

Playful Aging: Digital Games for Older Adults

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Executive Summary

Older adults are challenged to maintain their health and wellbeing in the face of physical, mental, and social changes brought about by increasing age. Maintaining their quality of life and remaining active and independent for as long as possible helps individual older adults as they age and eases the need for health care, in-home and institutional longer-term care, and other societal costs of supporting Canada's rapidly growing aging population. Our AGE-WELL research has focused on the contributions that digital games can make to maintaining and improving older adults' health and quality of life.

Games are engaging, entertaining ways for people to spend leisure time. Older adults play games for many reasons, such as to relax, be entertained, escape from unpleasant tasks, exercise, be challenged, avoid cognitive decline, learn, experience new worlds, connect with others including younger family members, and for general fun and enjoyment. Used in these ways, games can meet a variety of older adults' physical, cognitive, social, and personal needs. Games can also support healthy lifestyle choices including exercising, staying mentally active, learning, and strengthening interpersonal and social relationships.

Playing digital games can contribute to overall wellbeing and to specific aspects of older adults' health. There is some research-based evidence that playing exergames (digital games based on physical movement) may improve aspects of physical health for older adults, including mobility and balance; they appear to be effective for stroke and Parkinson's rehabilitation, fall prevention, general physical training, and encouraging physical activity.

Older Canadian adults have reported that they experienced cognitive benefits including mental exercise, fun, and improvements in attentional focus, memory, reaction speed, problem-solving, and reasoning from digital gameplay, and those who self-report higher gameplay skills experience greater cognitive benefits from their gameplay. Many older adults appreciate playing games in which they compete with others, the computer, or themselves.

Older adults, particularly those with more education, often become "lifelong learners" for both mental stimulation and entertainment. Much of our research and development has centred on online educational games that appeal to seniors. These replicate common board or card games that are familiar to older adults; we extend them with customized learning content to provide an engaging way for seniors to learn about favourite topics. Our experiments have shown us that older adults value the new knowledge, the learning experience, and the social connectedness that these educational games offer.

Playing digital games socially can enhance seniors' lives and positively affect their sense of wellbeing. Through gameplay, seniors can master game skills, build a sense of achievement, and experience satisfying "flow." Playing games can also be a way to meet and connect with others and decrease feelings of loneliness.

Intergenerational digital gameplay can encourage interactions across younger and older generations, strengthen relationships and favourable opinions of others, and allow each generation to play new roles as they relate to other players. However, games meant for younger

players can be difficult to play for seniors with physical or cognitive problems or who have limited experience with digital devices.

Good design for older adults, based on criteria for engagement, user-friendliness, readability, appropriate equipment, game utility, and safety, can make the difference between a game that they enjoy and accept and one that is discarded and forgotten. Studies by our team and others have identified useful criteria to guide the development and evaluation of educational digital games for older adults, helping to ensure that they can be effectively chosen and used.

Technical and social support for introducing game technology and learning to play a game are also crucial for helping new players overcome initial difficulties and realize benefits from their digital gameplay.

Playful Aging: Digital Games for Older Adults

Introduction

Older adults are challenged to maintain their health and wellbeing in the face of physical, mental, and social changes brought about by increasing age. Although each person is different, these changes often negatively affect peoples' quality of life and, when severe, lead to hospitalization, long-term care, and death. For older adults themselves, achieving a high quality of life for as long as possible is a fundamental goal. This is also important for families, caregivers, community organizations, and health care agencies that support aging adults.

Physical, mental, and social health are interconnected and work together as foundations for a high quality of life. Research has established many lifestyle approaches for improving health, such as non-smoking, diet, low alcohol consumption, physical exercise, mental exercise, and social engagement. Lifelong learning has a major part to play by helping seniors stay mentally active and entertained while they build knowledge about healthy lifestyles.

This paper adds a new possibility – playing digital games – to the mix. Our research, as part of Canada's AGE-WELL Network of Centres of Excellence, shows that digital gameplay can contribute to older adults' health, wellbeing, and lifelong learning in multiple ways. Here we explore how digital games can help, together with how they should be effectively designed to be engaging, playable, and safe for older adults with varying abilities. Our goal in presenting this work is to equip individuals, caregivers, seniors' centres, care homes, and agencies who care about enhancing older adults' quality of life with knowledge and motivation to adopt digital games as ways to support and enhance older adults' quality of life.

The Challenges of Growing Older

Because aging is a process rather than a single distinct event, we have no clear definition of "older adult" or "senior." Older adults are typically defined by Statistics Canada and other institutions as those aged 65 or older.^[1] However, some researchers^[2] include younger or "next generation" seniors, those aged 55 to 64, and some^[3] focus on the "oldest old," those aged 85 and older.

In Canada and worldwide, populations are aging. Propelled by the "baby boomer" generation, Canadians aged over 65 now outnumber children for the first time, and their numbers have increased 20% since 2011, compared to a 5% increase in the general population.^[4] The proportion of Canada's oldest old grew by 19.4% in that period to become 13.0% of the population; seniors aged over 100 made up the fastest-growing population group.^[5] In Canada, older adults are projected to make up 23-25% of the population by 2036.^[6] Conditions are similar in the United States: by 2030, 20.1% of the US population will be older than 65, compared to just 10% in 1970 and 13.1% in 2010.^[7] The United Nations warns that population aging will challenge our societies, institutions, and families as they are called upon to provide care and support for greater numbers of increasingly old people.^[8]

Canadian older adults are living longer: their life expectancy at age 65 is now 22 years for women and 19.2 years for men.^[9] They are also working longer: in 2015, 19.8% worked past age 65, the highest rate since 1981, and 5.9% worked full-time for the whole year.^[10] Their longer lifespans and work lives, together with better health for many, mean that support needs can be deferred or minimized for some seniors. But 2.4 million older Canadians are forecast to require continuing care by 2026, an increase of 71% since 2011,^[11] and the annual cost of this care is expected to increase from \$22 billion in 2019 to \$71 billion in 2050.^[12] Meanwhile, a smaller working-age population is unlikely to support the tax increases that would fund this care through public institutions, so that the need for unpaid and volunteer caregivers is expected to grow dramatically as numbers of seniors increase.^[11,12]

What is “Quality of Life”?

