR (long-term care adj3 (home* OR facilit* OR residen*)) OR (nursing adj3 (home* OR residen* OR care OR facility*)) OR (senior adj3 (home* OR facilit* OR residen*)) OR (assistive living adj3 (facilit* OR home* OR communit*)) OR (skilled nursing adj3 (home* OR facilit* OR residen*))</p>
VR	<p>(virtual or virtuality or VR) ((simulated or augmented or mediated) adj3 (reality or world* or environment*)) OR computer simulation/ OR (computer simulation) OR (videogame* OR ((video OR computer OR electronic OR online OR simulat* OR role playing) adj3 gam*)) OR (immerse* OR spatial presence)</p>
Acceptance	<p>Attitude to Computers.mp. Technology accept*.mp. Attitude to computer.mp. Attitude to technology.mp.</p>

DARE:

Older adults OR seniors OR older people OR geriatric

Virtual reality OR VR OR simulation OR video game

technology acceptance OR attitude to computer OR attitude to technology

AND ALL=(TOPIC:(virtual OR virtuality OR VR) ((simulated OR augmented OR mediated) AND (reality OR world* OR environment*)) OR computer simulation OR (computer simulation) OR (videogame* OR ((video OR computer OR electronic OR online OR simulat* OR role playing) AND gam*)) OR (immerse* OR spatial presence))

CHAPTER 3: QUANTITATIVE STUDY (STUDY 2)

This chapter presents the second manuscript associated with my dissertation. This quantitative study aimed to address the gaps identified in my dissertation's scoping review (study 1). The scoping review highlighted the need for utilizing quantitative and qualitative methods alongside validated technology acceptance questionnaires and tools. Additionally, the review found a lack of investigation into the individual and social factors affecting acceptance of VR technology among residents of LTC. The purpose of this quantitative study was to identify social and individual factors associated with the acceptance of VR games among older adults living in LTC facilities and have been overlooked in existing technology acceptance models. I conducted VR gaming sessions for 20 residents and tenants living in a LTC facility. They completed a composite questionnaire that investigated their demographic information, prior gaming experience, the time they spent sedentary, and the factors affecting their acceptance of a VR game. Informed by the gap identified by the scoping review regarding the lack of using validated questionnaires and consulting social theories of aging, I employed a composite questionnaire consisting of TAM, UTAUT, and STAM questionnaires, SOC questionnaire and FTP scales to explore individual and contextual factors associated with VR acceptance by. I identified significant correlations between the perceived ease of use of VR games and SOC strategies and attitudes towards gaming and SOC strategies. Additionally, differences were observed between older adults with and without prior gaming experience.

I submitted the quantitative manuscript of my dissertation to the journal *Disability and Rehabilitation: Assistive Technology*, which is currently under review. The journal aims to

enhance functioning and life quality for individuals with disabilities and chronic illnesses align perfectly with my research topic, which focuses on the physical activity and well-being of residents of LTC facilities.

Manuscript 2: Assessing Virtual Reality Acceptance in Long-term Care Facilities: A Quantitative Study with Older Adults

Abstract

Background: Virtual reality (VR) is suggested as a tool for enhancing physical activity (PA) and engagement among older adults in long-term care (LTC) facilities, addressing the growing need for maintaining health and independence in these settings. However, further research is necessary to comprehend the factors impacting VR acceptance in LTC and optimize its potential for promoting PA.

Objective: Our study aimed to investigate the factors associated with the acceptance of VR games among older adults living in LTC, with a particular emphasis on identifying social and individual factors that have been overlooked in existing technology acceptance models.

Methods: We conducted VR gaming sessions, followed by a composite questionnaire to explore the factors associated with the acceptance of VR games among residents of LTC with a focus on technology acceptance models (TAM) and social factors derived from Selective Optimization with Compensation (SOC) theory and Socioemotional Selectivity Theory (SST).

Results: We studied 20 older adults aged 65 and older. Moderate sedentary behaviour was observed, with the majority having prior gaming experience. Participants with prior gaming experience had higher mean scores in most SOC theory and SST subscales, except for elective selection. Significant correlations were found between perceived ease of use and selection strategies and between attitudes towards gaming and elective selection strategies. No significant score differences were observed between male and female participants.

Discussion: We found that participants perceived the technology as useful and easy to use, with no heightened gaming-related anxiety. The positive correlation between VR acceptance and

using SOC strategies suggests a positive response to focused experiences. Our study highlights VR exergaming's potential benefits for encouraging LTC residents' engagement in valued activities and pursuing goals. Moreover, social theories of aging can inform technology acceptance and guide the design and marketing of VR exergames to better suit older adults' needs and preferences in LTC.

Keywords: Virtual Reality, Older Adults, Technology acceptance models, Social theories of aging, Selective optimization with compensation, socioemotional selectivity.

Introduction

As the aging population continues to grow [1], there is an expected increase in the number of older individuals residing in LTC. As people age, they are more likely to require assistance with daily activities and may need to move into a LTC for additional support. In the field of LTC, the primary objective is to preserve residents' functional capabilities and social engagement [2,3].

PA has been acknowledged as an important aspect of the quality of care in these facilities by experts in the field [4]. This is because regular PA has been shown to improve overall health and well-being, including physical function, cognitive function, and mental health and reduce the risk of all-cause mortality, chronic diseases, and premature death in older adults [5]. It is thus recommended that older adults engage in regular PA to prevent aging-related functional declines. However, despite the recognized benefits of PA, many residents in LTC remain inactive [6,7] and face the negative health outcomes of this lifestyle, such as mental comorbidities, systemic hypertension, metabolic dysregulation, cancer, and depression [8].

Cunningham et al. [9] assessed the consequences of inactivity in older adults in 24 systematic reviews. They found that those reviews reported that the most significant decrease in health risks

is achieved through increased levels and intensities of PA. However, due to the use of psychotropic drugs and physical or cognitive limitations, many LTC residents spend a significant portion of their waking hours in a sedentary state, which can increase the risk of falls, depression, perceived poor health, lack of motivation [2], and sarcopenia due to muscle disuse [4]. Therefore, it is important that LTC provide opportunities and encouragement for residents to engage in regular PA to improve their overall health and quality of life.

The increasing population of older adults in institutionalized settings and the associated care costs necessitate prioritizing technologies that enhance independence and address age-related disabilities. Previous studies have highlighted the potential of technology, including video and VR games, to increase physical activity among older adults [10,11]. These games offer real-time feedback, competitiveness, and playfulness, while VR games have shown promise in reducing social isolation and promoting social engagement in LTC residents [5,12]. Multi-player virtual games facilitate joint participation and socialization, allowing users to cooperate and compete [13]. Although exergames may not match the effectiveness of regular exercise, they can still encourage physical activity through entertainment and fun. Given the constraints faced by LTC residents, such as health issues, limited space, and staffing shortages, any tool that can reduce inactivity deserves further investigation [14]. The use of technology in LTC facilities has the potential to enhance the quality of life for older adults and provide cost-effective care [2,3]; however, the uptake and use of technology by older adults can be influenced by a variety of factors, including age, health status, and previous experience with technology. Therefore, understanding the factors that influence the acceptance of technology by this population is crucial for the successful implementation and integration of technology into LTC facilities.

Technology acceptance and adoption are interconnected concepts important in integrating modern technologies. Technology acceptance refers to an individual's attitude towards a specific technology and is influenced by various factors [15]. This attitude significantly impacts the likelihood of adopting the technology [16]. Technology adoption encompasses the stages from initial awareness to full utilization of the technology [15]. It is a progressive process where acceptance acts as a prerequisite for adoption. Understanding and influencing the factors that shape technology acceptance is essential for successfully implementing modern technologies in organizations and society.

While the number of technologies for older adults is growing, acceptance remains low due to low usability [17] and ease of use [18]. Moreover, the use of VR games by older adults in LTC is constrained by other factors, including access to the technology within these facilities, organizational structures, workforce routines in LTC [19], and available social support, which all need more consideration in research on technology acceptance among older people [20].

Only recently have theorists attempted to locate factors associated with the design of technologies and user acceptance within a broader understanding of older adults' aging process and the life worlds [21]. Although technology acceptance and adoption have been studied by different disciplines, such as sociology and computer sciences, far fewer studies have been done on technology acceptance by older adults [15]. This gap is reflected in a lack of bridging between technology acceptance models and theories of aging [22,23]. The reigning approach to technology and aging embodies an interventionist logic that posits modern technologies as interventions or solutions to the “problems” of aging [23]. This logic reinforces a division between aging scholars and technology scholars and retards the development of theories of aging and

technology. Older adults are considered uninterested in and familiar with the technology in many technology projects. This assumption stems from aging scholars' failure to describe aging with technology and frames acceptability problems due to older people's technology skepticism [21]. Advancing a role for VR games in enhancing the health and wellness of older adults living in LTC requires a research approach that locates technology acceptance within a conceptual foundation that spans theories of aging and technology. We conducted a quantitative study involving VR gaming sessions and questionnaires to explore the factors affecting the acceptance of VR games among older adults living in LTC.

Theoretical Framework

The Technology Acceptance Model (TAM)

TAM [24] is a widely cited framework in technology acceptance studies. TAM proposes that *perceived Usefulness* (PU) and *perceived ease of use* (PEU) shape the attitudes of the user toward technology (AT) that, in turn, affect the intention to use and determine technology acceptance behaviour [24].

TAM, originally designed to assess technology acceptance among employees and working-age individuals, has limitations in explaining technology acceptance among older adults, principally because it was not constructed with constructs from the field of aging in mind [25].

The Senior Technology Acceptance Model (STAM)

STAM, an extended model based on TAM, focuses on the acceptance of gerontechnology among older adults and includes factors such as age, gender, education, self-efficacy, anxiety, health, ability, and facilitating conditions. It suggests that PU, PEU, and AT collectively determine technology acceptance, influenced by age-related factors and individual attributes. Individual

attributes are better predictors of technology use behaviour among older adults than traditional attitudinal factors (PU, PEU) [26].

Meekes and Stanmore [27] emphasize the need to explicitly demonstrate age-related factors as primary determinants in models of technology acceptance by older adults within the framework of STAM. Additionally, Chen and colleagues briefly mention the impact of social relationships, including personal satisfaction, support, and social participation, on PU, ease of use, and gerontechnology usage [26].

The Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT, developed by Venkatesh and colleagues, is a comprehensive model for studying technology acceptance and use in a consumer context [28,29]. It integrates eight theories and models and identifies seven core determinants of intention and usage, along with up to four moderate determinants. The direct determinants include performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit. Age, gender, and experience are moderators in user acceptance and usage behaviour. UTAUT recognizes age as a moderate determinant with an indirect impact on the intention to use technology. It defines social influence as a direct determinant of behavioural intention and includes "facilitating conditions" as a social factor influenced by age, gender, and experience [28].

Selective Optimization with Compensation (SOC) theory

SOC [30] suggests that as individuals age, they become more aware of losses and resource declines, prioritizing and selecting important goals, optimizing their performance, and compensating for unachievable goals to maintain functioning. [31,32]. Older adults who utilize optimization strategies report more positive emotions and greater satisfaction with aging and

can be expected to report greater technology acceptance. VR offers alternative solutions for performance failures and aligns with older adults' declining abilities and resources. Elective selection involves pursuing goals based on personal preferences, and VR provides immersive experiences customized to individual interests [30]. Loss-based selective strategies adapt goals to limitations using VR simulations and adjustable difficulty levels. Optimization strategies tailor the VR environment to meet older adults' specific needs, such as personalized exercise routines. VR also enables compensatory strategies for achieving goals by providing a safe environment for physical therapy and rehabilitation.

Socioemotional Selectivity Theory (SST)

SST, a lifespan theory [33], explains the shift of personal goals and behaviours with age. Older adults focus on emotionally meaningful relationships and current experiences, and positive future perception enhances commitment to self-improvement goals. VR aligns with emotional experiences through virtual tours, social VR platforms, and meditation apps, providing a sense of presence and connection in virtual environments [34,35]. Older adults value VR-related learning activities, and the Future time perspective (FTP) influences VR acceptance, particularly when it supports their goals and motivations.

Our study incorporates various theories and models that offer distinct perspectives and definitions of key concepts. While TAM-based models recognize the influence of others' beliefs on technology perception, there is no consensus on the definition of social relationships and their role in moderating technology acceptance. Therefore, integrating social processes is crucial for understanding the factors influencing technology acceptance and well-being in older age.

Technology and aging have gained significance due to technological advancements, increased life expectancy, and the growing demand for elderly care. Its objective is to enhance older adults' quality of life and independence through technology. However, despite efforts to explore the relationship between older adults and technology, there is a lack of literature in this area [32]. Lifespan development theories like SOC and SST have been employed to study various aspects of aging, but their application to modern technologies remains limited. Similarly, technology acceptance models lack aging-related factors and a unified definition of acceptance determinants, raising concerns about their effectiveness in explaining technology acceptance among older adults [36,37].

Hypotheses

Based on the social theories of aging, we propose two hypotheses.

1. In accordance with SOC theory, individual acceptance of VR exergames will be positively correlated with the use of SOC strategies when accounting for age as a covariate.
2. In accordance with SST theory, individual acceptance of VR exergames will be positively correlated with future time perceptions in the VR game setting when accounting for age as a covariate.

Material and Methods

Research Design

The study consisted of two main components. The first part involved three VR exergaming sessions to provide participants with firsthand experience. The second component was a composite questionnaire designed to evaluate the acceptability of the game

Selection of Theory-derived Measures and Design of Composite Questionnaire

The composite questionnaire incorporating TAM, STAM, UTAUT, SOC, and FTPS assessed technology acceptance. The questionnaire included constructs such as PU, PEU, game self-efficacy (GS-E), game anxiety (GA), social relationships (SR), attitudes toward game (ATG), psychological function (PF), facilitating conditions (FC), and hedonic motivation (HM) [30]. Participants rated acceptance questions on a five-point scale, with higher scores indicating greater levels of the corresponding construct. The SOC questionnaire assessed SOC strategies using 12 items, while FTPS measured SST-related variables. This study is the first to integrate three TAM instruments and examines the influence of previous technology experience and sedentary behaviour [30,33].

Study Sample and Recruitment

Data for our study were collected from a healthcare center for older adults in Ottawa, including residents (n=5) and tenants (n=15). Residents are older adults who require 24-hour care and assistance with daily activities, while tenants enter into a lease agreement with the facility and have more independence. We aimed to examine VR acceptance among older adults with diverse physical abilities. Eligible participants were 65 years or older, living in LTC, capable of using VR equipment, and proficient in English. Cognitive health was assessed based on administrator reports, self-reports, and comprehension of game tutorials. Exclusions were made for those with VR equipment intolerance, language barriers, and difficulty understanding game instructions. Tenant participants were recruited during their weekly coffee club, while potential resident participants were identified with input from facility administrators and staff before approaching them. Participants provided written informed consent upon enrollment ([Appendix 1](#)) and

received an orientation before the first gaming session. The chosen game met eligibility criteria, including options for seated and standing play, single and multi-player modes, and tracking calories burned and scores.

VR Equipment

The Oculus Quest 2 was chosen for the VR exergaming component of the study due to its accessibility, lightweight design, and reliable performance. The foam facial interface was replaced with a sanitizable silicone alternative to improve hygiene. A glasses spacer was also added to accommodate participants who preferred to wear glasses while playing the game.

VR Exergame

A VR exergame is an immersive virtual reality game that combines PA and gaming to promote well-being using a head-mounted display [38]. ***Song Beater (SB)***, a commercially available game, was selected. SB focuses on rhythm and dance and challenges players to slash flying beats by slicing blocks with their hands or tools in Real 360 mode [39]. It offers single-player and multi-player modes, allowing players to track their exercise progress and customize their environment. With five difficulty levels, the game accommodates players of varying physical abilities. Safety measures include playing seated or with one hand for balance. A researcher provides technical support and monitors sessions for safety. Participants were advised to rest briefly after gaming to minimize balance or dizziness concerns.

Procedures

Participants completed a series of VR exergame sessions with SB over two weeks. Each session lasted 30-35 minutes, with a 10-minute orientation before the first session. Participants played two ~3-minute songs at a "gentle" difficulty level during the gaming component. Adjustments to

difficulty and song selection were possible upon request. The headset was worn during gameplay, and participants could play additional songs if desired. The composite questionnaire ([Appendix 2](#)) was used to assess the acceptability of the VR exergame. Participants completed sections of the questionnaire after each gaming session, covering demographic information, sedentary behaviour, prior gaming experience (session 1), SOC, FTPS (session 2), and TAM, UTAUT, and STAM (session 3). This sequential approach allowed for comprehensive data collection. Research ethics approval was obtained. We obtained research ethics approval for our study from the University of Ottawa Research Ethics Board (Ethics File Number: H-02-22-7627).

Data Collection

Demographics and Background Information

The game was set on "no fail" mode, ensuring that players could complete the game without penalties for mistakes. This setup provided a consistent gaming experience for all participants. Our study did not measure participants' game performance, as the focus was on evaluating the acceptance of VR games. After the first gaming session, demographic information such as age, gender, education, and previous gaming experience was collected. Sedentary behaviour was assessed based on prolonged sitting activities, such as watching TV, listening to music, phone conversations, reading, and playing computer or video game [45]. Participants reported their prior experience with computer-based games on a six-point scale adapted from Czaja et al. [40] from never to more than five years. These factors were collected as control variables in the data analyses.

Data Analysis

Data were analyzed using SPSS version 29 (SPSS, Chicago, IL, USA). Descriptive statistics were used to summarize the demographic and background information. Spearman's rank correlations rho (r) was computed between the scores on the theory-based questionnaire, which measured SOC and SST variables and the attitudinal factors from the TAM (PEU, PU, and AT), partialling out the effects of age. The values of rho correlations were interpreted using the rule of thumb where correlations of 0.50 and above are considered a large magnitude of the correlation coefficient [40]. Potential gender differences were explored using Mann-Whitney U-tests. For these tests, the significance of the results and effect size for the difference in the median were considered for Cohen's d size (i.e. medium $d \geq 0.50$) for the difference [41]. The data were non-normally distributed for both techniques, and the cut-off for statistical significance was set at the 95% level (i.e. $p < .05$). Data from questionnaires were recorded and analyzed in SPSS.