Maintaining quality of life is therefore extremely important for older adults, but when we talk about quality of life, what do we mean? Medical practitioners often define quality of life (more specifically “health-related quality of life”) in objective terms that include people’s health and ability to function independently and effectively.^[13] It can also be defined subjectively as an individual’s perceived satisfaction with their overall life, in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns; it encompasses a person’s physical health, psychological state, level of independence, social relationships, personal beliefs, and relationships with their environment.^[14,15] In this paper we consider three major aspects of quality of life: physical health, mental health (particularly lifelong learning), and socioemotional health.

Physical Health

Physical health declines with age, although at vastly differing rates for different people. Encouragingly, older adults in Canada are generally healthy well into older age in terms of being able to carry out everyday tasks, but loss of functional capacity increases with age and most seniors have some limitations by age 85.^[16] In 2009-10, 82% of Canadians aged over 70 had at least one high-impact chronic condition.^[17] In a 2008 survey, 76% of Canadian seniors reported having at least one chronic condition compared with 48% of those aged 45 to 64; 24% reported having three or more chronic conditions including asthma, cancer, chronic pain, depression, diabetes, emphysema or chronic obstructive pulmonary disease (COPD), heart disease, high blood pressure, and a mood disorder other than depression and stroke.^[16] The “oldest old,” those aged 85 and over, have the highest long-term care requirements due to various chronic diseases.^[18]

Aside from chronic disease, falls pose one of the greatest physical dangers to older adults, leading to a high prevalence of injury-related hospitalizations.^[19] Faulty balance and falls can lead to injury, increased disease, fear of falling, decreased independence, and direct medical costs.^[20] Twenty to thirty percent of Canadian seniors fall each year,^[19] and falls cause 95% of seniors’ hip fractures, which triple the risk of death.^[21] Injuries due to falls were reported by 5.5% of 65 to 74-year-olds and 6.6% of seniors aged 75 or older in the baseline data collection from the Canadian Longitudinal Study on Aging (CLSA).^[22] In Europe, mortality from falls has been increasing since 2000, especially for those older than 75 years.^[23]

Physical declines with aging are not inevitable; we know from many studies that they can often be slowed or reversed through exercise, physical therapy, diet, and other lifestyle choices.^[24,25] There is evidence that various types of exercise are effective treatments for chronic diseases and conditions that affect seniors, including Parkinson's disease, multiple sclerosis, stroke aftereffects, hypertension, coronary heart disease, heart failure, COPD, osteoarthritis, impaired sense of balance, back pain, and general loss of physical fitness.^[26]

Overall Mental Health

As with physical health, mental health, encompassing cognitive, behavioural, and emotional wellbeing,^[27] often declines with age but at rates that vary greatly across individuals. In the CLSA's sample of over 51,000 Canadians aged 45 to 85, only about 5% self-reported fair or poor mental health; interestingly, this proportion declined with age.^[22] The Canadian Mental Health Association points out that mental and physical health are closely linked in that poor mental health is a risk factor for chronic physical conditions and people with chronic physical conditions are at risk of developing poor mental health.^[28]

Cognitive Health

Cognitive health is an important aspect of mental health in that it determines a person's ability to sense, think, remember, and act. In the CLSA's sample, cognitive test scores tended to be lower for older participants.^[22] Seniors' cognitive deficits may include decreased reaction time, manual dexterity, hand-eye coordination, memory, and general cognitive abilities.^[29] Impaired executive function has the most serious consequences because it is involved in many complex behaviours that enable people to engage in independent, adaptive behaviours and to achieve goals.^[30] Executive function controls and coordinates other cognitive processes, such as working memory, reasoning, problem solving, and attention to appropriate information.^[31]

Outside the scope of normal aging, age-related diseases such as Alzheimer's disease, Parkinson's disease, diabetes, hypertension, and stroke also affect cognition. Cognitive decline is a serious health threat for older adults,^[32,33] as it can greatly reduce their independence and quality of life.

Neuroscience evidence suggests that cognitive decline can often be slowed or reversed with appropriate training or therapeutic techniques.^[29] For example, one study examined the effectiveness of three cognitive training interventions on the mental abilities and daily functioning of older adults who lived independently; after 19 months, participants in experimental groups had improved processing speed, reasoning, and verbal episodic memory compared to the control group.^[33]

Socioemotional Health

Social interactions, connections, and support strongly enhance older adults' quality of life,^[34,35] while social isolation can adversely affect it.^[36] A person's social relationships and contacts influence life trajectories, physical and cognitive health outcomes,^[37,38] and general wellbeing.^[39] They give meaning to later life and provide a supportive foundation to help older adults handle difficulties.^[40] People's relationships and social networks often change with age, as seniors' networks decrease in size but become more meaningful.^[41] But if these social connections are suddenly disrupted by death, moving, or other events, older adults' isolation grows.

Social isolation (a lack of engagement and connectedness across social networks) tends to increase with age after age 65.^[17] Social isolation is associated with increased risk of death, chronic disease, and psychological distress as well as greater health care utilization and poorer overall health and wellbeing.^[22,42,43] Older adults have told researchers that psychosocial factors are more important than genetics, longevity, or physical health for successful aging,^[35] and active engagement with life that includes social engagement positively affects how people experience old age.^[35,44]

Loneliness, the subjective feeling of being isolated or needing companionship, is distinct from social isolation. In the US, 43% of 1604 survey respondents aged older than 60 said that they feel lonely at least some of the time, with higher incidence of loneliness for women in general and especially for women aged 75 or older. Loneliness rates were highest for people, especially men, who lived alone.^[22] Loneliness is significantly associated with chronic health problems, disability, sight and hearing problems, reported depression, increased risk of frailty, and functional decline and death.^[43-45]

We have only limited understanding of the roots of social isolation and loneliness and of ways to successfully mitigate them for older adults.^[46,47] Drawing on examples and systematic reviews, researchers suggest that interventions tend to be more effective when they are suggested by older adults themselves, address barriers to and causes of social engagement, emphasize action and engagement, distract from loneliness, are supported by professionals, and are integrated into older adults' regular activities.^[46,47]

How Can Digital Games Help Maintain Older Adults' Health and Wellbeing?

Older adults' quality of life is influenced by many objective factors, such as their health, income, education, independence, family and social relationships, access to care, and quality of care. It is also affected by individuals subjective expectations and perceptions about life, wherever they are on the aging path.^[34,48] Canadian seniors' overall self-reported life satisfaction is highest for those reporting excellent or good health and is positively correlated with satisfying personal and community relationships.^[49] A study of US adults aged 90 and older found that better physical health and greater social resources were associated with more positive feelings; past education was associated with better cognitive health.^[50]

Maintaining their present quality of life and remaining active and independent for as long as possible helps individual older adults as they age. This also eases the need for health care and in-home and institutional longer-term care, thereby reducing the personal and societal costs of supporting Canada's aging population.

Our AGE-WELL research has focused on the contributions that digital games can make to maintaining and improving older adults' health and quality of life.^[51] As we will see in the remainder of this paper, we have found that digital games can expand and support the range of actions that our seniors and those supporting them can take to meet the challenges of aging.

Games are engaging, entertaining ways for people to spend leisure time. They draw people into fictitious, puzzling, fantasy, and educational situations where they must meet challenges, compete, and win rewards.^[52-54] Older adults play games for many reasons, such as to relax, be entertained, escape from unpleasant tasks, exercise, be challenged, avoid cognitive decline, learn, experience new worlds, connect with others including younger family members, and for general fun and enjoyment.^[53-57] Used in these ways, games can meet a variety of older adults' physical, cognitive, social, and personal needs.

Seniors are often active technology users^[58] and increasingly play digital games. The proportion of Canadian older adults who play digital games increased from 9% in 1990 to 34% in 2014.^[59] In the US, 21% of gamers are aged 50 or older.^[60] Of nearly 3000 older Americans surveyed in 2016, 38% played digital games at least once per month, about 75% played at least weekly, and 40% played daily.^[54] Older adults play digital games with game machines, computers, tablets, smart phones, and online.^[54,57,61-63] In our 2016 survey of older Canadians, 590 out of 1,211 respondents had played digital games in the past year.^[64-70] Over 88% of these had played one day or more per week, and over 40% had played for two or more hours per day when they played; about 50% of these respondents had played for five years or more.^[71]

Games can support healthy lifestyle choices including exercising, staying mentally active, and strengthening interpersonal and social relationships; these help to improve seniors' quality of life and health outcomes.^[72-74] In a study in The Netherlands, for example, players using a fitness exergame found that it improved their physical and social wellbeing while providing entertainment, excitement, and fun.^[75] Playing digital games can help to satisfy seniors' individual needs for useful health outcomes as well as for pleasure for its own sake.^[56,76-81]

Digital Games and Physical Health

Exercise is crucial for maintaining aging adults' physical health and quality of life. "Exergames" encourage older adults to be more active by combining movement with game features such as scoring, competition, and achievement. Nintendo Wii and Kinect games are examples; they combine play with movement, using motion tracking technology to create game actions, such as hitting a virtual ball, bowling, or dancing, from players' physical movements. Exergames' popularity has grown rapidly within the older adult population.^[82] Although more rigorous studies need to be done,^[83] there is some research-based evidence that playing exergames may improve aspects of physical health for older adults, including mobility and balance; they appear to be effective for stroke and Parkinson's rehabilitation, general physical training, and encouraging physical activity.^[84-86]

One survey found that exergames targeting disease prevention, injury prevention, and rehabilitation could improve energy expenditure, strength, basic motor control, and various nonphysical measures of wellbeing.^[87] People using the games were motivated over time to stay with recommended treatments for their chronic diseases. Another project found that 29 Spanish and Swiss older adults who played an interactive exergame at home for three months significantly increased their endurance and also improved their lower body strength, mobility, balance, and performance on activities of daily living.^[88] A 2015 comprehensive literature review of Wii exergame studies found evidence of improvement after training for a number of specific

physical functions, including balance, mobility, strength, flexibility, function after knee replacement, and walking speed and endurance.^[89]