Results

Demographics and Background Information

All participants completed three gaming sessions with the projected number of songs and acquired the ability to navigate the virtual environment and default game setting. The available support from the researcher proved sufficient for their needs. We had 20 participants: 5 (25%) residents and 15 (75%) tenants. Participants' ages ranged from 66 to 95 (median 82). There were 11 females (55%) and nine males (45%). All had at least a high school diploma, and most had bachelor's or higher degrees (7, 35%). [Table 3.1](#) presents the participants' demographic and background information.

Sedentary activity

The most common sedentary activity reported was sitting and talking on the phone, with 40% of individuals engaging for 30 minutes or more. In contrast, sitting while listening to music was the least common, reported by only 10% of individuals for 30 minutes or more, while playing computer/video games was reported by 25% for 2 hours or more.

Watching television was the most time-consuming sedentary activity, with a mean value of 5.70 and a median value of 5.67. Sitting and reading followed, with a mean value of 4.05 and a median value of 4.38. Playing computer/video games had the lowest mean and median values, with 2.95 and 3.00, respectively.

It is important to note that the definition of sedentary time can vary across studies, making direct comparisons challenging. Previous studies have reported average sedentary times ranging from 8 to 10 hours per day for older adults [42,43]. However, our study's findings differ from these averages. Factors such as setting characteristics, participant demographics, health status, and study design variations could contribute to the differences in sedentary time reported. [Table 3.2](#) depicts a summary of participants' daily sedentary behaviour.

Prior Experience with Computer-based Games

Ten participants (50%) had over five years of computer gaming experience. 10% had 3-5 years of experience, 5% had 1-3 years of experience, and one participant had experience from six months to one year. The remaining 30% reported no prior computer gaming experience.

Thirteen participants reported engaging in weekly gaming activities. 25% of participants spent 1-5 hours playing games, while another 25% spent 6-10 hours. The remaining 5% of participants reported spending 16-20 hours, 20-25 hours, and more than 30 hours playing games each week,

respectively. These findings indicate that most participants engaged in gaming activities for short durations, with only a minority playing for longer periods of time. [Table 3.3](#) presents Weekly experience with computer-based games

Technology Acceptance among Participants

We compared two groups: participants with prior gaming experience and those without, to explore the correlation between gaming experience and technology acceptance. Most variables, including PEU, FC, ATG, and SR, showed comparable results in both groups. However, differences were observed in PU, GS-E, HM, and PF. The mean PU score was slightly lower in the experience group (3.76) compared to the no-experience group (4.22). The PEU mean was comparable between the groups (experience: 4.25, no experience: 4.26). GS-E mean was higher in the experience group (4.07) than the no experience group (2.83), with a statistically significant difference. GA means showed a slight difference (experience: 1.23, no experience: 1.20), but it was not statistically significant. FC mean was similar between the groups (experience: 4.00, no experience: 4.22). The HM mean was higher in the experience group (4.61) than in the no-experience group (4.33), but the difference was not statistically significant. ATG and SR means were comparable between the groups. PF mean was lower in the experience group (3.50) than in the no-experience group (2.50), but the difference was not statistically significant.

These findings suggest that prior gaming experience may moderately affect certain aspects of technology acceptance. The experienced group showed slightly lower PU scores, indicating less perceived value in VR technology. However, they exhibited higher GS-E scores, indicating a greater confidence in using modern technology. The experienced group also reported higher HM scores, suggesting greater enjoyment of VR games. Overall, prior gaming experience influenced

technology acceptance, but it was not a decisive factor. [Table 3.4](#) depicts the mean scores from the TAM questionnaire.

SOC strategies

The mean score for the Selection (total) subscale was 1.52, indicating a moderate level of selective strategies. Elective selection has the highest mean score of 1.66, emphasizing a focus on personally important goals. Loss-based selection has a mean score of 1.38, indicating consideration of negative outcomes. The Optimization subscale has a mean score of 1.25, reflecting a preference for the active pursuit of goals. The Compensation subscale has the highest mean score of 1.47, highlighting moderate compensation levels for losses or limitations.

Comparing experienced and no-experience groups, prior gaming experience was associated with using SOC strategies. The experienced group had higher mean scores in all subscales except for elective selection. They showed more deliberate choices (1.72 vs. 1.44) and better optimization (1.64 vs. 1.21). The compensation score was higher for the experienced group (1.40 vs. 1.33). No significant difference was found in the elective or loss-based selection, suggesting gaming experience may not influence these aspects. Overall, these findings suggest that prior gaming experience may contribute to a more intentional and strategic approach to using modern technologies like VR. Experienced individuals may adapt and utilize such technologies more effectively. [Table 3.5](#) shows the mean scores for the SOC questionnaire.

SST strategies

FTPS had a mean score of 3.02, indicating a moderate level of future orientation. The standard deviation of 0.65 suggests response variability, with some individuals being more future-oriented

than others. The range of 2.28 indicates significant variation in scores, ranging from low to high future orientation.

Comparing the two groups, the Experience group showed a higher mean score for SST compared to the no-experience group. This suggests that prior gaming experience may be associated with an extended FTP when playing VR technology, although the difference between the groups was not statistically significant.

Mann-Whitney t-test

Based on the Mann-Whitney test results, the p-values for all the variables were greater than 0.05, indicating no significant difference between the median scores of males and females in each variable. Therefore, we fail to reject the null hypothesis that there is no difference in the scores between males and females

Hypothesis testing

The SOC and SST hypotheses were tested using Spearman rho correlations. Statistical significance was set at the 95% level (i.e. $p < .05$).

H1: *Individual acceptance of VR exergames will be related to using SOC strategies when accounting for age covariate.*

Based on the correlation coefficients and p-values provided, there were significant correlations between PEU and the selection (total) strategy ($r_s = .60$, $p = .008$), as well as elective selection ($r_s = .50$, $p = .03$) and optimization ($r_s = .48$, $p = .04$) strategies. There was a significant correlation between ATG and the use of elective selection ($r_s = .50$, $p = .03$), suggesting that individuals with positive attitudes towards game technology use were more likely to engage in this strategy. Based on the results, the results supported the hypothesis H1. The significant correlations found

between individual acceptance of VR exergames and the use of SOC strategies suggest that these strategies play a role in determining technology acceptance. Additionally, the inclusion of an age covariate in the analysis indicates that age may also be a factor in the relationship between acceptance and these strategies. [Table 3.5](#) presents the correlations between the TAM and SOC measures.

H2: Individual acceptance of VR exergames will be positively correlated with future time perceptions in the VR game setting when accounting for age covariate.

The correlations indicated no significant positive relationship between TAM subscales and FTP. Therefore, based on these findings, H2, which suggests a relationship between acceptance of VR exergames and FTP when accounting for age as a covariate, is not supported. [Table 3.5](#) shows the partial correlations between the TAM and FTP measures when accounting for age covariate.

Discussion

In our study, a sizable proportion (65%) engaged in weekly gaming activities. Compared to other studies, our participants had lower sedentary time, potentially due to LTC facility programs or their health status. Watching television was the most prevalent sedentary activity, followed by sitting and reading.

Most participants (70%) had prior gaming experience and scored higher in TAM, SOC, and SST compared to those without prior gaming experience. This suggests that individuals with prior gaming experience may have developed greater confidence in modern technology and employed deliberate strategies to enhance their technology usage. Furthermore, their motivation to use VR technology for entertainment and social purposes aligns with the principles of the SST.

However, these findings are speculative, and further research is necessary to fully comprehend the underlying reasons for the observed group differences.

Our findings suggest that LTC residents find the technology useful and easy to use. However, opinions about ease of use varied widely among users. Additionally, users had moderate beliefs in their ability to use technology effectively. Interestingly, participants did not experience elevated levels of anxiety related to gaming and showed elevated levels of game self-efficacy. This finding suggests that gaming activities may be a viable technology-based intervention for LTC residents without causing stress or anxiety. Moreover, participants believed they had access to the necessary resources to use technology.

The association between SOC strategies and well-being has been repeatedly confirmed by research over the years [44]. The findings of our study suggest that older adults in LTC perform VR gaming as goal-directed instrumental behaviour. Regarding technology acceptance associated with successful aging, the results are consistent with findings that SOC and other adaptive processes are positively associated with indicators of successful aging.

The significant positive relationship between PEU of technology and the use of selection (total) strategies and loss-based selection strategies supported the hypothesis that the acceptance of VR exergames is related to the use of SOC strategies. The significant positive correlation between PEU and selection strategies suggests that individuals who find VR exergames easy to use and free of effort are more likely to employ selection strategies when using them.

The positive correlation between VR exergame acceptance and the use of elective selection, loss-based selection, and optimization strategies indicates that individuals who embrace VR exergames are inclined to purposefully engage with the technology, emphasizing enjoyable and

rewarding aspects of the experience. These findings have implications for the design and marketing of VR exergames, suggesting that users respond favourably to focused and streamlined experiences rather than overly complex or difficult ones.

The significant correlation between attitudes towards the game and elective selection suggests that older adults in LTC have a positive attitude toward aging and assign priority to undertaking new, physically demanding activities like VR game playing. Elective selection refers to the definition of goals to match a person's needs and motives with the available or attainable resources and aims at achieving higher levels of functioning.

We did not observe a significant relationship between FTP and technology acceptance. It suggests that the participants may not have identified VR gaming with self-improvement goals. Our study did not analyze game performance, and research has shown a positive correlation between FTP and work performance [46]. It is possible that participants who had more FTP performed better than those who did not. Further investigation is warranted by this finding.

Our findings support the independence between the constructs of SOC and SST. Given the differences in the focus and assumptions of SOC and SST, it is reasonable to expect that the constructs of these two theories are independent of each other. In other words, the mechanisms proposed in SOC theory are not inherently tied to those proposed in SST, and vice versa.

Our study demonstrates how social process models can provide insights into behaviours that enhance the adaptation process in aging. Process models should play a more significant role in research on the well-being of older adults in LTC, where the goal is to maximize well-being despite physical decline. While it is not feasible for all LTC residents to maintain high physical function in

their advanced years, VR exergaming provides a practical strategy for encouraging and supporting them to continue engaging in valued activities and pursuing goals.

Limitations and strengths

We utilized validated measures to assess VR acceptance, contributing to a better understanding of the benefits and challenges associated with VR technology and gaming in LTC settings. By exploring the association between aging-related theories and technology acceptance, our study offers innovative insights into the potential of technology and gaming interventions for improving the health and well-being of older adults in LTC settings. However, it is important to acknowledge certain limitations. The small sample size restricts the generalizability of the findings. The order in which the questionnaires were administered over three days may have influenced participant responses, potentially leading to fatigue or bias. Additionally, the study's inclusion of highly educated participants may limit generalizability, as their familiarity with technology and higher acceptance levels may not reflect the broader population's experiences, particularly those with lower education or less technological familiarity.

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Declaration of Interest statement

The authors declare that there are no competing interests associated with the publication of this manuscript. Neither financial nor personal relationships exist that could potentially influence the

interpretation or presentation of the research findings. This commitment to transparency and objectivity ensures an impartial assessment and discussion of the results.

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Appendix 1- Gaming Sessions Consent Form

**Study Title: Identifying the Factors Associated with Older Adults’
Acceptance of Virtual Reality Games
Understanding of my rights in research**

Please circle YES or NO

I read the letter about this study.	YES	NO
I decided that I want to be in this study.	YES	NO
I know that I do not need to be in this study if I do not want to.	YES	NO
I will participate in this study which includes Three 20-minute gaming sessions followed by short questions that will last 5 to 10 minutes.	YES	NO
I can stop my participation when I want.	YES	NO
It is okay for the researchers to use my answers when they tell people about their research.	YES	NO
I know that the researchers will not tell anybody my name.	YES	NO
It is okay for the researchers to ask me again if I want to continue participating in the study.	YES	NO

Participants:

I had an opportunity to discuss this study, and any questions that I have asked were answered to my satisfaction. I voluntarily consent to participate in the **gaming sessions** of the study “**Identifying the factors associated with older adults’ acceptance of virtual reality games.**” I understand that this study is independent from The Perley Health and that refusal to participate will have no effect on the services I receive at the Centre. I understand that I will receive a signed copy of this form.

Participant’s Signature

Date

Participant’s Name

By marking my initials here, _____, I agree to allow the researchers to contact me at a later time if they would like me to clarify any information.

Person obtaining consent:

I have discussed this study in detail with the participant. I believe the participant understands what is involved in this study.

Marjan Hosseini

Researcher's Name

Researcher's Signature

Date

If you have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5, Tel.: (613) 562-5387, Email: ethics@uottawa.ca).

Appendix 2- The Composite Questionnaire

Technology acceptance Questionnaire

SESSION:	DATE/TIME:
PARTICIPANT:	Questionnaire: Demographic information

Gender: _____

Age (in year): _____

Education

- No certificate, diploma or degree
- High school diploma
- Apprenticeship or other trades certificate
- College diploma
- University below bachelor's
- Bachelor's degree or higher

Sedentary behavior

On a typical day, how much time do you spend (from when you wake up until you go to bed) doing the following?

	None	15 m or less	30 min	1 h	2 h	3 h	4 h	5 h	6 h or more
Watching television									
Sitting while listening to music									
Sitting and talking on the phone									
Sitting and reading									
Playing computer/video games									

Prior experience with computer-based games

Never	Less than 6 months	More than 6 months, but less than 1 year	More than 1 year, but less than 3 years	More than 3 years, but less than 5 years	More than 5 years
1	2	3	4	5	6

If you said that you have experience playing computer-based games, how long do you usually play games for every week?

- 1-5 hours
- 6-10 hours
- 11-15 hours
- 16-20 hours

- 21-25 hours
- 26-30 hours
- 30+ hours

SESSION:	DATE/TIME:
PARTICIPANT:	Questionnaire: TAM questionnaire

	Perceived Usefulness (PU)	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1	Using VR games would enhance my effectiveness in life (to what extent using VR games can you imagine would affect your ability to do the things that are important to you)	1	2	3	4	5
2	Using VR games would make my life more convenient (would make my life easier)					
3	I would find VR games useful in my life					
	Perceived Ease of Use	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
4	My interaction with the VR game is clear and understandable					
5	Interacting with the VR game does not require a lot of my mental effort					
6	I find the VR game to be easy to use					
7	I find it easy to get the game to do what I want it to do					
8	I could be skillful at using VR game					
	Game self-efficacy	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
9	I could complete a level using the VR game if I have just the instruction manual for assistance					
10	I could complete a level using the VR game if there is someone to demonstrate how					
	Game anxiety	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
11	I feel apprehensive about using the VR game					
12	I hesitate to use the VR game for fear of making mistakes I cannot correct					
13	VR games make me feel uncomfortable					
14	VR games make me feel uneasy					
	Facilitating conditions	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree

15	I have the resources necessary to use the game					
16	I have the knowledge necessary to use the game					
17	A specific person (or group) is available for assistance with game difficulties					
	Hedonic Motivation	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
18	Playing VR games is fun					
19	Playing VR games is enjoyable					
20	Playing VR games is very interesting					
	Attitudes toward games	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
21	Using VR games for physical activity is a good idea					
22	Playing VR exercise games is an attractive way to be active					
	Social relationships	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
23	I am satisfied with my personal relationships					
24	I am satisfied with the support I get from my family and friends					
25	I participate in social or community activities					
	Psychological function	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
26	I feel that as I get older, I am less useful					
27	I am satisfied with my quality of life					

SESSION:	DATE/TIME:
PARTICIPANT:	Questionnaire: Selective Optimization with Compensation questionnaire (SOC) AND Future Time Perspective Scale SST

constructs
<p>Elective selection</p> <p>1. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> I concentrate all my energy on a few things <input type="checkbox"/> I divide my energy among many things
<p>2. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> I always focus on the one most important goal at a given time <input type="checkbox"/> I am always working on several goals at once
<p>3. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> When I think about what I want in life I commit myself to one or two important goals <input type="checkbox"/> Even when I really consider what I want in life I wait and see what happens instead of committing myself to just one or two particular goals
<p>Loss-based selection</p> <p>1. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> When things do not go as well as they have in the past, I choose one or two important goals <input type="checkbox"/> When things do not go as well as they have in the past, I still try to keep all my goals
<p>2. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> When I cannot do something important the way I did before I distribute my time and energy among many other things <input type="checkbox"/> When I cannot do something important the way I did before I look for a new goal
<p>3. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> When I cannot do something as well as I used to, I think about my priorities and what exactly is important to me <input type="checkbox"/> When I cannot do something as well as I used to, I wait and see what comes
<p>Optimization</p> <p>1. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> I keep working on what I have planned until I succeed <input type="checkbox"/> When I do not succeed right away at what I want to do, I don't try other possibilities for very long.
<p>2. Please select which of the two statements is more true for you.</p> <ul style="list-style-type: none"> <input type="checkbox"/> I make every effort to achieve a given goal <input type="checkbox"/> I prefer to wait for a while and see if things will work out by themselves

- 3.** Please select which of the two statements is more true for you.
- If something matters to me, I devote myself fully and completely to it
 - Even if when something matters to me, I still have a hard time devoting myself fully and completely to it.

Compensation

- 1.** Please select which of the two statements is more true for you.
- When things do not go as well as they used to, I keep trying other ways until I can achieve the same result I used to
 - When things do not go as well as they used to, I accept it

- 2.** Please select which of the two statements is more true for you.
- When something in my life is not working as well as it used to, I decide what to do about it myself without involving other people
 - When something in my life is not working as well as it used to, I ask others for help or advice

- 3.** Please select which of the two statements is more true for you.
- When it becomes harder for me to get the same results I keep trying harder until I can do it as well as before
 - When it becomes harder for me to get the same results as I used to It is time to let go of that expectation

	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1. Many opportunities await me in the future.					
2. I expect that I will set many new goals in the future.					
3. My future is filled with possibilities.					
4. Most of my life lies ahead of me.					
5. My future seems infinite to me.					
6. I could do anything I want in the future.					
7. There is plenty of time left in my life to make new plans.					
8. I have the sense that time is running out.					
9. There are only limited possibilities in my					

future.					
10. As I get older, I begin to experience time as limited.					

Table 3.1

Participants' demographic and background information

Variables	Participants
Age	
Range	66-95
Mean	81.25
Median	82
Gender	
Female	11 (55%)
Male	9 (45%)
Education	
High school diploma	3 (15%)
Apprenticeship or trades Certificate	3 (15%)
College diploma	3 (15%)
University below bachelor's	4 (20%)
Bachelor's or higher	7 (35%)
Residence	
Tenant	15 (75%)
Resident	5 (25%)

Table 3.2

Summary of participants' daily sedentary behaviour

Sedentary activity	None	15 m or less	30 min	1 h	2 h	3 h	4 h	5 h	6 h or more
Watching television	1 (5%)	-	2 (10%)	2 (10%)	4 (20%)	5 (25%)	2 (10%)	1 (5%)	3 (15%)
Sitting while listening to music	6 (30%)	2 (10%)	3 (15%)	5 (25%)	2 (10%)	2 (10%)	-	-	-
Sitting and talking on the phone	2 (10%)	8 (40%)	3 (15%)	3 (15%)	2 (10%)	2 (10%)	-	-	-
Sitting and reading	3 (15%)	1 (5%)	-	7 (35%)	6 (30%)	3 (15%)	-	-	-
Playing computer /video games	5 (25%)	3 (15%)	4 (20%)	5 (25%)	2 (10%)	1 (5%)	-	-	-

Table 3.3

Weekly experience with computer-based games

	1-5	6-10	11-15	16-20	21-25	26-30	30+
	hours	hours	hours	hours	hours	hours	hours
Weekly game playing	5 (25%)	5 (25%)	-	1 (5%)	1 (5%)	-	1 (5%)

Table 3.4

Mean scores from the TAM questionnaire and SOC Subscales

	TAM Subscale										SOC Subscale			
	PU	PEU	GS-E	GA	FC	HM	ATG	SR	PF	Selection (total)	Elective selection	Loss-based selection	Optimization	Compensation
Mean														
Overall	3.90	4.26	3.70	1.23	4.06	4.53	4.37	4.36	3.20	1.44	1.67	1.38	1.25	1.47
NoExperience	4.22	4.26	2.83	1.20	4.22	4.33	4.50	4.50	2.50		1.72	1.38	1.33	1.66
Experienced	3.76	4.25	4.07	1.23	4.00	4.61	4.32	4.35	3.50		1.64	1.38	1.21	1.40
SD														
Overall	.43	1.46	1.23	.41	.86	.66	.47	.74	1.31	.20	.35	.24	.26	.33
NoExperience	.46	.19	.45	.16	.26	.33	.34	.22	.38	.20	.44	.25	.21	.33
Experienced	.21	.13	.21	.09	.16	.13	.25	.16	.28	.18	.33	.25	.28	.32
Range	3	3	4	1	4	3	3	3	4	.58	1	.67	.67	1

Note: PU: Perceived usefulness; PEU: perceived ease of use; GS-E: Game self-efficacy; GA: Game anxiety; FC: Facilitating conditions; HM: Hedonic motivation; ATG: Attitude towards game; SR: Social relationship; PF: Psychological functioning

Table 3.5

Correlations between the TAM and SOC and FTP

Control Variable	TAM Subscale	SOC Subscale					FTP scale	
		Selection (total)	Elective selection	Loss-based selection	Optimization	Compensation	FTP	
Age	PU	<i>r_s</i>	.17	.41	-.36	.12	.12	.02
		<i>P</i> value	.49	.08	.14	.62	.63	.91
	PEU	<i>r_s</i>	.60	.50	.29	.48	.28	.28
		<i>P</i> value	.008	.03	.23	.04	.24	.26
	GSE	<i>r_s</i>	.22	.41	-.24	.35	-.06	.14
		<i>P</i> value	.36	.08	.32	.15	.80	.56
	GA	<i>r_s</i>	-.17	-.17	-.04	-.39	-.29	-.30
		<i>P</i> value	.48	.49	.85	.10	.23	.21
	FC	<i>r_s</i>	-.13	-.04	-.17	.15	.39	.21
		<i>P</i> value	.60	.85	.50	.54	.10	.40
	HM	<i>r_s</i>	.22	.28	-.56	.27	.02	.04
		<i>P</i> value	.38	.25	.82	.27	.91	.87
	ATG	<i>r_s</i>	.37	.50	-.12	.25	-.08	-.03
		<i>P</i> value	.12	.03	.61	.31	.74	.99
	SR	<i>r_s</i>	.06	.09	-.02	.30	.14	-.09
		<i>P</i> value	.80	.72	.91	.22	.57	.70
	PF	<i>r_s</i>	-.35	-.22	-.28	.16	.20	-.11
		<i>P</i> value	.15	.37	.25	.51	.40	.64

Note: TAM: technology acceptance models; SOC: Selective Optimization with Compensation theory; FTP: Future time perspective; PU: Perceived usefulness; PEU: perceived ease of use; GSE: Game self-efficacy; GA: Game anxiety; FC: Facilitating conditions; HM: Hedonic motivation; ATG: Attitude towards game; SR: Social relationship; PF: Psychological functioning

**p*<.05

CHAPTER 4: INTERVIEW STUDY (STUDY 3)

In this chapter, I present the qualitative manuscript associated with my dissertation. This manuscript followed the Interpretive description framework and aimed to explore participants' experience with VR exergames and identify the meaning they associate with their participation. It also examined the individual and contextual factors affecting participant's experience. The scoping review (study 1) identified a need for investigation in the individual and social factors affecting acceptance of VR technology by this group and the quantitative manuscript (study 2) investigated the association between acceptance of VR games and social factors using technology acceptance models and social theories of aging. Like other two studies, the qualitative manuscript (study 3) focused on the motivational factors in acceptance of VR games. This study explored individuals' experiences and aimed to identify the interaction between residents of LTC and VR games. It sought to understand how they engage with VR games, the benefits and challenges they experience, social connections, and how VR technology can improve their health and well-being. In this third study, I conducted semi-structured interviews with older adults and staff members to identify the individual and contextual factors affecting their acceptance and shaping their interaction with VR games. Both groups answered to nine open-ended questions and provided insights into VR acceptance in LTC facilities. I identified four themes from older adults' data and three themes based on staff members' interviews. Older adults found the gaming experience enjoyable and exciting, with potential to provide physical, cognitive, social, and motivational benefits for them. Staff members Proper guidance and personalized programs

can increase understanding and familiarity with VR, leading to a higher level of acceptance and engagement.

I submitted this manuscript to Journal POLS ONE and it is currently under review. The inclusive scope of PLOS ONE, spanning over 200 subject areas across science, medicine, and the social sciences and humanities, provides a fitting platform for my interdisciplinary research on VR acceptance in LTC care facilities. The journal's comprehensive editorial process guarantees the credibility and scholarly rigor of the published work, making PLOS ONE an excellent platform for my research.

Manuscript 3: Acceptance of Physical Activity Virtual Reality Games by Residents of Long-term Care Facilities: A Qualitative Study

Abstract

Background: Little is known about the experience and the social and contextual factors influencing the acceptance of virtual reality (VR) games among long-term care (LTC) residents. Our study aims to address this research gap by investigating the unique experience of older adults with VR games. The findings will provide valuable insights into the factors influencing VR acceptance among LTC residents and help design inclusive VR technology that meets their needs and improves physical activity (PA) and well-being.

Objective: We aimed to (1) investigate how participants experience VR exergames and the meaning they associate with their participation and (2) examine the factors that influence the participant's experience in VR exergames and explore how these factors affect the overall experience of VR gaming.

Methods: We used a qualitative approach that follows the principles of the Interpretive Description methodology. Selective Optimization with Compensation (SOC) theory, Socioemotional Selectivity theory (SST) and technology acceptance models underpinned the theoretical foundations of this study. We conducted semi-structured interviews with participants. 19 participants of a LTC were interviewed: five residents and ten tenants, aged 65 to 93 years (8 female and 7 male) and four staff members. Interviews ranged from 15 to 30 minutes and were transcribed verbatim and were analyzed using thematic analysis.

Results: We identified four themes based on older adults' responses that reflected their unique VR gaming experience, including 1) enjoyment, excitement, and the novel environment, 2) physical activity and motivation to exercise, 3) social connection and support, and 4) individual

preferences and challenges. Three themes were developed based on the staff members' data to capture their perspective on the factors that influence the acceptance of VR among LTC resident including 1) relevance and personalization of the games, 2) training and guidance, and 3) organizational and individual barriers.

Conclusions: VR gaming experiences are enjoyable, exciting, and novel for LTC residents and can provide physical, cognitive, social, and motivational benefits for them. Proper guidance and personalized programs can increase understanding and familiarity with VR, leading to a higher level of acceptance and engagement. Our findings emphasize the significance of social connection and support in promoting acceptance and enjoyment of VR gaming among older adults. Incorporating social theories of aging helps to gain a better understanding of how aging-related changes influence technology acceptance among older adults. This approach can inform the development of technology that better meets their needs and preferences.

Introduction

The world's population of individuals aged 65 and above is projected to reach 16% by 2050, indicating a significant increase in the number of older adults (United Nations, 2022). In Canada, the number of people aged 65 or older (18.8%) is growing faster than the number of children aged 0 to 14 years (15.6%) (Statistics Canada, 2022). With the increasing proportion of older adults compared to other age groups, it is anticipated that there will be a corresponding growth in the population of older individuals residing in long-term care (LTC) facilities (CCSMH, 2016). Ensuring the well-being of older adults in LTC facilities is crucial, as they often exhibit lower levels of physical activity (PA) due to various factors (Bender et al., 2021; Y. M. Chen, 2010) with estimates suggesting that they spend about 75% of their waking hours being sedentary (de Souto

Barreto et al., 2016). Promoting tailored PA programs that consider the specific needs and abilities of older adults can enhance social engagement and overall well-being (McPhee et al., 2016).

Recent research has demonstrated the effectiveness of immersive and interactive VR games in promoting PA among older adults (Peng et al., 2011; Skjæret et al., 2016). However, for older adults to embrace and utilize new technology, positive experiences are crucial, highlighting the need to understand acceptance factors (Thordardottir et al., 2019). Further investigation is necessary to fully explore the potential of VR technology in enhancing PA and well-being among older adults in LTC, given their vulnerability to the negative effects of physical inactivity (Marston et al., 2013).

Qualitative studies have explored the potential benefits of VR technology in promoting PA, well-being, and social interaction among older adults (Chaze et al., 2022; Kruse et al., 2021; C. S. Lin et al., 2018) However, each study has specific limitations. Chaze et al. (2022) focused on evaluating VR content tailored to a specific organization, limiting generalizability. Lin's study (2018) approached VR leisure activities from a marketing perspective, potentially differing from the needs of LTC residents. Kruse's study (2021) compared acceptance of VR exergames with traditional video games but did not delve into the influencing factors among older adults. Therefore, further research is needed to understand acceptance factors, inform design, and implement effective VR interventions for LTC residents, promoting PA and overall health outcomes.

The Technology Acceptance Model (TAM) (Davis, 1989) is commonly used to study technology acceptance but has limitations in real-life contexts (Wu, 2012). This criticism highlights the need

to understand the social determinants of VR acceptance among older adults, which requires research informed by social theories of aging. Open-ended interviews, as suggested by Lin et al. (Lin et al., 2018). This research can inform the design and implementation of VR technology for older adults, enhancing accessibility and effectiveness.

Considering the identified research gaps, exploring the social determinants of VR acceptance among older adults can provide valuable insights into improving the accessibility and effectiveness of VR technology for this population. This focus is aligned with the objective and research questions of our study.

Objectives and Research Questions

The main objective of this study was to explore the experiences of older adults with VR exergames, as well as the factors that influence these experiences. To accomplish this, we identified two research questions:

1. How do participants experience VR exergames, and what meaning do they attach to their participation?
2. What are the factors that influence the participants' experience, and how do these factors affect the experience?

Theoretical Framework

Our study was guided by SOC (Baltes et al., 1999) theory and SST (Carstensen, 1995) as frameworks to investigate the social and contextual determinants of acceptance of VR technology. The study also draws on the components from TAM (Davis, 1989), The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and The Senior

Technology Acceptance Model (STAM) (Chen & Chan, 2014) to investigate psychological factors affecting the acceptance of VR technology among older adults.

While technology acceptance models focus on psychological factors to explain users' acceptance of technology, they overlook the social processes associated with aging. To fully understand VR acceptance among older adults, both psychological and social factors should be considered. This integrated approach informs interventions and strategies for promoting VR adoption and use. By uncovering social and contextual determinants, this study aims to enhance VR uptake and use among older adults, improving their overall health and well-being.

Our study integrated SOC theory and SST to tailor VR exergame interventions to older adults' preferences, well-being, and continued participation (Baltes et al., 1999; Carstensen, 1995; Joshi, 2020). SOC theory's strategies for successful aging guide the selection and optimization of activities, compensating for losses. SST emphasizes prioritizing emotionally meaningful social interactions. Incorporating features that support social connections, emotional well-being, and cognitive and physical stimulation in VR games is crucial to fulfill older adults' life goals.

Theoretical frameworks of aging guided our data analysis, identifying themes related to social support and goal-driven attitudes towards VR gaming. By analyzing participant interviews, we aimed to understand the role of social support and the influence of goals on attitudes towards VR games. These themes were derived from the application of social theories of aging, providing structure and direction to our study.

To gain insight into factors influencing older adults' acceptance of VR exergames, we employed TAM components in analyzing staff perspectives. The use of TAM models helped identify key themes related to acceptance. By integrating these models, we focused on specific aspects of

aging and social interaction, providing a structured approach to understanding the acceptance of VR technology among older adults.

Materials and Methods

Methodology

Our study utilized interpretive description (Thorne, 2008) as a qualitative research methodology to understand the unique VR gaming experiences of LTC residents. This approach goes beyond traditional descriptive methods, aiming to uncover deeper meanings and explanations in specific contexts. Given that our focus was on VR gaming experiences of LTC residents, interpretive description allowed us to delve into the unique perspectives, challenges, and coping mechanisms that shape their lived experiences. Through semi-structured interviews with residents, tenants, and staff members, we gained practical insights and theoretical understanding by exploring characteristics, patterns, and structures. By employing deductive reasoning, we identified initial codes, themes, and concepts derived from existing theories and models. This study was conducted with ethical approval from the University of Ottawa's Health Sciences and Sciences Research Ethics Board (Ethics File Number: H-02-22-7627).

Participant recruitment

Data were collected at a community healthcare center serving older adults and veterans in long-term care homes and independent apartments. The facility accommodates two types of individuals: residents and tenants. Residents, typically elderly adults, require round-the-clock care and assistance with daily tasks. On the other hand, tenants sign lease agreements with the facility for a specific duration and enjoy greater autonomy. The participants in this study were a subsample from a related study on VR games conducted a few days prior to the interviews.

Residents who met the following inclusion criteria were selected for participation: (1) aged 65 or older, residing in LTC; (2) previously took part in the VR games study (Hosseini et al., submitted for publication); and (3) able to communicate and read in English. Written informed consent was obtained from those who agreed to participate in the interviews.

Staff members who met the following criteria were included: (1) employed at the facility for at least six months; (2) proficient in English; and (3) directly involved in resident care. Exclusions included staff with less than six months of employment, limited English proficiency, or no direct experience with residents. Gathering staff perspectives provided a comprehensive understanding of the study topic given their proximity and extensive knowledge. Purposive sampling involved sending emails to staff members responsible for resident activities and programs. The first four staff members who agreed to participate were selected for interviews and provided written informed consent. This sampling approach ensured the selection of staff members most suitable to provide insights into the experiences of older adults and veterans in LTC facilities and independent apartments.

In our VR games study, participants engaged with *Song Beater*, a VR rhythm game that challenges players' sense of rhythm through dance and slashing flying beats (Oculus, 2021). Despite not being specifically designed for older adults, Song Beater offers several features that make it suitable for this population, including customizable difficulty levels, seated playing option, one-handed playing with balance support, customizable environment, and the ability to use personal music and adjust song speed. Participants played the game three times within a two-week period and completed a technology acceptance questionnaire to assess factors influencing their acceptance of VR exercise games.

Data Collection

Semi-structured interviews were conducted in person between July and August 2022, within three days after the VR gaming study. Prior to the interviews, participants were provided with an information letter and asked to sign consent forms, ensuring the confidentiality of their responses. All participants were asked the same set of questions regarding their experience with the VR game.

Participants were interviewed once, within 3 days after their participation in the VR gaming study, allowing for sufficient reflection time and reducing initial biases or immediate reactions. Interviews took place in participants' apartments or private rooms at the LTC facility to ensure comfort and ease during the process. The interviews lasted 15-30 minutes, respecting participants' time and attention spans while gathering meaningful information. A set of nine open-ended questions, focusing on game characteristics, preferences, experiences, and goals, were used ([See supplementary Document S1](#)). Probing questions and follow-up prompts were employed to elicit detailed responses and ensure comprehensive coverage of relevant aspects (Britten, 1995).

Staff members were interviewed after resident data collection to gather potential feedback. They received information letters, provided informed consent, and answered nine open-ended questions ([See supplementary Document S2](#)) regarding barriers to physical activity and factors influencing technology acceptance by LTC residents. Interviews took place during staff members' break time in their offices, lasting 15-30 minutes to minimize work disruption.

Data Analysis

Interviews were audio-recorded and transcribed verbatim. The data analysis followed the interpretive description methodology (Thorne, 2008) and involved three stages: data familiarization, theme and pattern identification, and theme labeling and reporting. NVivo 12 qualitative analytic software (QSR International, release version 1.6.1) was used for coding the transcripts. Inter-rater reliability (Armstrong et al., 1997) was ensured through independent coding of five transcripts (three of the transcripts were the same and two were different) by two researchers, followed by consensus discussions to address any discrepancies. As analysis progressed, the theme "game characteristics" was refined into "Enjoyment, excitement, and the environment" to capture a comprehensive understanding of player experiences.

Preliminary themes were developed through detailed analysis and discussions, considering the source data and codes (Rubin & Rubin, 2005). Observations and field notes provided valuable context (Rubin & Rubin, 2005). The data were examined for themes related to TAM, SOC, and SST constructs, providing a theoretical foundation for the study. A combination of social and psychological theories was employed to explore technology attitudes and their age-related variations. SOC guided the exploration of participants' interests, goals, and social interactions, while SST focused on emotional experiences and social connections. TAM facilitated the examination of game characteristics, perceived usefulness, and ease of use.

Result

Participants' characteristics

Twelve tenants (80%), three residents (20%), and four staff members from an LTC facility participated in the interviews. The participants' ages ranged from 66 to 93, with a median age of

78. The gender distribution was eight female participants (53.3%) and seven male participants (46.7%). Educational backgrounds varied, with 40% having a bachelor's degree or higher. Most participants (66.7%) had prior gaming experience, while the remaining (n=5, 33.3%) did not.