Examples: Exergames for Fall Prevention

Specifically addressing the risk of falls, the iStopFalls system (www.istoppfalls.eu) uses Kinect exergames to deliver an unsupervised exercise program to older adults at home. In an international multicenter randomized controlled trial with 153 participants aged 65 years and older, older adults significantly reduced their measures of physiological fall risk and postural sway and improved their stepping reaction time after participating in the program.^[90]

In 2013 study, seven older adults in a Buffalo, New York assisted living residence played Wii Fit games for 30 minutes, twice weekly for eight weeks. Led by two nursing Ph.D. students, they worked in pairs and encouraged each other in sessions that included exercises for range of motion, aerobic conditioning, strength training, balance improvement, and deep breathing and yoga. At the sessions they discussed health education and motivational topics such as reasons to exercise, how to stay safe, and how to keep going. All participants completed the program safely with no falls or injuries. After the program they showed significant improvement in balance, as well as improved mobility, walking distance, and confidence in performing daily activities without falling. Although a large scale study is needed because this sample was very small, these results were consistent and promising.^[91]

Beyond exergames, some seniors, particularly in Asia, have enthusiastically embraced the augmented reality game Pokémon GO, typically thought of as a young person's fad, as a way to boost their outdoor exercise and social lives.^[92] Pokémon GO is a free smartphone app that combines gaming with the real world. The game uses location tracking and mapping technology to create an "augmented reality" where players catch and train Pokémon characters in real life locations. A University of Tokyo study found that people over 40 who played the game in their communities had significantly increased step counts for up to seven months after the game was released, compared to their step counts before the game was released and compared to non-players.^[93] Although we found no studies of seniors playing Pokémon GO, this study of middle-aged adults suggests that Pokémon GO and, more generally, augmented reality games, have the potential to engage seniors and encourage them to increase their physical activity.

Digital Games and Cognitive Health

Researchers and older adults themselves agree that staying "mentally sharp" is a key aspect of seniors' quality of life.^[35,94] We have found that many older adults see playing games as a useful form of mental exercise.^[56,65,71,95] Older Canadian adults have reported that they experienced mental exercise, fun, and improvements in attentional focus, memory, reaction speed, problem-solving, and reasoning from digital gameplay, and those who self-report higher gameplay skills experience greater cognitive benefits from their gameplay.^[65,71,96]

There are also objective indications that various types of digital games can enhance older adults' cognitive function.^[86] Although evidence is inconsistent and seems to depend on study design,^[97]

several types of digital games have been shown to enhance cognitive function.^[98] These include digital games intended for entertainment, such as Tetris, Medal of Honor, and World of Warcraft; brain training games such as Brain Age^[99] and Lumosity;^[100] and games such as NeuroRacer^[101] that were developed as research projects.

Examples: Digital Games and Cognitive Function

UFOV is an acronym describing the useful field of view, or the area over which information can be acquired visually in a brief look without moving the eyes or head.^[102] In a randomized controlled trial with 58 older adult non-gamers aged 65-91 that tested whether video game training could improve their UFOV performance, training with the action game Medal of Honor and with the arcade game Tetris significantly improved their performance compared to the no-training group. However, a clinically validated UFOV training program yielded significantly greater improvements than did training with either video game.^[103]

In a randomized controlled trial with 27 adults aged 57-77, the experimental group of 15 people played Lumosity video games in 20 one-hour sessions over 10-12 weeks, while the control group participated in three group meetings but had no video game training. The games were designed to train the cognitive abilities of processing speed, mental rotation, working memory, concentration, and mental calculation. Following the training, both groups were tested on (a) their ability to maintain focus on a task despite distracting sound and (b) alertness (time to respond to an audio signal). While accuracy on the tested tasks did not increase, response times indicated benefits from the video game training, suggesting that neuroplasticity (the ability of the brain to form and strengthen neural connections) is present not just in younger people but also for older adults.^[100]

Physical exercise is positively linked with cognitive function in older adults.^[85,104,105] Exergame play with a game machine involves cognitive as well as physical skills and so has potential for improving cognition due to the brain's neuroplasticity. Randomized controlled trials have produced evidence that playing exergames significantly improves global cognition, executive function, attentional processing, and visuo-spatial skills.^[106] In a specific example, pedalling with a bicycle game over six months significantly improved executive function, memory, and everyday cognition in 14 older adults with, or at risk for, mild cognitive impairment.^[107] Another study found that a 12-week Wii-based physical training program using several different games significantly improved game performance, physical function, executive control, and processing speed (although not visuospatial functions) for sedentary older adults, compared to a control group.^[82]

Digital Games and Socioemotional Health

Playing digital games socially can enhance the lives of older adults and positively affect their sense of wellbeing.^[74,86,108,109] Through gameplay, seniors can master game skills, build a sense of achievement, and experience satisfying "flow."^[72,110] Playing games can also be a way to meet and connect with others and decrease feelings of loneliness.^[61,78,111-114]

Example: Changing Outlooks with Wii Sports

In one experiment, 11 older women in a residential home played Wii Sports games twice per week for six weeks with technical support and encouragement from their peers. Afterwards, the participants reported that while they had been forced out of their comfort zones by the game, playing the game changed their perceptions of themselves from old and disconnected from the world to younger and less isolated. They experienced improved physical and social wellbeing and deeper social connections while having new shared experiences with younger family members.^[115] Although the sample size was small, these results are promising.