Table 4.1 depicts resident and tenant participants' characteristics.

Table 4.1 *Participants' characteristics*

Characteristics	No. (total= 15)	% (100)
Age (y)		
93	1	6.7%
78	3	20%
82	2	13.3%
75	1	6.7%
84	1	6.7%
70	1	6.7%
81	1	6.7%
77	1	6.7%
66	1	6.7%
83	1	6.7%
85	1	6.7%
69	1	6.7%
Gender		
Female	8	53.3%
Male	7	46.7%
Education level		
High school diploma	2	13.3%
Apprenticeship or other trades certificate	3	20%
College diploma	2	13.3%
University below bachelor's	2	13.5%
Bachelor's degree or higher	6	40%
Live in		
Long-term care apartments	3	20%
Tenant apartments	12	80%
Prior gaming experience		
Yes	10	66.7%
No	5	33.3%

We interviewed four staff members (two women and two men). They had varying years of experience in the facility from 1-10 years. Three were health professionals while the fourth was a recreation specialist.

Identified themes

We developed four themes to understand older adults' VR experience and perceptions: (1) enjoyment, excitement, and the novel environment; (2) Physical activity and motivation to exercise; (3) social connection and support; and (4) individual preferences and challenges. In addition, three themes were identified from staff members' data, including (1) relevance and personalization of the games; (2) training and guidance; and (3) organizational and individual barriers.

Themes developed from older adults' data were analyzed using SOC and SST. These themes relate to the experience of VR gaming and how older adults prioritize certain activities and social connections as they age and compensate for declines in other areas and how they prioritize emotionally meaningful goals.

Staff members' themes of "Relevance and personalization," "Training and guidance," and "Organizational and individual barriers" were analyzed using TAM, STAM, and UTAUT. These themes relate to the perceived usefulness and ease of use of the technology, as well as individual and organizational factors that may facilitate or hinder its acceptance.

Older adults' Themes- The meanings attached to the VR gaming experience

These themes represent the experience of VR exergaming and portray the meanings that older adult participants attached to their VR gaming experience.

Enjoyment, excitement, and the novel environment

This theme represents older adults' reflections on the pleasure, enthusiasm, and sense of novelty derived from engaging in VR gaming. Participants in the VR gaming experience found themselves immersed in a captivating world, filled with excitement, vibrant environments, and joyous

interactions. As one participant put it, *"I felt so excited! It was fun! It's really neat! It just brings happiness"* (P5).

Participants found the VR gaming experience enjoyable, with the most cited features being the novel environment and fun nature of the game. Three participants specifically identified their gaming experience as fun, with one stating, *"Look at the beautiful fish"* (P5), another expressing, *"Neat, awesome"* (P14), and a third participant exclaiming, *"I saw a cat! I thought it was my cat!"* (P12). They continually commented on the environment and game details and laughed when surprised during gameplay. One participant expressed their overall enjoyment, stating, *"It's been a fun experience which I am thankful for"* (P11).

Participants emphasized the importance of various game characteristics. Vibrant colors, immersive environments, and high-speed dynamics were key factors contributing to their enjoyment. The realistic design elements, such as Egyptian pyramids and underwater worlds, along with animated animals and fish, further enhanced the gaming experience. One participant appreciated the visually stunning environment, stating, *"I liked the environment; it was very beautiful, the underwater environment"* (P11). Another participant expressed fascination with dynamic elements in the background, particularly observing animals like the lion, which added to their immersion: *"Something that I found interesting was in the background. The animals and the other things going on and watching the big cat, the lion..."* (P6). These insights provided a deeper understanding of the specific game characteristics that captivated and brought enjoyment to the participants.

The VR game's fast and seamless responsiveness to participants' movements was surprising, providing an empowering and liberating experience, especially for those with physical limitations.

One participant expressed their astonishment, stating, *"How crazy is that in this world? You are not vulnerable even, the VR, move a piece, and it happens right away!"* (P5). This quote suggests that VR allows individuals to freely engage in activities without feeling vulnerable, a possibility that may not exist in the physical world.

The game provided a unique and engaging experience, capturing participants' attention and interest throughout gameplay. It instilled a sense of accomplishment and satisfaction as they progressed. One participant described it as follows: *"It was very engaging... it built intensity... it wasn't just one thing around every minute. It slowly introduced maneuvers, picked up the speed, and became very challenging"* (P4).

Many participants appreciated the immersive nature of VR technology, which enabled them to fully engage in the virtual game world and interact with it realistically and intuitively. As one participant expressed, *"I feel like I'm facing real life, but the design is not quiet. I want to be immersed more in the game"* (P9).

Music played a crucial role in generating excitement during the game. Participants actively paid attention to the songs and recognized their impact on the game's rhythm and flow. Some even sought out other songs from the game's playlist to increase the pace and excitement. Perspectives on the role of game music varied among participants. One participant expressed deep appreciation, explaining how it enhanced their personal involvement and enjoyment: *"I love music; I love dancing, so then it brought more of me with the music. The music, I would say, I'm present more. [Laugh]"* (P7). In contrast, another participant viewed game music as mere auditory disturbance, describing it as *"Music is a noise"* (P11).

Such findings align with the framework of SOC which proposes that individuals adapt to the aging by focusing on their goals and optimize the meaningful activities while compensating for the limitations. Participants optimized the enjoyment by engaging in VR game, compensating for any physical limitations. The findings align with the SST framework. Participants in this study sought out VR gaming to maximize enjoyment and positive emotions. The SST lens highlights how older adults are driven by emotional motivations, seeking enjoyable experiences like VR gaming to foster positive emotions and enjoyment throughout the aging process.

Physical activity and motivation to exercise

This theme explores older adults' perspectives on the role of VR exergaming in promoting PA, motivation, and adherence to exercise routines. Participants recognized the connection between PA and motivation during their VR gaming experience. They acknowledged the importance of PA within the VR context, which provided benefits such as improved coordination, balance, and upper body workout. Two participants highlighted the positive exercise effects; P4 stated, *"I have some exercise from it, and I'm conscious of that, as my arms go back and forward and try to catch those Frisbees"* (P4). Similarly, P9 described the game as "a good way to exercise" and emphasized the muscular and visual benefits: *"For my age, it's a good way to exercise, for the muscle and for the visuality"* (P9).

Another participant mentioned feeling warm during the gameplay and needing to turn on a fan, suggesting that the game provided a demanding PA that raised their body temperature. However, some participants viewed the game as an *"add-on"* (P2) or an *"upper body exercise"* (P8), focusing primarily on engaging the upper body rather than the entire body.

In addition to physical benefits, Participating in the VR game also brought awareness to some older adults regarding their physical limitations. One participant expressed frustration with their left hand's accuracy compared to their right hand, stating, *"I was annoyed with myself that my left hand was not as accurate as my right hand. I've always been right-handed. I don't use my left hand very much at all"* (P8). This realization showcases how VR has the potential to enhance self-awareness and uncover previously unnoticed physical limitations.

Besides the physical benefits, the challenge of the game and the sense of accomplishment that came with overcoming it motivated the players to perform better, achieve higher scores, and test their abilities. Some players even saw it as a challenge against the VR machine and tried to outsmart the system. As one participant stated: *"I think the challenge of getting as highest score as you possibly can, so you do it once, you get a score, the second time you want to beat your score."* (P4)

A participant expressed that the game served as motivation for PA and helped them escape daily life challenges, offering a distraction and alleviating depression, *"It takes me out of my everyday tasks and everything and brings me to another world... you see the fishes and things like that and makes you forget you are in the house, and you take the thing [headset] out, and you see oh! I'm in the house"* (P12). Another participant emphasized the importance of the VR experience in combating social isolation and building confidence post-COVID-19 lockdowns. The VR experience brought them happiness and a sense of security, preparing them for rejoining society. *"A really good space to be in, after you have a bad day, wow! Increase your thoughts and your endorphins, you know, just puts you in a happy mood."* (P5)

The use of SOC revealed that VR gaming gave older adults a sense of purpose, motivating them to improve scores and challenge themselves. It also increased self-awareness, as one participant discovered accuracy differences between their hands. VR gaming contributed to physical well-being by providing a meaningful activity that enhanced self-awareness and personal growth.

Also, SST helps us understand the motivation aspect of the theme. According to SST, individuals choose goals and activities that provide personal satisfaction while minimizing effort. In this case, VR gaming offered a fun way for older adults to be physically active, providing a sense of accomplishment and motivation. It motivated participants to exercise, bringing happiness and well-being by serving as a distraction from daily challenges.

Social connection and support

This theme refers to older adults' experiences of social interactions, connection, and emotional support facilitated through VR gaming, including the impact on social relationships. Participants viewed the game as an opportunity to socialize and connect with others, whether with their friends in the facility or family members who live far away: *"I wouldn't mind playing my grandson. [It] Would be a challenge, if I wasn't successful that was fine, but this is something to do together."* (P7) One participant expressed their preference regarding a possible setup for the game for group gameplaying: *"If it could be set up for two players and one hit one colour, and one hit the other colour, that would be a challenge"* (P10).

Participants went beyond involvement, recommending friends to the researcher as potential participants. Their proactive approach and follow-up inquiries demonstrated interest in the study's success and created a sense of community. This highlighted the importance of social

support in promoting engagement and participation, showcasing the potential benefits of VR gaming for LTC facility residents.

Participant sharing of VR gaming experiences enhanced self-efficacy and performance, highlighting the potential of social support and knowledge sharing. Technical support increased confidence in technology use, with a desire to continue playing if volunteer assistance is available: *"If we have a volunteer, hopefully, we can. Somebody that could be available"* (P5). Two participants emphasized the importance of support in navigating the game: *"You escorted me through... if I had been there by myself, I might have had difficulties"* (P4), *"If you weren't here, I don't know how I would go through"* (P5).

Staff and family encouragement significantly influenced acceptance and enjoyment of VR games. One couple shared their scores with their son, who expressed amazement and motivated them to continue: *"I certainly would be interested in another project... I said to my son: I tried that [VR], and I guess I was pretty good at"* (P7).

Participants were motivated to engage in VR gaming for socialization, aligning with SOC principles. SST emphasizes prioritizing emotionally meaningful relationships as individuals age. Participants' enthusiasm and support for the VR gaming study highlight potential benefits for LTC residents and the importance of social support in promoting engagement. Technical assistance during the VR gaming experience was crucial, emphasizing the role of emotional support and guidance.

Individual preferences and challenges

This theme explores participants' preferences, challenges, and barriers in VR exergaming, including technical difficulties, physical limitations, and personal preferences for game features.

Participants' experiences were influenced by their interests and prior gaming experience. Some expressed enthusiasm to explore the full potential of VR: *"I would like to continue with VR and explore its capacity"* (P3, experienced gamer). Others, with less experience or health concerns, appreciated the exercise and novelty: *"Good exercise, concentration, focus, and challenge"* (P14, with comorbidities).

The gaming experience had some challenges for participants. Those without prior experience found the game setup and menu navigation difficult, hindering their engagement. Some participants, even after adjusting the speed, felt the game was too fast for their reflexes: *"Perhaps for an older person, it must be slower"* (P7). These challenges impacted their enjoyment and acceptance of the game.

The boxing game involved punching flying objects without button presses, but the controller buttons posed challenges for some participants. Accidental button presses interrupted the game, requiring extra effort to resume: *"I was happy to see how easy it was, except about the controllers. I never got master of those."* (P7) Additionally, some participants found the headset weight burdensome, further affecting their experience and interaction with the game.

Some participants prioritized health-related goals to maintain an active and enjoyable life: *"to keep a healthy and active life"* (P1) and *"to reach 100"* (P5) to spend time with grandchildren. The goals expressed by participants align with the SOC theory, as they actively select and optimize important goals while compensating for age-related limitations. These goals include maintaining physical activity, controlling blood sugar, and losing weight, reflecting their focus on health and well-being.

The participants in our study actively selected and optimized health-related goals, such as

maintaining physical activity and controlling blood sugar, while compensating for age-related limitations, aligning with the SOC theory. These goals were emotionally meaningful, contributing to their overall quality of life. Additionally, goals related to family time and fostering social connections within their living facility were consistent with the SST, highlighting the importance of social relationships and emotional well-being.

Staff Members' Themes- Determinants of VR acceptance by residents

The staff members' perspectives provided valuable insights into the factors influencing the acceptance of VR games among LTC residents. Being in frequent communication with the residents and involved in decision-making regarding recreational programs and physiotherapy practices, the staff members were aware of the residents' needs and preferences.

Relevance and personalization

Staff members stressed the importance of tailoring VR games to LTC residents' individual needs and interests for better acceptance. This involves designing games with relevant themes and user-friendly equipment. One staff member stated, "*Having whatever they see relevant to their lives may affect them here*" (S1). Participants' experiences support this approach, with one likening the game to the View-Master and another recalling positive memories while playing. VR gaming has the potential to evoke positive emotions and increase acceptance among older adults.

The relevance and personalization of VR games can be analyzed using TAM's perceived usefulness component. TAM highlights that perceived usefulness and ease of use determine technology acceptance. When games align with players' interests, they are seen as more useful,

increasing acceptance. Additionally, user-friendly equipment enhances ease of use, further promoting acceptance.

Training and guidance

Staff members highlighted the role that education and support from both family members and staff members play in the acceptance of VR games among residents. They emphasized the importance of educating LTC residents on the proper use and potential benefits of VR games. This education can help increase residents' understanding and familiarity with the technology, leading to higher acceptance and engagement.

They believed that family members could provide emotional support and act as a source of guidance and information, helping residents feel more comfortable and confident using VR games *“If you have a family that is very supportive of this project and trying this new thing, it would play a huge role.”* (P3). On the other hand, staff members can provide hands-on assistance and support during VR games, helping residents navigate the technology and troubleshoot any issues that may arise:

A staff member emphasized the need for researchers and staff to prioritize relationship-building when working with LTC facility residents, especially in research or implementing new technologies like VR. Due to the residents' vulnerability and unique perspectives, it is crucial to consider their specific needs. Older adults who are introduced to VR require trust and a sense of safety to fully embrace the new experience. This can be established through effective communication and comprehensive training provided by researchers: *“Taking that time to build those relationships because using a headset it’s like, virtual reality, it changes your reality, so you need to know that you are safe, somebody safe is there with you.”* (S4)

Staff members believed that educating LTC residents on the benefits of VR games and providing them with guidance can help increase their understanding and familiarity with the technology, leading to higher acceptance and engagement: *"It's just really a lot about education."* (P4). This aligns with the TAM model's emphasis on perceived usefulness as a key factor in technology acceptance.

Organizational and individual barriers

Staff members noted organizational and individual challenges that hinder the acceptance of VR games among LTC residents. These barriers, identified through interviews, can be categorized as affordability, equipment maintenance, and a shortage of staff to assist with VR headset usage and the individual barrier relates to health issues.

One significant organizational barrier is the cost of purchasing VR sets, which can limit availability and accessibility for LTC residents: *"How much does it cost for that technology? And then would the facility be able to buy it?"* (S1). Troubleshooting, equipment maintenance, and a shortage of staff assistance further hinder the implementation of VR gaming in LTC settings. Technical issues require specialized knowledge, and the limited availability of trained staff to assist residents with VR headset usage poses challenges: *"If it takes a long time to set up... whatever it is... But also troubleshooting. Because if there is a problem with it, I know the healthcare team doesn't have any time to really do it"* (S1).

Individual barriers encompass cognitive and physical health issues faced by LTC residents. Cognitive impairments, such as dementia or age-related decline, can hinder their comprehension and engagement with VR gaming: *"There are barriers with Dementia... your perception of reality might be disordered"* (S3). Mobility limitations can also impact their ability to interact with VR

equipment and participate in physical activities within the virtual environment: *"Maybe it's a ball game asking to the left, and the physical problem would be on the left arm. So, the difficulty would be how to reach the ball on time"* (S2).

The mentioned organizational barriers, including affordability, difficulties with equipment maintenance, and staff shortage, can be associated with the UTAUT model's construct of price value and facilitating conditions (Venkatesh et al., 2003). Individual barriers, such as physical and cognitive health issues, can be linked to the STAM model's constructs of physical functioning and cognitive ability (Chen & Chan, 2014).

Discussion

Participants in the study found the VR gaming experience enjoyable, citing the game's novel environment, fun nature, vibrant colors, immersion, and speed. PA played a crucial role, offering benefits like improved coordination, balance exercises, and upper-body workouts. Interacting with others during gameplay enhanced socialization, and the cognitive stimulation, problem-solving challenges, and improved hand-eye coordination and reaction time added to the positive experience. The VR game also facilitated improved social interactions with relatives outside the facility, providing an escape from pandemic-related stress and isolation. The participants successfully adapted to the technology, highlighting the importance of staff members' understanding of residents' needs and preferences when implementing personalized VR programs. Education and support from family and staff were identified as key factors for VR game acceptance. Organizational barriers encompassed the cost, troubleshooting and maintenance difficulties, and staff shortages associated with VR equipment usage.

The themes derived from the older adults' data drew upon social theories of aging, such as SOC

and SST, providing insights into how they prioritize activities and social connections while compensating for declines in other areas. On the other hand, the staff members' themes were rooted in technology acceptance models like TAM, STAM, and UTAUT. These themes explored the perceived usefulness, ease of use, and individual and organizational factors impacting acceptance. This indicates that older adults' experiences with VR technology are influenced by emotions and priorities, while staff members' perceptions focus on practical considerations like usefulness and ease of use.

Overall, this study found that the VR gaming experience was enjoyable for the participants, providing them with PA, social interaction, and cognitive stimulation. The study's findings suggest that VR technology may have the potential to enhance the lives of older adults living in LTC facilities, providing them with new opportunities for engagement and interaction. Further research is needed to explore the potential benefits of VR technology in this population and to develop interventions that can maximize its benefits.

This study provided a theoretical explanation for some of the experiences and benefits reported in the VR game study. Specifically, the use of social theories of aging and technology acceptance models helped to provide a deeper understanding of how older adults prioritize certain activities and social connections and how staff members perceive residents would accept VR technology.

Strengths and limitations

Our study addresses the gap in research on VR technology acceptance among older adults in LTC facilities. We examined both individual and social factors, uncovering dimensions not fully accounted for in existing acceptance models. Additionally, we explored the effects of VR on

physical activity and social interactions, revealing the potential benefits of integrating VR into their daily routines.

Our study has certain limitations that need to be acknowledged. The use of masks during data collection, necessitated by the COVID-19 pandemic, posed challenges for participants with hearing issues, potentially affecting the quality and validity of the data. The prolonged lockdowns and communication restrictions could have influenced participants' experiences and priorities, warranting consideration of the pandemic's impact. Furthermore, the study's focus on specific VR content restricts the generalizability of conclusions regarding VR technology and other VR games acceptance in the broader population.

Conclusion

Our study aimed to investigate older adults' attitudes towards a VR PA game and to identify the factors that influence their acceptance of this technology. We paid particular attention to both individual and social aspects that may have been overlooked in the existing models of technology acceptance.

We gained valuable insights into the participants' perceptions of the usefulness of VR technology, their experiences of immersion, and their feelings of comfort and safety while using VR technology. Our findings suggested that residents of LTC can benefit from VR gaming experiences, which provide physical, cognitive, social, and motivational benefits. These findings are in line with findings from Peng et al. (2011) and Skjæret et al. (2016) which demonstrate the benefits of VR games in facilitating PA and overcoming space or staffing limitations. Our study showed that older adults enjoy playing VR games and can adapt to new technologies with proper

guidance. Our findings highlighted the importance of knowledge of older adults' needs and preferences in designing and delivering VR programs that are personalized to the players.

In line with the studies conducted by Lin et al. (2018) and Chaze et al. (2022), our research emphasized the significance of ensuring a positive experience with VR technology. Older adults valued VR leisure activities that were fun, safe, and easy to engage with. Therefore, providing emotional and hands-on support, educating residents on the proper use and benefits of VR games, and establishing a sense of trust and safety are important for increasing their acceptance and engagement with the technology. These measures contribute not only to the promotion of PA but also to preventing mental issues associated with social isolation, which is especially relevant during a pandemic when physical isolation is prevalent. VR technology has the potential to provide an escape from stress and isolation, particularly during a pandemic, for people who are physically isolated, which can help prevent mental issues associated with social isolation.

Our study revealed that the themes derived from the data collected from older adults and staff members had different origins. Themes from older adults were derived from social theories of aging, including SOC and SST, whereas themes from staff members came from TAM models. The themes derived from the older adults' perspectives and experiences represented the challenges they face in accepting and using technology due to their age-related changes in physical, cognitive, and social functioning. On the other hand, the themes derived from the staff members' expertise in technology implementation and adoption represented the key factors that influence technology acceptance and use among older adults, as identified by the TAM models. The different origins can be attributed to the lack of integration of aging theories in the study of technology, highlighting the need for incorporating social theories of aging. By doing so, we can

gain a better understanding of how aging influences technology acceptance among older adults. Our study emphasized the significance of examining the experiences of older adults with technology through a lens of social theories of aging to identify the factors that affect their acceptance of technology. Incorporating social theories of aging can provide a comprehensive perspective on how older adults prioritize and value certain activities and social connections as they age and how they adapt to the changes that come with aging. This approach can help identify the factors that influence the acceptance of technology among older adults and inform the development of technology that better meets their needs and preferences.

Recommendations

This study contributes to the growing body of research on the use of VR in LTC facilities and provides practical implications for future research and implementation.

For future research

Future studies on technology acceptance among older adults should incorporate social theories of aging, such as SOC and SST, to gain a comprehensive perspective on the factors influencing their acceptance of technology. This approach will help identify their needs and preferences and inform the development of technology that better meets their requirements. Additionally, investigating how aging influences older adults' acceptance of technology through their experiences can provide valuable insights.

To successfully integrate VR gaming into the lives of LTC residents and understand the interaction between older adults and VR games, several areas of study are necessary. Exploring the long-term effects of VR gaming on physical activity levels, motivation, and mental health can determine its

overall impact on the well-being of older adults. Analyzing the impact of different types of music on gameplay and user enjoyment can create more tailored experiences. Moreover, investigating the potential of VR gaming as a form of physical therapy and exercise can help individuals increase their self-awareness of physical limitations.

The importance of social support in promoting engagement and acceptance of VR gaming among LTC residents is evident from our observations. Future studies should incorporate social support in their design and implementation to maximize the benefits for this population. Designing personalized and relevant VR games that appeal to LTC residents' interests is crucial. Educating and supporting both residents and their families to increase acceptance and engagement with VR games should be a focus. Establishing trust and safety when introducing new technologies and addressing organizational and individual barriers are essential considerations.

Finally, research should explore the potential of VR gaming as a tool to combat social isolation, a significant issue for many older adults. These areas of study can contribute to effective implementation of VR gaming in LTC facilities and improve the quality of life for older adults.

For Designers

To enhance the usability of VR games for older adults, designers can incorporate the following design principles. Firstly, the game's interface should be simple and intuitive, with easy-to-navigate menus, larger buttons and text, and clear instructions. This minimalistic design approach makes the interface more user-friendly. Secondly, the gameplay should be slow-paced, with longer intervals for each task, to prevent motion sickness and increase enjoyment. Thirdly, designers should limit the number of head and body movements required, considering that older adults may have difficulty with quick or extensive movements. Minimizing movement

requirements increases accessibility. Finally, offering customizable settings, such as adjustable brightness, contrast, speed, and text/button size, allows older adults to personalize the game to their needs and preferences. By incorporating these design principles, VR game designers can create games that are more usable and enjoyable for older adults.

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Supplementary Document S1- OLDER ADULTS INTERVIEW GUIDE

Interview Script

Background and purpose

Thank you for agreeing to participate in this interview for my thesis project on the acceptance of VR technology among residents of LTC facilities. Through this research, I explore the factors associated with the acceptance of new technologies to better understand the interaction between this group and technology.

This interview should take 30 minutes and will be audio-recorded so that I can more easily review the notes afterward.

General questions

- What do you think of the VR exercise game?
- How did you feel when you were playing the game?

Game preference questions

- What do you like about the game you played?
- What do you dislike about the game you played?
- Is this a game that you would like to continue playing?
- What is interesting about this game that would make you continue playing?
 - **If they said No:** How can we make it better/more interesting for you?
- How do you prefer to play? (Alone or with others)
- Does playing a game like this make you feel like you are exercising/ moving?
 - **If they said No:** Is it something about the game, your condition, ...?
- Prob questions: What stops you? Can you tell me? Why do you say that?

At this point, let me ask you do you want to add something? I have one more question to ask you. Let's talk about what kind of goals you have set for yourself. Do you have goals for yourself? If the answer is NO, the prob question would be, what about your health? Do you have hobbies? How about other activities and hobbies? E.g. doing puzzles, book clubs, knitting, and visiting grandchildren?

Thank you so much for your time. Sharing your experience and thoughts on VR gaming will help us to reach a better understanding of technology acceptance by seniors.

Supplementary Document S2- STAFF MEMBERS INTERVIEW GUIDE

1. Please briefly introduce yourself and your responsibility at this facility.
2. How often do you meet with residents?
3. Do you have any responsibility for making decisions for recreational and therapeutic activities or programming for residents? Yes: describe
4. Are you familiar with VR technology?
5. Yes: Please describe.
6. Do you think VR could be a good way to encourage residents to exercise?

What would you say are the potential benefits of VR tech for residents?

What do you think are the potential barriers to using VR technology with residents?

7. What are the factors that you think may affect the acceptance of VR among residents?
8. What are the factors that you think may affect the implementation of VR at the facility?
9. Are there any other things that you would like to tell me that might help our understanding of VR with this population?

CHAPTER 5: INTEGRATED DISCUSSION

The main purpose of my dissertation research was to explore factors that affect VR technology acceptance by LTC residents. To achieve this goal, I conducted two studies including a scoping review and a mixed-methods study. My two studies have yielded three manuscripts: (1) a scoping review on the application of VR games at LTC; (2) a quantitative manuscript including gaming and questionnaire components with LTC residents and tenants of LTC to investigate the factors that are associated with the acceptance of VR games by this group, with a particular emphasis on identifying social and individual factors; (3) a qualitative manuscript using semi-structured interviews to explore the individual experience of participants and examine the factors that influence the participants' experience in VR exergames.

In this final chapter, I first provide a summary of each study's findings in **Table 5.1**. Then I expand on the findings of the studies associated with my dissertation following the table. Next, I integrate the information from each study. Then, I discuss my study's implications for future research and design of VR gaming technology. After describing the strengths and limitations of this study, I provide a conclusion.

Table 5.1. Summary of Dissertation Findings

Overall purpose of dissertation: To identify the key factors influencing the acceptance of technology among older adults, focusing on individual and social factors. To explore the interaction between residents of LTC and VR games.			
	Study 1: Scoping review (Chapter 2)	Study 2: Gaming study (Chapter 3)	Study 3: Interview study (Chapter 4)
Objectives	To identify evidence on older adults' acceptance of PA VR games in LTC facilities, describe research designs used, define key acceptance concepts, and identify knowledge gaps for future research.	To investigate the factors associated with the acceptance of VR games among older adults living in LTC, with a particular emphasis on identifying social and individual factors that have been overlooked in existing technology acceptance models	To investigate how participants experience VR exergames and the meaning they associate with their participation. To examine the factors that influence the participant's experience in VR exergames and explore how these factors affect the overall experience.
Methods	Scoping review of 5 articles following Arksey and O'Malley's framework	A quantitative study, including VR gaming sessions, followed by a composite questionnaire including TAM models, SOC, and SST.	A qualitative study, including semi-structured interviews, following the principles of the interpretive description methodology.
Results/ Themes	<ul style="list-style-type: none"> - Two main approaches to the acceptance of VR exergames were identified: the presence and the extent of acceptance (three studies) and the effective factors on acceptance (two studies) - One study used a mixed-methods design and four studies used analytical methods (RCT, uncontrolled trial) and observational study (cross-sectional) - Reviewed studies did not provide clear definitions and a shared vocabulary for key concepts - Only two studies used technology acceptance models to study VR acceptance. 	<ul style="list-style-type: none"> - 20 older adults aged 65-95 (5 residents, 15 tenants) participated. - Moderate sedentary behaviour was observed - The majority had prior gaming experience - The experienced group exhibited higher mean scores in most SOC and SST subscales, except for elective selection. - Significant correlations were identified between perceived ease of use (PEU) and selection strategies and between attitudes towards gaming and elective selection strategies. - No significant differences were found in scores between male and female participants. 	<ul style="list-style-type: none"> - 19 Participants of a LTC were interviewed: 5 residents and 10 tenants, aged 65 to 93 years (8 female and 7 male) and four staff members. - Older adults' themes including (1) enjoyment, excitement, and the novel environment; (2) PA and motivation to exercise; (3) social connection and support; and (4) individual preferences and Challenges. - Three themes were developed based on the staff members' data including (1) relevance and personalization of the games; (2) training and guidance; and (3) organizational and individual barriers.
Findings and implications	<ul style="list-style-type: none"> - Validated acceptance questionnaires are needed in VR research. - Use of qualitative and quantitative methods can enhance understanding of 	<ul style="list-style-type: none"> - Participants found the technology useful and easy to use without experiencing elevated levels of anxiety related to gaming. 	<ul style="list-style-type: none"> - VR gaming experiences are enjoyable exciting, and novel for LTC residents and can provide physical, cognitive, social, and motivational benefits for them.

	<p>technology acceptance, alongside exploration of individual, environmental, and age-related factors.</p> <ul style="list-style-type: none"> - Detailed reporting of VR interventions are recommended to comprehend acceptance factors. 	<ul style="list-style-type: none"> - The users were likely to respond positively to focused and streamlined experiences. - VR exergames have potential benefits as a practical strategy for encouraging and supporting LTC residents to continue engaging in valued activities and pursuing goals. 	<ul style="list-style-type: none"> - Proper guidance and personalized programs can increase understanding and familiarity with VR, leading to a higher level of acceptance and engagement. - Social connection and support have a significant role in promoting acceptance and enjoyment of VR gaming among older adults.
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LTC: Long-term care PA: Physical activity VR: Virtual reality PEU: Perceived ease of use RCT: Randomized controlled trial TAM: Technology acceptance model SOC: Selective optimization with compensation SST: Socioemotional selectivity theory

Summary of Findings

Scoping Review (study 1)

Despite the proven benefits of physical activity in LTC facilities (Paterson & Warburton, 2010), residents exhibit lower levels of physical activity than those in the community (Weeks et al., 2008) due to factors such as health conditions and environmental limitations. Implementing technology, particularly VR exergaming, can address staffing shortages and improve person-centred care, but barriers such as lack of awareness, accessibility, and acceptance hinder integration. The potential of VR technology in promoting physical activity, health outcomes, and social engagement among older adults has been demonstrated (Peng et al., 2011). However, there is a lack of understanding regarding the factors influencing the acceptance and engagement of older adults with VR technology. The current VR interventions available for older adults do not adequately consider their interests and needs, and there is no universally accepted definition of technology acceptance in this context.

To address these gaps, my scoping review aimed to comprehensively explore the literature on the acceptance of physical activity VR games by older adults in LTC settings. The review had four objectives: (1) to identify the available evidence on older adults’ acceptance of VR games in LTC

facilities; (2) to describe the research designs used, including the utilization of validated acceptance questionnaires; (3) to define key concepts related to the acceptance of VR games; and (4) to identify knowledge gaps and proposing areas for further research.

I used the Arksey and O'Malley framework for this study. I drew the research data from published and unpublished journal articles between January 1, 2000, and May 31, 2023, in 13 electronic databases and supplementary sources for published articles and unpublished trials. Out of 1628 initial titles, five studies were included in this review based on specific criteria. I found low to high levels of VR acceptance among participants of the reviewed studies. Most studies employed an analytical design, particularly a randomized controlled trial (RCT), to assess acceptance. The studies followed two main approaches to the acceptance of VR exergames, including the presence and the extent of acceptance (three studies) and the effective factors on acceptance (two studies). Only Meekes & Stanmore's study (Meekes & Stanmore, 2017) used a validated questionnaire based on the technology acceptance model (TAM) to identify the factors influenced older adults' motivation to use exergames. They indicated that their participants found the exergame easy to use and showed positive attitudes towards the exergame. However, there is an inconsistency in definition and a shared vocabulary for key concepts related to acceptance, which limits comparability across studies in technology acceptance literature. To address this gap, it is recommended to adopt an integrated approach that combines qualitative and quantitative methods. Furthermore, leveraging technology acceptance models can provide valuable insights into the acceptance process. Another important finding was the lack of knowledge about the impact of contextual factors on acceptance. To address this gap, the utilization of social theories of aging was suggested, as they offer a framework to better

comprehend the contextual and individual factors that influence the acceptance of VR. Additionally, detailed reporting of VR interventions is recommended to comprehend acceptance factors.

Quantitative study (Study 2)

As the scoping review demonstrated, there is a gap in our knowledge of the factors influencing VR acceptance among older adults in LTC settings. To begin to address this gap, I investigated the factors associated with the acceptance of VR games among older adults in LTC, specifically identifying social and individual factors that have been overlooked in existing technology acceptance models. I used multiple theories in my theoretical framework, including the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), the Senior Technology Acceptance Model (STAM), the Selective Optimization with Compensation Theory (SOC), and the Socioemotional Selectivity Theory (SST). I had two hypotheses: (1) In accordance with SOC theory, individual acceptance of VR exergames will be positively correlated with the use of SOC strategies when accounting for age covariate; and (2) In accordance with SST theory, individual acceptance of VR exergames will be positively correlated with future time perceptions (FTP) in the VR game setting when accounting for age covariate.

I implemented a quantitative study design, which included VR gaming sessions followed by a composite questionnaire. The study involved twenty older adults aged 65 and older, consisting of 5 residents and 15 tenants. Significant positive correlations were identified between perceived ease of use and the selection (total), elective selection, and optimization strategies. Additionally, a significant correlation was found between the attitudes towards games (ATG) and elective selection strategies. The results supported the first hypothesis. The correlations indicated no

significant positive relationship between TAM subscales and FTP. Therefore, based on these findings, the second hypothesis, which suggested a relationship between acceptance of VR exergames and FTP, was not supported.

Participants displayed moderate sedentary behaviour, with the majority having prior gaming experience. The group with prior gaming experience demonstrated higher mean scores in most subscales of SOC (except for elective selection), suggesting that prior gaming experience may contribute to a more intentional and strategic approach to using modern technologies like VR. Experienced participants also had higher SST scores, indicating that prior experience may be associated with higher FTP. Additionally, participants with prior experience exhibited higher game self-efficacy scores, indicating a greater confidence in using modern technology and higher hedonic motivation scores, suggesting greater enjoyment of VR games. I accounted for age as a covariate to examine the potential effect of age on relationship between acceptance and these strategies. The findings suggested that the use of SOC and SST strategies is not associated with advanced age, which is consistent with findings from other studies (Zajac-Lamparska, 2021). There were no significant differences in scores between male and female participants.

Participants found the technology useful and user-friendly, with no significant increase in gaming-related anxiety. The significant correlation between participants' attitudes towards the game and elective selection suggests that they have a positive attitude toward aging and assign priority to undertake new, physically demanding activities like VR game playing. These findings emphasize the potential advantages of VR exergaming as a practical approach to motivating and supporting LTC residents in their engagement with meaningful activities and pursuing personal goals. On the other hand, I did not observe a significant relationship between FTP and technology acceptance

which suggests that the participants may not have identified VR gaming with self-improvement goals. Since I did not analyze their performance, it is possible that participants who had more FTP performed better than others. Further investigation is warranted by this finding. The results suggest that social theories of aging can contribute to the understanding and prediction of technology acceptance among older adults in LTC, thereby guiding the development and promotion of VR exergames that better align with the needs and preferences of this population.

Qualitative Study (Study 3)

A research gap exists in understanding the individual and contextual factors that drive older adults in LTC facilities to accept technology. By addressing these motivational factors, inclusive VR technology can be designed to effectively meet their needs and promote improvements in physical activity and well-being. The primary objectives of this qualitative research were: (1) to investigate participants' experiences and the significance they associate with engaging in VR exergames and (2) to examine the factors that influence participants' experiences in VR exergames and explore the subsequent impact on their overall engagement.

To achieve these objectives, I employed the Interpretive Description methodology. The theoretical foundations of this study were underpinned by SOC, SST, and TAM. Semi-structured interviews were conducted with 19 participants from an LTC facility, including five residents, ten tenants aged 65 and 93 years (eight females and seven males), and four staff members. The interviews, ranging from 15 to 30 minutes, were transcribed verbatim, and a thematic analysis was employed to analyze the collected data.