Digital game playing often naturally involves social interaction,^[116] and older players value this social contact.^[78,117] Digital games can be played in many different social contexts and locations, such as in groups in the same physical location, online with other players, or alone but with virtual game opponents. Making gameplay more social can also make it more fun.^[118,119]

Examples: Building Social Connections with Bowling and Bingo

One of our research teams facilitated an eight-week, team-based Wii Bowling tournament for 73 players aged 60 or older in seniors' independent living, assisted living, and community centres. Teams of three or four players from each site played two games each week, and scores were posted online and on paper. Winning teams received cash prizes. Surveys before and after the tournament showed that players' loneliness significantly lessened and social connectedness significantly increased. Players built new friendships during the tournament and continued new social interactions afterwards.^[70,117,120,121]

We created the online Bingo educational game "Live Well, Live Healthy!" with learning content about nutrition and health topics. In a study with 50 participants who played the game weekly for four weeks, the players reported that their social connectedness improved significantly while they played together in teams and increased their knowledge about healthy living and nutrition. They highly valued this combination of social interaction and learning, reporting that they enjoyed playing with others, making new friends, feeling the excitement of competing and winning, and cooperating with their teammates.^[70,122]

Games played online or on social networks also create social links among players.^[123] For example, researchers found that an older adult who tested a Facebook-based social digital game for five weeks with her relatives was enthusiastic about how it could reduce loneliness and increase social interaction in the family.^[124]

Massively multiplayer online role-playing games (MMORPGs) such as World of Warcraft (WoW) offer social interaction with others in online virtual worlds. Older adult WoW players have reported that enjoying relationships within the game and developing online “bridging and bonding” social capital are important reasons that they enjoy the game.^[125-129] Playing MMORPGs also offer seniors new ways to strengthen off-line relationships and build new ones with real-life family and friends.^[130]

Digital Games and Overall Psychological Wellbeing

Digital games have shown potential to contribute to overall psychological wellbeing, which encompasses mental and emotional health together with subjectively experienced wellbeing.^[86,131] Looking specifically at games that promote physical exercise, researchers reviewed the effects of playing exergames using a framework that emphasized psychological, behavioral, and social health in addition to physical condition.^[132] They found positive impact from playing on intrinsic motivation, attitude, self-control, and self-efficacy (belief in one’s ability to succeed in specific areas).^[87] In another exergames project, the majority of ten older adult participants found these games to be a way to have fun while exercising and feeling better afterwards.^[133]

Examples: Feeling Better with Gameplay

In an experiment to evaluate the effect of playing one of our educational games on older adults’ perceived quality of life, 56 seniors aged between 55 and 90 played the French version of our Bingo game “Live Well, Live Healthy!” (“Pour bien vivre, vivons sainement”) one to four times during a one-week period. They reported that playing the game improved their perception of gameplay benefits for most quality of life variables including physical wellbeing (fatigue, sleep, eating habits), social wellbeing (building ties, social connectedness, friendships), and psychological wellbeing (depression, difficulty doing activities, mood, and feeling of being loved). Some variables (sadness, isolation, proximity to family, and physical habits) generated only a weak perception of positive benefits for participants.^[134-136]

In a survey of 140 older adults looking at socioemotional functioning, casual and regular gamers reported significantly greater wellbeing than non-gamers as well as lower levels of negative emotions. The researchers suggested that using digital games as a source of entertainment can increase older adults’ wellbeing and reduce depression.^[137]

The 11 older women who took part in the Wii Sports study described above reported that they experienced a sense of empowerment and improved psychological wellbeing, despite their physical frailty, as they learned to play the games.^[115]

Digital Games and Learning

Learning is an important way for many older people to enhance their quality of life.^[42,122,138,139] Older adults, particularly those with more education, often become “lifelong learners” for both

mental stimulation and entertainment.^[55,140,141] Adult learning theory tells us that older learners want to learn topics that are practical and transferable to their everyday lives,^[122,142] and they are motivated to use technology when its benefits outweigh the time and effort needed to learn and use it.^[141,143,144] They appreciate digital games that offer learning objectives and cognitive exercise, and they value the learning experience for its own sake.^[56,71,145-147]

Many older adults enjoy playing games because they can be challenged and can compete with others, the computer, or themselves to win rewards. While games such as puzzle, sports, and driving games may have a learning aspect along with their primary aim of entertainment, we have concentrated on designing and building games to provide enjoyment but with clear learning objectives. Our approach has been to build online applications called “frame games” in the form of familiar board or card games such as Bingo and Solitaire that can be extended with learning content that is relevant and engaging for older adults. The games’ educational content is in the form of closed and open questions, with feedback provided so that learning can occur. These games structure the content to be learned and reinforce the learning through repetition, positive reinforcement, feedback, and organizing the material into smaller chunks.^[148,149]

Example: Learning with an Online Bingo Educational Game

Our online Bingo educational game “Live Well, Live Healthy!” integrates learning content in the form of pop-up questions about nutrition, physical exercise, socializing, and disease prevention. The questions are in true/ false and multiple-choice formats with three difficulty levels. A player needs to have a row of numbers covered, horizontally, vertically, or diagonally, in order to win and can cover a number only by correctly answering a pop-up question; feedback appears on the player’s answer, whether or not it is correct. Players receive points based on question difficulty, and the player with the most points when “Bingo” is called wins the game. An individual game can be set to a “basic, medium, or difficult” level according to the difficulty of questions posed during the game. The game thus includes learning and challenge features not present in traditional Bingo.