Based on the responses of older adults, I identified four thematic areas that encapsulated their unique experiences with VR gaming: (1) enjoyment, excitement, and the novel environment; (2)

physical activity and motivation to exercise; (3) social connection and support; and (4) individual preferences and Challenges. Additionally, I developed three themes from the insights provided by staff members to capture their perspective on the factors that influence the acceptance of VR among LTC residents, including (1) relevance and personalization of the games; (2) training and guidance; and (3) organizational and individual barriers.

My findings indicated that VR gaming experiences are highly enjoyable, exciting, and novel for LTC residents, offering potential benefits in terms of physical, cognitive, social, and motivational aspects. Effective guidance and personalized programs can enhance understanding and familiarity with VR, fostering higher acceptance and engagement levels. Integrating social theories of aging enables a deeper understanding of how age-related changes impact technology acceptance among older adults. This approach can significantly inform technology development that caters to their needs and preferences better.

INTEGRATED DISCUSSION

After summarizing the main findings of each study, I now integrate the results from the various parts of this dissertation research regarding the acceptance of VR among LTC residents. Additionally, particular emphasis is placed on the specific contributions each research study makes within the context of my research. These themes include the findings from the scoping review and the quantitative and qualitative studies conducted as parts of the research:

5.1 Positive Attitudes and Acceptance of VR Technology

This theme is a key finding that emerged from the scoping review and the quantitative and qualitative studies. This theme suggests that older adults generally have a favourable perception of VR technology and are willing to embrace it as a therapeutic tool and exergame.

The quantitative study provided empirical evidence supporting this theme by revealing that most participants had prior gaming experience. This finding is significant because it suggests that older adults familiar with gaming may be more receptive to VR technology. Their previous exposure to gaming may have reduced barriers and skepticism associated with adopting new technologies, enabling them to approach VR with a positive attitude. This positive attitude likely contributed to their overall acceptance of VR technology and willingness to engage. This finding aligns with Line et al. findings (C. X. Lin et al., 2018). They found that using a VR system provided significant benefits and enhanced older adults' emotional and social well-being.

The qualitative study further enriched my understanding of this theme by exploring the subjective experiences and perceptions of older adults using VR technology. The study highlighted the enjoyable and immersive nature of the VR gaming experience, which participants reported. The participants described excitement, engagement, and feeling immersed in a different virtual world while playing the VR game. These positive experiences align with previous research on the enjoyment and immersion factors contributing to technology acceptance among various age groups.

The presence of positive attitudes and acceptance of VR technology among older adults has important implications. It suggests that older adults are open to exploring and utilizing new technologies, including VR, as part of their therapeutic and recreational activities. This finding challenges the stereotype that older adults are resistant to technology or find it difficult to adapt to innovations (Peine & Neven, 2019). Instead, it highlights the potential for older adults to embrace technology to enhance their well-being, cognitive stimulation, and social interaction.

Understanding the positive attitudes and acceptance of VR technology among older adults can inform the development of interventions and programs that address their needs and preferences. It underscores the importance of providing access to VR technology in various settings, including LTC facilities, community centers, and homes for older adults. By incorporating VR into their care and recreational programs, these settings can offer engaging and stimulating experiences that promote physical and cognitive health, social connections, and overall quality of life.

Furthermore, the positive attitudes towards VR technology observed in my study can serve as a foundation for future research and innovation. Researchers and developers can build upon this acceptance and work towards refining VR applications specifically tailored to the needs and interests of older adults. Positive attitudes and acceptance can be further enhanced by addressing potential barriers, such as physical limitations or unfamiliarity with technology.

To sum up, all three studies of my dissertation collectively highlighted that older adults demonstrate positive attitudes and acceptance towards VR technology. Their prior gaming experience and the attractive nature of the VR game contributed to this favorable perception. These findings challenge the stereotype of older adults being resistant to technology and emphasize their openness to embrace VR as a therapeutic and recreational tool. The implications of this acceptance include the development of tailored interventions and programs that cater to the needs and preferences of older adults, as well as the potential for future research and innovation in refining VR applications for their specific needs. Overall, understanding and harnessing the positive attitudes and acceptance of VR technology among older adults can lead

to enhanced well-being, cognitive stimulation, social interaction, and quality of life for this population.

5.2 Potential Benefits of VR Technology

The theme of potential benefits of VR technology for older adults emerged from the scoping review and the qualitative study, indicating that VR technology may offer numerous advantages in promoting the well-being and overall health of older adults.

The scoping review and qualitative study collectively provided a comprehensive understanding of the potential benefits of using VR technology among older adults. The scoping review offered an overview of the existing literature, highlighting the advantages associated with VR technology in this population. Additionally, the qualitative study contributed by exploring the experiences of older adults who engaged in VR gaming.

The qualitative study aligned with the scoping review's findings, as it revealed that participants reported various positive outcomes resulting from playing VR games. These outcomes include cognitive stimulation, social interaction, and improved hand-eye coordination and reaction time. These findings suggest that VR technology has the potential to offer cognitive and physical benefits to older adults by challenging and exercising their cognitive skills and motor functions. This alignment supports and reinforces the conclusions drawn by Dwivedi et al., further strengthening the evidence regarding the advantages of VR technology for older adults (Dwivedi et al., 2018).

These findings are common areas discussed in Eisapour et al. (Eisapour et al., 2020) and their exploration of the potential benefits of VR-based interventions in enhancing physical activity levels and overall engagement among older adults living with dementia. The immersive nature

of VR experiences may help older adults maintain and improve their cognitive abilities while also promoting physical activity and coordination.

Furthermore, the qualitative study illustrated the potential for VR technology to improve eye-hand coordination and balance. This finding suggests that VR technology could be utilized in rehabilitation programs or as a tool for physical therapy for older adults. VR technology can help older adults improve their motor skills, coordination, and balance in a safe and controlled environment by providing an interactive and engaging platform.

In addition to uncovering new knowledge about the physical benefits of VR technology, my dissertation has shed light on the overlooked social benefits it offers for older adults. Through the qualitative study, it became evident that VR gaming experiences provided participants with more than just physical engagement. They expressed enjoyment in the social interactions that were facilitated during these gaming sessions. They appreciated the potential of VR gaming to allow them to connect with loved ones and spend time with friends, both in-person and online. These findings are significant as they demonstrate that VR has the potential to address prevalent issues of social isolation and loneliness among older adults. By fostering social interaction and creating a sense of community, VR technology can contribute to enhancing the overall well-being and quality of life of older adults.

5.3 Role of contextual factors

The role of contextual factors is informed by the findings from all three studies. The scoping review highlighted a significant gap in the literature examining contextual factors concerning VR technology acceptance among older adults in LTC facilities. Despite the acknowledged impact of contextual factors on residents' attitudes and behaviors (Ling & Xu, 2020), the reviewed studies

paid limited attention to these factors. This indicates a need for more comprehensive research considering the specific LTC facility setting, staff attitudes and knowledge, organizational barriers, and resident preferences and needs. By understanding the contextual factors that influence VR technology acceptance, interventions and strategies can be tailored to address these factors and enhance the likelihood of successful implementation.

The quantitative study demonstrated how social theories of aging can provide insights into behaviours that enhance the adaptation process in aging. This study found a significant correlation between individual acceptance of VR exergames and the use of SOC strategies. This correlation indicates that older adults who employ SOC strategies may be more likely to accept and engage with VR technology. SOC strategies refer to the adaptive mechanisms that individuals use to optimize their functioning and compensate for age-related changes or limitations. By utilizing these strategies, older adults may be better equipped to navigate the challenges and complexities associated with VR technology, thereby enhancing their acceptance of such interventions.

The qualitative study further addressed the gap in the literature by exploring the role of contextual factors, specifically focusing on residents' and staff members' experiences and perspectives within the LTC facilities. The study highlighted the importance of staff members' knowledge, support, and organizational barriers in accepting VR games among residents. Staff members indicated that being knowledgeable about the technology and its potential benefits enables them to support and encourage residents' engagement with VR technology. On the other hand, organizational barriers, such as limited resources or competing priorities, could hinder the successful integration of VR technology into the LTC facility.

Understanding and addressing these contextual factors are crucial for designing effective interventions and promoting technology acceptance among LTC residents. In the study of VR game acceptance among older adults in LTC facilities, the concept of situated acceptance (Bobillier Chaumon, 2021) is important. Situated acceptance underscores that the adoption of technology is intricately linked to the unique context and environment in which it is implemented. This aligns seamlessly with the integration of social theories of aging, such as SOC and SST, which delve into the social and psychological dynamics of aging individuals. By acknowledging the role of situated acceptance, the study recognizes that older adults' acceptance of VR technology is context-dependent, influenced by factors specific to their LTC environment. The availability of social support, relevance of the technology to their needs, and overall LTC facility dynamics play vital roles in shaping their acceptance of VR games.

By involving staff members in the implementation process and providing them with the necessary knowledge and support, the acceptance of VR technology can be improved. Additionally, addressing organizational barriers, such as resource allocation and prioritization, is essential for successfully integrating VR technology into LTC facilities.

Considering the preferences and needs of residents is also important in enhancing the acceptance of VR technology. Factors such as individual interests, physical and cognitive abilities, and previous experiences with technology should be considered when exploring the acceptance of VR and designing VR interventions for older adults in LTC facilities. By tailoring the VR experiences to align with the unique characteristics and preferences of the residents, the likelihood of acceptance and engagement can be increased.

In conclusion, my dissertation contributes to the literature by uncovering new knowledge about the role of individual and contextual factors in the acceptance of VR technology among older adults in LTC facilities. The scoping review revealed a gap in the literature regarding the examination of contextual factors specific to LTC settings, emphasizing the need for comprehensive research in this area. The quantitative study highlighted the importance of social theories of aging, demonstrating a correlation between individual acceptance of VR exergames and the use of strategies that optimize functioning and compensate for age-related changes. The qualitative study further addressed the gap by exploring the perspectives of residents and staff members within LTC facilities, emphasizing the impact of staff knowledge, support, and individual and organizational barriers on VR technology acceptance. By understanding and addressing these contextual factors, interventions and strategies can be tailored to enhance technology acceptance among LTC residents.

5.4 Need for a Clear Definition of Key Concepts

This theme derived from the scoping review and shed light on the inconsistent use and understanding of terms related to VR acceptance in the existing literature. This lack of clarity may arise from various factors, including limited knowledge of technology acceptance models, researchers' adoption of alternative theoretical frameworks, or an interventionist logic that posits new technologies as interventions or solutions to the “problems” of aging. This logic reinforces a division between aging scholars and technology scholars and retards the development of theories of aging and technology. In many technology projects, older adults are considered as being not interested in and familiar with the technology. This assumption stems

from aging scholars' failure to provide a description of aging with technology and frames acceptability problems as results of older people's technology-skepticism (Peine & Neven, 2019). The scoping review emphasized the importance of establishing a precise and shared understanding of key concepts within the field of VR acceptance. Without a clear and standardized definition, there is a risk of confusion, which can hinder research progress and limit the comparability of findings across studies. To address this issue, the review suggests adopting established models such as TAM to define and study key concepts. The TAM provides a comprehensive and widely accepted theoretical foundation for understanding technology acceptance and usage behaviour. By aligning with established models, researchers can enhance their findings' reliability, validity, and comparability.

In summary, this theme has highlighted the importance of establishing a clear definition of key concepts in VR acceptance. Inconsistencies in understanding and usage hinder research progress and comparability across studies. Adopting established models like TAM can enhance reliability and comparability. This contributes to advancing theories of aging and technology.

5.5 Gender-based analysis

Research has demonstrated that gender is a significant factor affecting technology use, with older women lagging behind older men in adoption of technology (Smith, 2014). Employing a life-course perspective explains this gap and offers insights into the difference in experiences, responsibilities, and opportunities over the course of individuals' lives (Kim et al., 2016). Despite the importance of gender differences in technology acceptance, none of the reviewed articles in the scoping review included a gender-based analysis to explore potential differences in the rates and influencing factors on acceptance between male and female participants in LTC facilities.

I conducted a gender-based analysis in my quantitative study to address this gap. I found no significant differences in technology acceptance rates and influencing factors between male and female participants in the LTC facility; that is an important finding to highlight. The study's finding suggests that, in the specific context of LTC facilities, gender may not play a significant role in determining technology acceptance among residents. This indicates that male and female residents will likely have similar attitudes and behaviours towards technology use in LTC settings. While gender differences in technology acceptance have been observed in other contexts, such as general population studies or specific domains, the unique environment of LTC facilities may minimize or mitigate these differences. Factors such as the shared living environment, common health challenges, and similar social connection and support needs may contribute to a more homogeneous technology acceptance landscape regardless of gender.

However, it is important to note that even if the study did not find significant gender differences, it does not necessarily mean no variations. The sample size and characteristics of the participants and the specific technologies examined could impact the study's ability to detect smaller gender-based differences. Future research with more diverse samples could provide further insights into potential gender-related nuances in technology acceptance within LTC facilities.

In conclusion, my dissertation has made contribution to the literature by conducting a gender-based analysis within the context of LTC facilities, addressing a gap in previous research. The findings indicate that there were no significant differences in technology acceptance rates and influencing factors between male and female participants in these facilities. This suggests that, within LTC settings, gender may not play a prominent role in determining technology acceptance among residents. The unique environment of LTC facilities, characterized by shared living,

common health challenges, and similar social connections and support needs, may contribute to a more homogeneous technology acceptance landscape regardless of gender.

5.6 Application of Social Theories of Aging and Technology Acceptance Models

By incorporating social theories of aging into the theoretical framework of this mixed-methods study, I explored and captured the social aspects of VR gaming acceptance among older adults. The themes derived from the qualitative study, grounded in SOC and SST, shed light on the enjoyment, social interaction, and cognitive stimulation experienced by older adults during VR gaming. These findings further emphasize the relevance of social factors in understanding technology acceptance among older adults in LTC facilities.

The qualitative study showed the application of social theories of aging, specifically the SOC theory and SST, and TAM models in understanding older adults' perspectives on and acceptance of VR technology. The SOC theory posits that as individuals age, they adapt to the changes and losses associated with aging by selectively focusing on specific goals, optimizing their resources to achieve them, and compensating for any declines in other areas. In the context of the study, the SOC theory helped explain how older adults prioritize certain activities and social connections, potentially using VR technology to compensate for limitations or losses in physical mobility or social interactions. This theoretical framework provided insights into the motivations and goals that older adults might have when considering the adoption of VR technology in LTC facilities.

SST suggests that as people age, they become more focused on fulfilling emotional and meaningful goals, such as seeking social connections and maintaining positive relationships. This theory helps explain why older adults in LTC facilities may value VR technology for its potential

to facilitate social interactions and provide meaningful experiences, even in the face of physical limitations. By incorporating SST, the qualitative study shed light on how VR technology could address older adults' emotional and social needs, contributing to their overall well-being.

Furthermore, my study applied TAM, a widely used framework for understanding individuals' acceptance and adoption of technology. TAM considers two key factors: perceived usefulness (the extent to which individuals believe technology will enhance their performance or make tasks easier) and perceived ease of use (the degree to which individuals perceive technology as effortless and user-friendly). By examining staff members' perceptions of technology acceptance, the study highlighted the practical considerations that influence their attitudes towards VR technology, such as its perceived usefulness in improving resident care or easing their work responsibilities, as well as the ease of use in implementing and managing the technology within LTC facilities.

The findings from the quantitative study suggest that the use of social theories of aging in studying the acceptance of technology by older adults in LTC facilities provides valuable insights. The findings indicate that the experience group showed a higher mean score for SST than the no-experience group. This suggests that prior gaming experience may be associated with an extended FTP when playing VR technology, and they are more likely to have greater confidence in modern technology and employ deliberate strategies to enhance their technology usage. This aligns with SST principles, which emphasize older adults' motivation to use technology for entertainment and social purposes. The positive correlation between using SOC strategies and accepting VR exergames suggests that older adults respond favourably to focused and streamlined experiences. Additionally, the significant correlation between perceived ease of use

(PEU) and selection strategies indicates that individuals who find VR exergames easy to use are more likely to employ selection strategies when using them. These findings highlight the relevance of social theories of aging in understanding the factors influencing technology acceptance among older adults in LTC facilities and their potential to bridge the gap between technology acceptance models and theories of aging (Birren & Bengtson, 1988). Moreover, the findings can inform the design and marketing of VR exergames to better meet their needs and preferences

The integrated discussion of my three studies suggests that VR technology has the potential to be well-accepted and beneficial as a therapeutic tool and exergame for older adults in LTC settings. The scoping review, quantitative study, and qualitative study provide complementary perspectives on the acceptance of VR technology among older adults in LTC settings. Overall, the findings from these studies are complementary, highlighting the potential benefits and positive attitudes towards VR technology among older adults.

The scoping review identified studies that reported positive attitudes and acceptance of VR technology among older adults in dependent and independent settings. These findings align with the qualitative study, where participants reported finding the VR gaming experience enjoyable, highlighting its benefits in physical activity, cognitive stimulation, and social interaction. The qualitative study further emphasized the potential of VR to provide a sense of escape from stress and isolation, which complements the scoping review's recognition of VR as a valuable addition to the care and well-being of older adults in LTC facilities.

While the scoping review reported a gap in our knowledge about measuring VR acceptance, the quantitative study provided insights into the characteristics and attitudes of older adults towards

VR technology. The findings showed that participants with prior gaming experience scored higher in technology acceptance measures, suggesting a positive association between gaming experience and the acceptance of VR technology. Additionally, the quantitative study highlighted the positive relationship between the acceptance of VR exergames and the use of SOC strategies, indicating that individuals who embrace VR exergames are willing to engage purposefully with the technology.

In conclusion, the findings from the scoping review, quantitative study, and qualitative study are aligned with each other, indicating that VR technology has the potential to be well-accepted and beneficial for older adults in LTC settings. The studies collectively highlight the positive attitudes, enjoyment, physical activity, cognitive stimulation, and social interaction associated with VR gaming among older adults. While there may be some variations in the findings, they can be viewed as complementary, contributing to a comprehensive understanding of VR technology's acceptance and potential benefits for older adults in LTC facilities. Future research should address the identified limitations and further explore the impact of VR technology on the quality of life for older adults in LTC facilities. Additionally, personalized programs, guidance, and support from family and staff members should be considered in facilitating acceptance and engagement with VR technology among older adults.