The 50 participants who played the online Bingo quiz game weekly for four weeks significantly increased their knowledge of the game’s content and commented that their new knowledge was valuable and relevant to them. They were highly engaged, commenting about their feelings of fun, enthusiasm, excitement, comfort, and accomplishment, and enjoyed the game’s challenges, rewards, and winning.^[122]

Another example of an educational game for the elderly, using the game SolitaireQuiz, is "In Anticipation of Death." We interviewed 167 seniors aged 55 and over and found that these participants were interested in the actions to be taken upon the death of their spouse; more than 72% expressed a lack of knowledge about dealing with the affairs of their spouse. The objectives of the game are to empower seniors to recover amounts of money owed to their spouse, to pay any outstanding debts, and to fulfill their spouse’s wishes concerning the disposition of their body. Regarding the learning that was achieved with the game, we examined the number of questions that were correctly answered by the players based on the number of times they played

the game. The first time the game was played, respondents answered 24.2% of the questions correctly. As a result of using the game, the number of correct answers increased from 24.2% to 88.4% after playing the game for the fifth time, indicating a progressive learning experience in relation to the number of times the game was played. Three months later, we looked at the results of questions from participants who continued to play the educational game online. They indicate that knowledge has been acquired and maintained, as well as a slight improvement in the average score for seniors (91.6%). These results suggest that repeated use of a game on a topic of interest to seniors promotes learning and retention.^[150]

Intergenerational Digital Gameplay

Intergenerational ties can help older adults to feel younger and happier, and intergenerational contact can help younger adults learn how to take responsibility for other people and enjoy common cultural activities. Young people are often motivated to take part in intergenerational programs as a way to search for skills and talents and develop personal meaning and direction. The two age groups can connect and build relationships through play, which encourages them to enjoy each other's company, learn and resolve problems together, and laugh over difficulties and shared mistakes.^[151-157]

Gameplay by multiple generations can be an enjoyable and enriching way for family members of different ages to connect. Intergenerational digital gameplay can encourage interactions and strengthen relationships and favourable opinions of others across younger and older generations.^[158-164] Intergenerational digital gameplay benefits players by reinforcing family bonds, enhancing reciprocal learning, increasing understanding of the other generation, and reducing social anxiety related to family interactions.^[164]

Example: Learning and Growing from Intergenerational Digital Gameplay

To study how older adults and younger people interact with each other during intergenerational digital gameplay, 11 pairs with one older (aged between 65 and 92) and one younger adult (a university student) took part in an experiment in which they played Wii Sports Cycling and Canoeing games for 45 minutes per week over six weeks. Each game is simple to play but can only be won if players communicate and coordinate with each other.

The research team analyzed audio recordings of each pair's game sessions, documenting how the pairs learned the games, got into the game flow, encouraged each other to work as a team, and dealt with setbacks in the game. The older adult players improved their gaming skills with the guidance from their younger partners; they could not play the game independently, verbally accepting roles as learners and treating their younger partners as technology teachers. They also acted as storytellers during breaks in the gameplay sessions, sometimes sharing life experiences, while the younger players encouraged them by showing appreciation, surprise, and praise as well as patience and kindness. The younger people played more mature roles as instructors, leaders, and encouragers, staying patient when responding to unexpected questions from their older partners. They offered options to engage the older players in

decision making and verbally expressed encouragement and confidence in older players who became discouraged.^[161]

Mentoring and coaching by the younger participants allowed the older adults to learn new gameplay skills and knowledge. As gameplay began and progressed, they learned the game mechanisms by asking questions and receiving feedback from their younger partners, while the younger people answered questions, highlighted and corrected mistakes, focused attention on key concepts and scenes, handled misunderstandings, and explained game events. This situated guidance from the younger players helped the older adults develop game knowledge and make sense of their gameplay experiences. As the older adults built their ability to discuss game strategies, coordinate with their younger partners to meet challenges, and encourage each other, they gradually moved from being novice to more experienced players.^[160]

Older Adults' Digital Game Preferences

Older adults choose to spend their leisure time in ways that meet their needs for physical activity, mental stimulation, entertainment, achievement, social connection, and general relaxation,^[141] and digital gameplay is only one of many activities that seniors can choose to meet these needs. But playing games is an important leisure activity for them.

Seniors' leisure time choices often mirror their favourite activities earlier in life, and their digital gameplay choices can be a natural extension of a lifetime of playing "traditional" nondigital games. A survey of 886 older Canadians found that 73% who played nondigital games preferred to play card, board, and puzzle games and also played gambling games, tile/ tabletop games (such as Yahtzee or Mahjong), and sports games.^[95] A UK survey found that digital gamers aged five to 65 years preferred to play puzzle, quiz, and board games.^[41] Our surveys of Canadians identified seniors' preferred nondigital game types as card, board, dice, and "pieces" games (typically puzzle or tile games) with Solitaire their favourite card game and Bingo their most-played board game.^[122,165,166] Their most-played game types were puzzle games and card/ board/ tile games.^[166] Finally, participants in a recent Canadian exergames study, in which they played a variety of different types of exergames, reported that they most enjoyed familiar activities such as bowling and dancing, and they especially appreciated games that brought back good memories.^[133]

A study comparing the video games Medal of Honor (a first-person shooter game) and Tetris (a puzzle game) observed that senior gamer participants learned to play Tetris more easily. They found it more difficult to actively engage in playing the shooter game, suggesting a reason that that puzzle games might be more attractive to senior gamers than shooter games.^[167] Most older participants in a study of shooter video games said that they did not want to play a realistic first-person shooter game after seeing a video clip of the game; three of six seniors who tried the shooter did not want to play the game again. A survey comparing generations found that older gamers had lower preference levels for first-person shooter games and role-playing games such as World of Warcraft, compared to younger adults and adolescents.^[168]

Researchers have frequently reported that older adults prefer to play digital "casual games," which are easy to learn and play, widely available as downloads, inexpensive, and quick to play

(often needing less than 20 minutes).^[61,63,169] One study found that 16 older adults who played various casual games found casual puzzle games easiest to learn and most enjoyable to play.^[170] Participants in a questionnaire study of 68 older American adults preferred intellectually stimulating puzzle, educational, or strategy games; females preferred social gameplay and familiar games to a greater degree than did males.^[171]

Our survey of older Canadians found that their most frequently reported cognitive benefits from digital gameplay were focusing, memory improvement, improved reaction speed, and problem solving; their most often reported socioemotional benefits were developing self-confidence, dealing with loneliness, and connecting with family. For cognitive benefits, both problem solving and speed in reacting/responding were associated with playing arcade games, such as Angry Birds and Super Mario, that required both strategic thinking and quick reaction time. The socioemotional benefits of connecting with current friends and with family were both associated with strategy games, while playing sports games was associated with connecting with friends.^[166]

Designing and Evaluating Educational Digital Games for Older Adults

For our goal of developing educational games for older adults, it was important to take into account both older adults' preferences and the principles of effective game design. Although older adults can realize many benefits from digital gameplay, games meant for younger players can be difficult to play for seniors with physical or cognitive problems. Gameplay is not fun or rewarding if the game does not allow for reduced eyesight or hearing, poor motor skills, limited physical movement, declining reaction time, or other impairments. Also, older adults may not have the technology experience to easily learn to use devices such as tablets, touch screens, or game controllers.

Realizing that older adults are a distinct gamer population, researchers have studied how digital games should be designed to make them appealing for these players, identifying features to compensate for possible age-related limitations. Good design for older adults can make the difference between a game that they enjoy and accept and one that is discarded and forgotten. In this section we outline criteria to use in designing or evaluating games for older adults.

User-Centred Design

Our game design guidelines for older adults are rooted in user-centred design (UCD), an iterative process of needs assessment, testing, feedback, and game revision with people who will play the game or represent its intended audience. For example, one UCD model divides the process into three stages: concept design, game design, and game development, each incorporating user ideas, feedback, and results of their tests of the game as it evolves.^[172,173] User-centred design integrates criteria of usability and utility.^[174]

Because seniors vary greatly in their needs and preferences, it is important to work with actual game players to work out designs that meet their requirements. An online educational game is effective when it meets two quality criteria: it must be *usable*, i.e., easy to learn (user-friendly and readable) and to play (hardware adapted to users), and it must be *useful*, or adapted to the learning objectives and the prior knowledge of users.^[175,176] Most importantly, it must engage older adults and maintain their interest and motivation.

Example: User-Centred Design for Usability with Older Adults

We used a UCD model to develop a digital escape game for older adults in which teams solve puzzles and accomplish tasks in order to escape from virtual rooms in a limited time. The game was designed to provide players with cognitive challenges, social interaction, and opportunities for learning. By being fun and easy to play, we hoped that it would also bring them emotional benefits and an increased sense of competence in playing digital games.

In the first phase of the project, ten older adults played two real-life (physically located) escape games with different themes and storylines and then took part in focus group interviews. Using their feedback, we worked with digital media students to create a conceptual design for our virtual escape game. Six older adults reviewed the concept; their feedback suggested that they preferred familiar types of puzzles and a familiar literary theme and wanted to be active throughout the game, with well-defined roles and tasks known at the start of gameplay. They wanted to be rewarded throughout the game rather than just at the end and preferred to have no time limits. They preferred voice chat for communication while playing the game. Based on these results, we brainstormed with our student team to design the game as a two-player one based on a maze connecting three rooms. One player is inside the maze and the other player, who has a bird's-eye view of the maze, gives navigation directions to the first player through voice chat. The theme, providing visuals and ideas for the puzzles, is *Alice in Wonderland*.

In the development phase, 12 older adults tested the first working prototype, focusing on playability, mechanics, puzzles, and overall gameplay. Using written surveys and focus groups, we found that most players found that the game had a clear goal, interesting theme, engaging challenges, easy-to-understand puzzles, and a duration that was “just right.” However, the majority found it difficult to navigate in the game and to figure out what to do next and thought that the game pace was too fast. Most also thought that they were not rewarded enough during the game, with some suggesting a scoring system with immediate feedback when a puzzle was solved. Most had difficulties with the game controller and with using the Skype-based voice chat.

Using this feedback, we created a second prototype with a slower pace, simpler visuals, more hints, built-in voice chat, scoring and other rewards, and simpler controllers. We then tested this version for usability with 12 seniors who were new to the game. In detailed surveys, they identified features that did or did not work for them; the researchers also observed the tests to identify game features that worked or that needed improvement. The result of the overall process was a prototype escape game that was appealing to its older adult audience but with specific features that needed further development.^[174,177-180]

Engagement

Whether players seek specific benefits or general entertainment, they play games that they find fun and engaging. Games draw players in with challenge, competition, interesting content, and

feedback. Poor design of these features often discourages older adults from playing a digital game. Seniors have reported giving up on games that they found dull, that moved too fast for them to remember or react, that were beyond their physical capabilities, or that left them confused about what game actions were needed.^[133,136,150,180-181] To engage and entertain senior gamers, the following aspects of a game should fit the needs, capabilities, and preferences of its audience:^[133,136,150,180-187]