Implications for Research

The successful integration of VR technology in LTC facilities not only addresses immediate concerns related to physical activity but also has broader implications in research. This transformative shift towards innovative and person-centered approaches creates opportunities to explore new avenues in understanding the factors influencing technology acceptance among

older adults. By actively incorporating social theories of aging and investigating the long-term effects of VR gaming on various aspects, future research can contribute to the development of tailored VR experiences that enhance overall well-being. Furthermore, exploring the potential benefits of VR technology for specific subgroups of older adults and conducting comparative studies can establish an evidence base for integrating VR into standard care protocols, advancing our understanding of its applications for older adults in LTC settings.

Future research on technology acceptance among older adults should consider incorporating social theories of aging, such as SOC and SST, to understand the factors influencing their acceptance of technology. By examining the experiences of older adults with technology through the lens of social theories of aging, researchers can identify how aging influences their technology acceptance and inform the development of technology that better meets their needs and preferences. Moreover, future studies should explore the long-term effects of VR gaming on physical activity levels, motivation, and mental health among older adults, as well as the impact of different types of music on gameplay and user enjoyment. Understanding these factors can contribute to developing tailored VR experiences that enhance the overall well-being of older adults. Additionally, investigating the potential of VR gaming as a form of physical therapy and exercise for older adults can provide valuable insights into increasing self-awareness of physical limitations.

The study's findings showed the importance of social support in promoting engagement and acceptance of VR gaming among LTC residents. Future research should consider including social support in the design and implementation of VR gaming interventions to maximize their benefits for this population. Designing personalized and relevant VR games that appeal to LTC residents'

interests and exploring effective methods of educating and supporting both residents and their families are crucial areas for future investigation. Building trust and safety when introducing new technologies to LTC residents and addressing organizational and individual barriers that may affect the acceptance of VR are also important research areas. Furthermore, the potential of VR gaming as a tool to combat social isolation among older adults should be explored. By addressing these areas of study, researchers can better understand how to effectively implement VR gaming in LTC facilities and improve the quality of life for older adults.

Future studies should address the limitations identified in the current studies to further advance research in this field. Longitudinal studies assessing the long-term effects of VR technology on older adults' well-being and quality of life in LTC settings would provide valuable insights. Investigating the specific factors contributing to the positive attitudes and acceptance of VR technology among older adults can help researchers understand the underlying mechanisms and design interventions to enhance the adoption and usage of VR in LTC facilities. Furthermore, research should explore the potential benefits of VR technology for specific subgroups of older adults, such as those with cognitive impairments or mobility restrictions, to develop inclusive and effective interventions tailored to their unique needs and challenges. Comparative studies comparing the effectiveness of VR technology to traditional therapeutic approaches can also establish an evidence base for integrating VR into standard care protocols for older adults in LTC settings. By addressing these implications for research, future studies can contribute to a deeper understanding of the potential benefits and applications of VR technology for older adults in LTC settings.

Implications for Design

To enhance the usability, effectiveness, and acceptance of VR games for older adults, designers can consider incorporating various design principles and strategies. Firstly, the game's interface should be simple, intuitive, and user-friendly, with easy-to-navigate menus, larger buttons and text, and clear instructions. This minimalistic design approach can facilitate ease of use for older adults. Additionally, designers should ensure slow-paced gameplay, allowing longer intervals between tasks to prevent motion sickness and increase enjoyment. It is important to minimize the number of head and body movements required to play the game, considering the potential limitations of older adults regarding mobility. By reducing the movement requirements, designers can enhance accessibility for this population. Moreover, providing customizable settings such as adjustable brightness, contrast, speed, and text and button size can enable older adults to personalize the game according to their individual needs and preferences. By incorporating these design principles, VR game designers can create games that are more usable and enjoyable for older adults and tailored to their specific requirements.

In addition to the design principles, there are several implications for VR designers based on the study's findings. Firstly, designers should adopt user-centred design approaches, involving older adults in the design process and incorporating their feedback to ensure the technology meets their expectations and requirements. This participatory approach can enhance the relevance and usability of VR applications for older adults. Secondly, designers should prioritize creating intuitive and user-friendly interfaces accessible to older adults with varying levels of technological literacy. Clear instructions, simplified navigation, and larger text and visual elements can enhance the usability of VR applications for this population. Thirdly, customization

and personalization options should be incorporated into VR systems to accommodate individual preferences and abilities. This can include adjustable difficulty levels, varied content, and adaptable user interfaces to cater to diverse cognitive and physical capabilities. Fourthly, considering the social nature of aging, designers should explore ways to incorporate social interaction features into VR applications. This can include multiplayer modes, virtual communities, or opportunities for shared experiences among older adults, fostering social connections and reducing feelings of isolation. Lastly, designers should prioritize the safety and comfort of older adults when designing VR experiences, considering ergonomic factors, minimizing motion sickness, and ensuring that the technology does not pose physical or cognitive risks to users.

By incorporating these recommendations into their practices, VR designers can create more inclusive and effective VR applications for older adults, addressing their specific needs, preferences, and challenges. This user-centred approach, along with the integration of design principles such as simplicity, customization, and social interaction, can contribute to developing VR experiences that enhance older adults' well-being and quality of life.

Future Directions

While my study has contributed to unraveling the complexities of VR acceptance among older adults in LTC facilities, several questions remain. Key questions for future research include:

Contextual Factors

Examining the influence of specific contextual factors, such as organizational culture within LTC facilities, on the sustained acceptance of VR technology among older adults is a crucial area for

future research. Understanding the role of resident preferences in shaping the impact of these technologies over time will provide insights into optimizing the integration of VR in LTC settings.

Rehabilitation Programs

Future research should focus on customizing interventions within rehabilitation programs that utilize VR exergaming to address the diverse needs of older adults in LTC settings. Identifying specific elements contributing to the effectiveness of these programs in enhancing overall well-being will pave the way for more tailored and impactful interventions.

Long-term Acceptance

Exploring the factors influencing the long-term acceptance and sustained engagement of VR technology among older adults in LTC facilities is essential. Investigating how interventions can be adapted to meet evolving needs and preferences over an extended period will contribute to the development of strategies that ensure lasting positive outcomes.

Involvement of Older Adults

Proposing future directions, researchers should explore methods to enhance the active involvement of older adults in the co-design and development of VR exergaming interventions. Strategies aimed at aligning these technologies with the unique needs, preferences, and lived experiences of older adults in LTC settings should be a focal point of research. Adopting participatory design methodologies and conducting usability studies can be instrumental in achieving this goal.

By addressing these questions, researchers can further advance our understanding of the acceptance and potential benefits of VR technology for older adults in LTC facilities, ultimately contributing to the development of more effective and person-centered interventions.

Strengths and Limitations

My mixed-methods study employed qualitative and quantitative approaches, offering a comprehensive examination of the potential of VR gaming as a technology-based intervention in LTC settings. The integration of these approaches provided a well-rounded understanding of the experiences and perceptions of older adults regarding VR technology acceptance, as well as its impact on physical activity levels and social interactions. Using validated measures in the quantitative study contributed to a deeper understanding of VR acceptance and its association with aging-related theories. The qualitative study, on the other hand, shed light on the subjective and experiential aspects of technology acceptance and highlighted the potential benefits of incorporating VR technology into the daily routines of LTC residents.

However, there are some limitations associated with my study that need to be acknowledged. I administered the questionnaires after each session to avoid exhaustion and boredom. However, the order in which the questionnaires were administered in the quantitative study is a potential limitation that could have influenced participant responses. The administration of questionnaires may have introduced bias or fatigue, as the previous day's questions could have influenced participants or may have experienced mental fatigue from the extended assessment process. This could have impacted their responses and potentially skewed the results.

Another limitation of the study is the inclusion of highly educated participants, which may limit a wide range of perspectives from being included. Highly educated individuals tend to have

higher levels of technological familiarity and acceptance, which may not accurately represent the broader population of older adults living in LTC settings. People with lower levels of education or less technological familiarity may have different perceptions and experiences regarding VR technology acceptance. Therefore, the study's findings may not fully capture the perspectives and behaviours of older adults with diverse educational backgrounds or varying levels of technological literacy.

My study faced limitations due to the COVID-19 pandemic. The facilities guidelines required wearing a mask and eye protection goggles while conducting the gaming sessions and interviews. This might have impacted communication with participants who had hearing issues and relied on lip reading to comprehend others, potentially affecting their performance and the quality and validity of the data collected. The pandemic's long-time lockdowns and communication restrictions may have also influenced participants' experiences and priorities, emphasizing the need to consider these contextual factors when interpreting the findings. The pandemic-induced restrictions may have increased the desire for social connections and interactions among older adults. Therefore, this heightened need for social connection may have influenced their acceptance and engagement with VR gaming, which offers opportunities for virtual social interactions. Similarly, the importance of physical activity and well-being may have been amplified during the pandemic due to the restrictions on outdoor activities and limited access to exercise facilities. As a result, participants' perceptions of VR gaming to promote physical activity and well-being may have been influenced by the unique circumstances of the pandemic.

Furthermore, the study focused solely on VR gaming. It did not explore other types of VR content, which limits the ability to draw definitive conclusions about the acceptance of other applications for VR technology.

Despite these limitations, this mixed-methods study provides valuable insights into the acceptance and potential benefits of VR gaming for older adults in LTC settings. VR design has various implications, such as considering specific needs and preferences, creating user-friendly interfaces, incorporating customization options, and integrating social interaction features. Additionally, prioritizing safety and comfort in VR design provides actionable guidance for future VR design endeavours. By acknowledging the limitations and leveraging the study's strengths, researchers can further advance the understanding and effective utilization of VR technology as a therapeutic tool and exergame for older adults in LTC settings.

Conclusion

There is a need for a deeper understanding of factors that affect technology acceptance among the growing population of older adults residing in LTC settings. Aiming at addressing this gap, this mixed-methods study revealed valuable insights into the acceptance and potential benefits of VR gaming for older adults in LTC settings. By combining three studies, this dissertation has generated new knowledge about older adults' positive attitudes and acceptance of VR technology. The methodological advancements, such as the comprehensive scoping review, the application of technology acceptance mode and social theories of aging, and the integration of quantitative and qualitative approaches have improved the validity and breadth of the findings. These research findings provide a foundation for future studies and innovations that refine VR applications to meet the specific needs and interests of older adults. Ultimately, these

advancements aim to enhance well-being, cognitive stimulation, social interaction, and overall quality of life for this population.

The qualitative study shed light on the participants' attitudes, experiences, and preferences regarding VR technology acceptance. It highlighted the importance of personalized and user-friendly design, emotional and hands-on support, and establishing trust and safety to enhance acceptance and engagement among older adults. The qualitative findings also emphasized the potential of VR gaming to promote physical, cognitive, social, and motivational benefits, providing an escape from stress and isolation, particularly during a pandemic.

The quantitative study provided data on the acceptance of VR gaming among older adults. It revealed that many participants engaged in weekly gaming activities, with prior gaming experience associated with higher acceptance levels. The findings suggested that VR gaming was perceived as useful and easy to use without causing stress or anxiety. The quantitative results also highlighted the association between technology acceptance and aging-related theories, as SST and SOC strategies. The positive correlations between VR acceptance, the use of selection strategies, and the positive attitude towards VR gaming indicated the potential of VR gaming in promoting purposeful engagement and enjoyable experiences among LTC residents.

Overall, the integrated findings of the mixed-methods study provided a comprehensive understanding of the acceptance and potential benefits of VR gaming for older adults in LTC settings. They underscore the importance of considering technology acceptance's individual and social aspects, incorporating personalized design, providing support and education, and ensuring trust and safety. The study also emphasizes the need to integrate social theories of aging into the

study of technology acceptance among older adults, as it can provide a more comprehensive perspective on their needs, preferences, and adaptive processes.

The implications of this study extend to VR design, highlighting the importance of user-centred design approaches, intuitive interfaces, customization options, social interaction features, and safety considerations. By addressing the limitations of the study, such as small sample size, potential bias or fatigue from questionnaire administration, and the need for broader inclusion of educational backgrounds, future research can further advance the effective utilization of VR technology as a valuable therapeutic tool and exergame for older adults in LTC settings.

Contribution of Collaborators

Collaborators' contributions to the research process are discussed in this chapter as members of the team, co-authors of manuscripts, and contributing individuals.

Research team collaborators

As the primary investigator, I conceptualized, led, and participated in all research activities included in the studies associated with this dissertation, in partial fulfillment of the requirements of the degree of Doctorate in Philosophy at the University of Ottawa. All collaborators were carefully chosen based on their specialized research knowledge, their potential to apply the research findings as knowledge users, and their ability to contribute to the development of novel insights through an interdisciplinary approach.

I am a PhD candidate in Rehabilitation Sciences, and my academic background includes a degree in Social Sciences with a focus on Communication Sciences and new technologies for older adults. I received the University of Ottawa Admission Scholarship and have been granted funding through Dr. Jeffrey Jutai's research grants. Furthermore, I have served as a teaching and research assistant at the University of Ottawa, contributing to the academic community.

This research had several collaborators, namely my supervisors and thesis advisory committee members (Table 5.2).

Jeffrey Jutai (JJ) is a Full Professor in the faculty of Health Sciences at the university of Ottawa. He is past editor-in-chief of the journal Assistive Technology and was a member of the research

management committee of AGE-WELL, Canada’s technology and aging network. He has served as my Ph.D. supervisor since I enrolled to this program in 2019.

Roanne Thomas (RT) is a Full Professor in the faculty of Health Sciences at the university of Ottawa. She has a professional background in Sociology and uses innovative tools, such as photovoice (storytelling and photography) and other visual arts, including mixed media, to help people to improve their sense of well-being and to support themselves through life’s transitions. She holds a Canada Research Chair in Creative Practices and Well-being. She has served as my Ph.D. supervisor since I enrolled to this program in 2019.

Lara Pilutti (LP) is an Associate Professor in the faculty of Health Sciences at the university of Ottawa. She has a professional background in Kinesiology and focuses on the role of exercise in the management and treatment of disability arising from neurological disorders, particularly multiple sclerosis. She served as my thesis advisory committee since 2020.

Pascal Fallavollita is an Associate Professor in the faculty of Health Sciences at the university of Ottawa. His main research focus is to promote healthy aging and AR/VR for medical education & rehabilitation. He acted as my thesis advisory committee since 2020.

Table 5.2 Summary of contribution of collaborators

	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5
<i>Details</i>	<i>Introduction</i>	<i>Manuscript 1: Scoping Review</i>	<i>Manuscript 2: Quantitative study</i>	<i>Manuscript 3: Qualitative study</i>	<i>Integrated Discussion</i>
Design and conceptualization	MH	MH, JJ, VC	MH, JJ	MH, JJ, RT	MH, JJ,
Data collection	MH	MH			
Data analysis and interpretation	MH	MH, JJ	MH, JJ	MH, JJ, RT, FH	MH, JJ, RT
Draft preparation	MH	MH	MH	MH	MH
Review and revision	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF
Approval of final version	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF

Manuscript authorship	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF	MH, JJ, RT, LP, PF
Responsible for content	MH	MH	MH	MH	MH

Other collaborators and acknowledgements

In addition to these collaborators, my research has other contributors who made significant contributions. Victoria Cole (VC), the librarian at the University of Ottawa assisted me in developing the literature search strategy for the scoping review. Farah Hatoum, a Ph.D. candidate in the Interdisciplinary School of Health Sciences, contributed to inter-rater reliability, through coding the transcripts of five interviews (Study 3) to reach final themes.

The recruitment process for quantitative and qualitative studies involved other organizations and individuals. I would like to acknowledge the contribution of Perley Health Veteran and Senior Care Center for their invaluable support and assistance during the course of my research. I would like to extend my sincere gratitude to Nikita Rayne (NR), Research Coordinator at Perley Health. She played an important role in facilitating the recruitment process and providing invaluable guidance throughout the data collection phase. Her expertise, knowledge, and insightful contributions greatly enhanced the quality of the research. I would also like to acknowledge David O'Neill (DO), Business Lead and Senior Living of Perley Health, for his assistance and collaboration, which greatly enriched the study.

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APPENDICES

Appendix A: Recruitment Material

Information Letter (Older Adults)

Study Title: Identifying the factors associated with seniors' acceptance of virtual reality games

Request for participation:

This letter is intended to give you detailed information about the research study, which will be discussed with you. Please take the time to read this information carefully and to understand what is involved. Being informed of what is involved in this study will help you to decide whether you want to be a part of this study. When you agree to participate in this study, you will be asked to sign a consent form.

You can take as much time as you need to make your decision. If you would like to discuss any aspects of the study or if you have more questions, please contact the researchers via phone call or email using the contact information below:

Principal Investigator:

Marjan Hosseini

University of Ottawa

School of Rehabilitation Sciences

Faculty of Health Sciences

Phone: ----- Email: -----

Supervisor:

Professor Jeffrey W. Jutai

University of Ottawa

Interdisciplinary School of Health Sciences

Faculty of Health Sciences

Phone: ----- Email: -----

Supervisor:

Professor Roanne Thomas

University of Ottawa

School of Rehabilitation Sciences

Faculty of Health Sciences

Phone: ----- Email: -----

Purpose:

This study is aimed at identifying the important factors that affect technology acceptance by seniors. We examine the acceptance of a physical activity game that uses virtual reality technology. We also would like to explore the relationship between emotion-related goals and acceptance of technology by seniors.

Invitation:

You are invited to participate in this study by attending gaming sessions with a virtual reality game three times, answering a questionnaire and attending a voluntary interview. The virtual reality game called *Song Beater* is a rhythm game that players hit flying objects synced with the music beats by hand movements in a virtual and simulated environment. The game allows you to choose the difficulty and speed level based on your physical ability and change the location (beach, desert, winter, ...) and play your favorite song to play with.

Procedure:

There are three mandatory and one optional activity to do in this study. If you participate, you will be asked to:

- 1- Participate in a 10-minute orientation session to become familiar with the game and the study before the first gaming session starts. Through this session, the principal investigator will explain the game and the study purpose and show you how to play with the game and what are the benefits and potential risks of the game.
- 2- Once the information about the game and sessions is given to you, you will be asked to start playing with *Song Beater* game. The gaming sessions will last 20 minutes that includes the time required for wearing the headset and standing/sitting at gaming position, setting the game up, playing with two or three songs, taking off the headset of your head, and sitting for 1-2 minutes to make sure you can maintain your balance after completing the session.
- 3- Complete a technology acceptance questionnaire to identify factors affect your acceptance of the game you played with.

- 4- The last part of this study is a 30-minute interview. Through this part you will be asked to answer some questions about your unique experience with the game. This part is **voluntary** and will be audio-recorded.

All the activities will take place at Perley Health.

Conditions for participation:

Your participation in this study is completely voluntary. You may refuse to participate, withdraw at any time, and decline to answer any question without negative consequences. You may notify the researcher that you wish to withdraw from the study at any point. Please note that the study is independent from the Perley Health and that refusal to participate will have no effect on the services you receive. If you decide to withdraw, you may choose to have any data collected from you not to be used in the study and destroyed.

Risks/Benefits:

The only potential risk that participating in this study might cause, is dizziness due to wearing VR headset. This does not mean that you will definitely feel dizzy by playing the game. The researchers will take all the necessary measures to provide a safe experience for you by putting a chair behind you if you choose to play standing.

The direct benefit of participating in this study is being physically active by engaging in physical activity programs for two weeks. You may benefit indirectly by sharing your experience about the technology with others and help researchers to consider your preferences and needs while designing technology.

Confidentiality:

All information from this study will be used for research purposes only and will be treated confidentially. All participants will be assigned a code (a pseudonym) that will be used in data files. There will be a list of your name linked to the code which will be kept in a secured place. This list is separate from your data files. All paper documents that include your name, contact information, signed consent form, questionnaire, and interview transcripts will be kept in a secured locked office at the researchers' institution. All the electronic documents will be kept in the principal investigator's computer with updated

antivirus, secure password, and encryption for all files. Your name will not be used if the results of study are published.

Dissemination of findings:

You may request a copy of the study results at the end of the study by contacting the researchers. If you would like to receive a copy of the study report, please indicate by marking a checkmark here:

Rights of participants:

You may choose not to participate or refuse to answer any question. By accepting to take part in this study, you do not waive any of your legal rights, nor do you release the investigators, the sponsor, or the institution where this research study is being conducted from their civil and professional responsibilities.

The ethical aspects of this study have been approved by the Research Ethics Board (REB) at the University of Ottawa. The REB is responsible for ensuring that participants are informed of the risks associated with the research and that participants are free to decide if participation is right for them.

Contact Persons:

If you would like to discuss any aspect of the study, please feel free to contact:

1. Principal Investigator: Marjan Hosseini at ---- or email: ----
2. Supervisor: Professor Jeffrey W. Jutai at ---- or email: ----
3. Supervisor: Professor Roanne Thomas at ----- or email: ----

If you have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5, Tel.: ----, Email: -----).

Thank you.

Recruitment Flyer

Are you interested in participating in a research study on technology and physical activity?

We would like to learn about :

- Your interaction with virtual reality (VR) games for physical activity
- The factors influence your acceptance of new technologies that are designed for physical activity
- The game characteristics that might affect your acceptance as well as the personal characteristics that are effective

Participation in this study includes 4 steps:

1. Participating in a 10-minute orientation session.
2. Participating in three 20-minute gaming sessions in two weeks.
3. Answering short questions (5 to 10 minutes) after gaming sessions related to your demographic information and your acceptance of technology
4. Participating in a voluntary 30-minute interview to share your individual experience with the game

You are eligible if you are:

- Living in an apartment or the community receiving Assisted Living Services
- Able to speak and write English
- 65 years of age or older
- Able to wear a headset, move hands, and hold controllers whether standing or seated
- Interested in trying virtual reality physical activity games
- Able to provide informed consent
- Able to answer questions about your experience of playing with the game

**All the steps will take place at Perley Health
We use the simple rule of “first come, first serve” for recruitment**

For more information, please contact:

Phone: ----- Email: -----

Telephone Script

Hello, my name is Marjan Hosseini, and I am the coordinator of our research project called, "Identifying the factors associated with seniors' acceptance of virtual reality games". Thank you for agreeing to speak with me about participating in this project.

I need to ask you some questions in order to see if you are eligible to participate.

Do I have your consent to proceed? YES or NO.

If the answer is NO, I will thank him/her and end the conversation.

If the answer is YES, I will proceed with the following questions:

1) Are you able to speak and understand English?

Yes? No?

2) Are you 65 years of age or older?

Yes? No?

3) Are you able to provide informed consent?

Yes? No?

4) Are you living at the Perley Health Apartments or living in the community and receiving Assisted Living Services from Perley health?

Yes? No?

If the answer to any of the above questions is NO, I will thank him/her and end the conversation.

If the answer is YES, I will proceed to booking an appointment with them.

Booking an appointment

1) Is there a day and time of the week of (determine week) that is usually better for you?

2) Is there a location of meeting that works better for you?

3) If you need to cancel or if you will be late, call me at [----]. Please leave a message if I don't answer.

4) Thank you very much for answering my questions today. I will see you on (date, time, and location).

End Conversation.

Verbal consent for study participation YES → *Complete following items* NO

Reminder phone call YES NO

Name of participant: _____

Participant's telephone number: _____

Preferred time to be reached: _____

Name of person obtaining verbal consent: _____

Date: _____

Appendix B: Data Collection Tools

Composite Questionnaire (Study 2)

SESSION:	DATE/TIME:
PARTICIPANT:	Questionnaire: Demographic information

Gender: _____

Age (in year): _____

Education

- No certificate, diploma or degree
- High school diploma
- Apprenticeship or other trades certificate
- College diploma
- University below bachelor's
- Bachelor's degree or higher

Sedentary behavior

On a typical day, how much time do you spend (from when you wake up until you go to bed) doing the following?

	None	15 m or less	30 min	1 h	2 h	3 h	4 h	5 h	6 h or more
Watching television									
Sitting while listening to music									
Sitting and talking on the phone									
Sitting and reading									
Playing computer/video games									

Prior experience with computer-based games

Never	Less than 6 months	More than 6 months, but less than 1 year	More than 1 year, but less than 3 years	More than 3 years, but less than 5 years	More than 5 years
1	2	3	4	5	6

If you said that you have experience playing computer-based games, how long do you usually play games for every week?

- 1-5 hours
- 6-10 hours
- 11-15 hours
- 16-20 hours
- 21-25 hours
- 26-30 hours
- 30+ hours

SESSION:	DATE/TIME:
PARTICIPANT:	Questionnaire: TAM questionnaire

	Perceived Usefulness (PU)	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1	Using VR games would enhance my effectiveness in life (to what extent using VR games would affect my ability to do the things that are important to me)	1	2	3	4	5
2	Using VR games would make my life more convenient / easier					
3	I would find VR games useful in my life					
	Perceived Ease of Use	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
4	My interaction with the VR game is clear and understandable					
5	Interacting with the VR game does not require a lot of my mental effort					
6	I find the VR game to be easy to use					
7	I find it easy to get the game to do what I want it to do					
8	I could be skillful at using VR game					
	Game self-efficacy	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
9	I could complete a level using the VR game if I have just the instruction manual for assistance					
10	I could complete a level using the VR game if there is someone to demonstrate how					
	Game anxiety	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
11	I feel apprehensive about using the VR game					
12	I hesitate to use the VR game for fear of making mistakes I cannot correct					
13	VR games make me feel uncomfortable					
14	VR games make me feel uneasy					
	Facilitating conditions	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
15	I have the resources necessary to use the game					

16	I have the knowledge necessary to use the game					
17	A specific person (or group) is available for assistance with game difficulties					
	Hedonic Motivation	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
18	Playing VR games is fun					
19	Playing VR games is enjoyable					
20	Playing VR games is very interesting					
	Attitudes toward games	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
21	Using VR games for physical activity is a good idea					
22	Playing VR exercise games is an attractive way to be active					
	Social relationships	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
23	I am satisfied with my personal relationships					
24	I am satisfied with the support I get from my family and friends					
25	I participate in social or community activities					
	Psychological function	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
26	I feel that as I get older, I am less useful					
27	I am satisfied with my quality of life					

SESSION:	DATE/TIME:
PARTICIPANT:	Questionnaire: Selection, Optimization, Compensation questionnaire (SOC) AND Future Time Perspective Scale (SST)

constructs
Elective selection
1. Please select which of the two statements is more true for you. <input type="checkbox"/> I concentrate all my energy on a few things <input type="checkbox"/> I divide my energy among many things
2. Please select which of the two statements is more true for you. <input type="checkbox"/> I always focus on the one most important goal at a given time <input type="checkbox"/> I am always working on several goals at once
3. Please select which of the two statements is more true for you. <input type="checkbox"/> When I think about what I want in life I commit myself to one or two important goals <input type="checkbox"/> Even when I really consider what I want in life I wait and see what happens instead of committing myself to just one or two particular goals
Loss-based selection
1. Please select which of the two statements is more true for you. <input type="checkbox"/> When things do not go as well as they have in the past, I choose one or two important goals <input type="checkbox"/> When things do not go as well as they have in the past, I still try to keep all my goals
2. Please select which of the two statements is more true for you. <input type="checkbox"/> When I cannot do something important the way I did before I distribute my time and energy among many other things <input type="checkbox"/> When I cannot do something important the way I did before I look for a new goal
3. Please select which of the two statements is more true for you. <input type="checkbox"/> When I cannot do something as well as I used to, I think about my priorities and what exactly is important to me <input type="checkbox"/> When I cannot do something as well as I used to, I wait and see what comes
Optimization
1. Please select which of the two statements is more true for you. <input type="checkbox"/> I keep working on what I have planned until I succeed <input type="checkbox"/> When I do not succeed right away at what I want to do, I don't try other possibilities for very long.
2. Please select which of the two statements is more true for you. <input type="checkbox"/> I make every effort to achieve a given goal <input type="checkbox"/> I prefer to wait for a while and see if things will work out by themselves

3. Please select which of the two statements is more true for you.

- If something matters to me, I devote myself fully and completely to it
- Even if when something matters to me, I still have a hard time devoting myself fully and completely to it.

Compensation

1. Please select which of the two statements is more true for you.

- When things do not go as well as they used to, I keep trying other ways until I can achieve the same result I used to
- When things do not go as well as they used to, I accept it

2. Please select which of the two statements is more true for you.

- When something in my life is not working as well as it used to, I decide what to do about it myself without involving other people
- When something in my life is not working as well as it used to, I ask others for help or advice

3. Please select which of the two statements is more true for you.

- When it becomes harder for me to get the same results, I keep trying harder until I can do it as well as before
- When it becomes harder for me to get the same results as I used to It is time to let go of that expectation

	Strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1. Many opportunities await me in the future.					
2. I expect that I will set many new goals in the future.					
3. My future is filled with possibilities.					
4. Most of my life lies ahead of me.					
5. My future seems infinite to me.					
6. I could do anything I want in the future.					
7. There is plenty of time left in my life to make new plans.					
8. I have the sense that time is running out.					
9. There are only limited possibilities in my future.					
10. As I get older, I begin to experience time as limited.					

Older Adults' Interview Guide (Study 3)

Interview Script

Background and purpose

Thank you for agreeing to participate in this interview for my thesis project on the acceptance of VR technology among residents of LTC facilities. Through this research, I explore the factors associated with the acceptance of new technologies to better understand the interaction between this group and technology.

This interview should take 30 minutes and will be audio-recorded so that I can more easily review the notes afterward.

General questions

- What do you think of the VR exercise game?
- How did you feel when you were playing the game?

Game preference questions

- What do you like about the game you played?
- What do you dislike about the game you played?
- Is this a game that you would like to continue playing?
- What is interesting about this game that would make you continue playing?
 - **If they said No:** How can we make it better/more interesting for you?
- How do you prefer to play? (Alone or with others)
- Does playing a game like this make you feel like you are exercising/ moving?
 - **If they said No:** Is it something about the game, your condition, ...?
- Prob questions: What stops you? Can you tell me? Why do you say that?

At this point, let me ask you do you want to add something? I have one more question to ask you. Let's talk about what kind of goals you have set for yourself. Do you have goals for yourself? If the answer is NO, the prob question would be, what about your health? Do you have hobbies? How about other activities and hobbies? E.g. doing puzzles, book clubs, knitting, and visiting grandchildren?

Thank you so much for your time. Sharing your experience and thoughts on VR gaming will help us to reach a better understanding of technology acceptance by seniors.

Staff Members' Interview Guide (Study 3)

1. Please briefly introduce yourself and your responsibility at this facility.
2. How often do you meet with residents?
3. Do you have any responsibility for making decisions for recreational and therapeutic activities or programming for residents? Yes: describe
4. Are you familiar with VR technology?
5. Yes: Please describe.
6. Do you think VR could be a good way to encourage residents to exercise?

What would you say are the potential benefits of VR tech for residents?

What do you think are the potential barriers to using VR technology with residents?

7. What are the factors that you think may affect the acceptance of VR among residents?
8. What are the factors that you think may affect the implementation of VR at the facility?

Are there any other things that you would like to tell me that might help our understanding of VR with this population?

Appendix C: Ethical Approval and Consent Forms

Certificate of Ethics Approval

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-02-22-7627
Titre du projet / Project Title	A mixed-methods study on identifying the factors associated with older adults' acceptance of virtual reality games
Type de projet / Project Type	Thèse de doctorat / Doctoral thesis
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	21/03/2022
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	20/03/2023

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Rôle
Seyedehmarjan HOSSEINI	École des sciences de la réadaptation / School of Rehabilitation Sciences	Chercheur Principal / Principal Investigator
Jeffrey JUTAI	École Interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Superviseur / Supervisor
Roanne THOMAS	École des sciences de la réadaptation / School of Rehabilitation Sciences	Co-superviseur / Co-supervisor

Conditions spéciales ou commentaires / Special conditions or comments

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Ottawa (Ontario) K1N 6N5 Canada Ottawa, Ontario K1N 6N5 Canada

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Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'Énoncé de politique des Trois conseils (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout événement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

Riana MARCOTTE

Responsable d'éthique en recherche / Protocol Officer

Pour/For Daniel LAGAREC Président(e) du/ Chair of the Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board

University of Ottawa

Office of Research Ethics and Integrity

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completed four weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

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Older Adults' Gaming Sessions Consent Form (Study 2)

Study Title: Identifying the Factors Associated with Older adults' Acceptance of Virtual Reality Games
Understanding of my rights in research

Please circle YES or NO

I read the letter about this study.	YES	NO
I decided that I want to be in this study.	YES	NO
I know that I do not need to be in this study if I do not want to.	YES	NO
I will participate in this study which includes Three 20-minute gaming sessions followed by short questions that will last 5 to 10 minutes.	YES	NO
I can stop my participation when I want.	YES	NO
It is okay for the researchers to use my answers when they tell people about their research.	YES	NO
I know that the researchers will not tell anybody my name.	YES	NO
It is okay for the researchers to ask me again if I want to continue participating in the study.	YES	NO

Participants:

I had an opportunity to discuss this study, and any questions that I have asked were answered to my satisfaction. I voluntarily consent to participate in the **gaming sessions** of the study "**Identifying the factors associated with older adults' acceptance of virtual reality games.**" I understand that this study is independent from The Perley Health and that refusal to participate will have no effect on the services I receive at the Centre. I understand that I will receive a signed copy of this form.

_____ Participant's Name
Participant's Signature _____ Date

By marking my initials here, _____, I agree to allow the researchers to contact me at a later time if they would like me to clarify any information.

Person obtaining consent:

I have discussed this study in detail with the participant. I believe the participant understands what is involved in this study.

Marjan Hosseini

Researcher's Name

Researcher's Signature

Date

If you have any questions regarding the ethical conduct of this study, you may contact the

Protocol Officer for Ethics in Research, University of Ottawa, Tel.: ----, Email: ----

Older Adults' Interview Consent Form (Study 3)

Study Title: A Study on Identifying the Factors Associated with Seniors' Acceptance of Virtual Reality Games

Understanding of my rights in research

Please circle YES or NO

I read the letter about this study.	YES	NO
I decided that I want to be in this study.	YES	NO
I know that I do not need to be in this study if I do not want to.	YES	NO
I will participate in this study. Each of the three phases will last 30-45 minutes.	YES	NO
I can stop my participation when I want.	YES	NO
It is okay for the researchers to use my answers when they tell people about their research.	YES	NO
I know that the researchers will not tell anybody my name.	YES	NO
It is okay for the researchers to ask me again if I want to continue participating in the study.	YES	NO

Participants:

I had an opportunity to discuss this study, and any questions that I have asked were answered to my satisfaction. I voluntarily consent to participate in the **interview phase** of the study "**Identifying the factors associated with seniors' acceptance of virtual reality games**". I understand that this study is independent from The Perley Health and that refusal to participate will have no effect on the services I receive at the Centre. I understand that I will receive a signed copy of this form.

Participant's Name (Print) Participant's Signature _____
Date

By marking my initials here, _____, I agree to allow the researchers to contact me at a later time if they would like me to clarify any information.

Person obtaining consent:

I have discussed this study in detail with the participant. I believe the participant understands what is involved in this study.

Researcher's Name (Print) Researcher's Signature _____
Date

If you have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5, Tel.: (613) 562-5387, Email: ethics@uottawa.ca).

Staff Members' Interview Consent Form (Study 3)

Study Title: A Study on Identifying the Factors Associated with Seniors' Acceptance of Virtual Reality Games

Understanding of my rights in research

Please circle YES or NO

I read the letter about this study.	YES	NO
I decided that I want to be in this study.	YES	NO
I know that I do not need to be in this study if I do not want to.	YES	NO
I will participate in this study which includes one 30-minute interview.	YES	NO
I can stop my participation when I want.	YES	NO
It is okay for the researchers to use my answers when they tell people about their research.	YES	NO
I know that the researchers will not tell anybody my name.	YES	NO
It is okay for the researchers to ask me again if I want to continue participating in the study.	YES	NO

Participants:

I had an opportunity to discuss this study, and any questions that I have asked were answered to my satisfaction. I voluntarily consent to participate in the **interview phase** of the study "**Identifying the factors associated with seniors' acceptance of virtual reality games**". I understand that this study is independent from The Perley Health and that refusal to participate will have no effect on my work at the Centre. I understand that I will receive a signed copy of this form.

Participant's Name (Print)

Participant's Signature

Date

By marking my initials here, _____, I agree to allow the researchers to contact me at a later time if they would like me to clarify any information.

Person obtaining consent:

I have discussed this study in detail with the participant. I believe the participant understands what is involved in this study.

_____	_____	_____
Researcher's Name (Print)	Researcher's Signature	Date

If you have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tel.: ----, Email: ----