- Challenge: The game should have adjustable levels of difficulty (e.g., for goals, pace, and learning content) to be encouraging rather than too hard for players of varying abilities and preferences and so that challenge can grow as players build their gameplay skills.
- Competition: Competition with other players, the computer, or with oneself keeps players engaged but needs a balance between motivation and too much pressure. Competition arises from the goals of the game (how to win), time limits, scoring, and rewards and penalties. If players can customize these, the game can be made to fit their individual needs.
- Content: The type of game should be familiar to older adult players. Learning content should be interesting and relevant to older adults. To maintain players' interest, the game should balance learning time and play time.
- Startup and feedback: Use tutorials and timely, clear feedback to help players learn and understand game mechanics, develop gameplay skills, and learn content. Use immediate feedback for specific tasks to help players identify successful and unsuccessful actions. For learning content, show players an overview of what they have learned at the end of the game.
- Social connectedness: To encourage social interaction, build competition and/or cooperation into the rules of the game, e.g. through playing in teams against other teams.

Example: Building in Game Engagement

Based on our knowledge of design principles together with feedback from groups of older adults, we designed our Bingo educational game to include the following features:

- Challenge: Players can vary the duration of the game by choosing how the Bingo game ends: a complete row of boxes requires less time than a full card or another more complex end point. Learning content in the form of randomly-appearing questions must be answered correctly for players to progress in the game; at the start of the game, players can choose from three levels of difficulty based on their knowledge about the game's learning content. Bonus balls drawn at random intervals during the game reduce the gap between strong and weak players. Acquiring points in connection with performance increases older adults' self-confidence, while displaying players' scores and highlighting the winner motivates seniors to replay the game.
- Competition: The Bingo game is designed to be played in groups, with three or more participants needed to create competition. Winning is based on players' scores at the end of the game, and players can view their scores at any time. Players receive points for answering questions correctly, being the first to correctly click "Bingo," and being awarded bonus balls. They receive penalties for incorrect answers and for claiming "Bingo" incorrectly, but the penalties are lower than rewards to maintain the players' interest and motivation.

- Learning content: The nutrition and health topic was suggested in our initial needs assessment with older adults. To balance learning time and play time, questions are displayed when a randomly generated number matches a number on a player's card.- Feedback is used to highlight and explain correct and incorrect answers. A tutorial is always available to guide players during the game. At the end of a game, players see their total points, scores are ranked, and achievement is highlighted with the sound of applause.^[181-184]

User-Friendliness

A game is user-friendly for older adults when it is intuitive and accessible to play and can adapt to their individual characteristics. User-friendliness is high if a game is easy to understand and play, with simple, fluid player-game interactions, and if gameplay is easy to learn and to remember.^[188-190]

Seniors' difficulties with technology are often due to poor user-friendliness. These can be resolved by appropriate designs for screen display, game navigation, and readability, again based on both established guidelines and older adult feedback. The following game screen display and navigation guidelines are based on what we have learned in our AGE-WELL research.^[185,191-194]

- Ensure that players can easily access all components (such as cards, tokens, navigation buttons, instructions/tutorials, and scores) needed for the game to run smoothly.
- To facilitate players' movements in the game, make sure that the game and its components are fully visible without overflowing the screen.
- Ensure that display resolution works for all devices (such as tablets and computers of various sizes) likely to be used by the target audience.
- Use a consistent layout across screens so that players can easily find elements of the game.
- Minimize the use of superimposed windows. Clearly show window changes to avoid confusion.
- Limit game elements and content to one screen page without scrolling. This avoids long and tedious scrolling on the screen, which particularly demotivates seniors with short attention spans.
- Have all relevant information available with single clicks.

Example: Designing SolitaireQuiz to be User-Friendly

Our educational game SolitaireQuiz combines online Solitaire with question-based learning content. We chose Solitaire because it can be played in a short time and was identified as one of older adults' favorites in our initial survey and by other researchers.^[166,171,195] At regular

intervals during the game, depending on the number of card movements, the player encounters a question; the right or wrong answer changes the player's score (credits that can be used to buy advantages from the online game store). Time is also important, since a bonus or a penalty is given depending on the length of the game.

Based on a user-centred design process, screen display and navigation were adapted to older adult needs in these ways:

- The display size of the game board is 1024x768, the smallest resolution used by our target audience. For screens with larger dimensions, a background of the same color as the background of the board has been inserted and the board is positioned in the centre of the screen.
- The board is always visible, although a second window may appear superimposed on top of the game board. Its size varies but is always smaller than the game board.
- When the second window appears in the center of the screen, the game board becomes gray and inactive.
- Learning questions show all relevant information (question statements, answers, degree of difficulty, feedback, credits earned or lost) in the second window.
- Each question comes up at least twice during a game that completes a full deck; this repeats learning content so that players can more easily remember it.
- Feedback adds visuals (smiley and sad faces) as well as text and audio.
- A standard screen design has been used that divides the game interface into three areas: (1) the information zone containing everything needed to understand how the game unfolds, including an options menu, timer, accumulated credit score, and the access icon for the online store; (2) the game board including all the playing elements of the game: the Stock pile, the seven columns and the four stacks of cards; and (3) the "apprenticeship" zone showing a tutorial accessible at all times, a progression line indicating current status, and a question to be answered after every five movements of the cards in the game.
- All player actions are done using single clicks. Because players often have little technology experience, buttons are often labelled with words and symbols or images.

[150,185,196]

Readability

Readability is an aspect of user-friendliness that is particularly relevant for older adults, who may have greater difficulty than younger players seeing, hearing, and understanding the game as it is presented with screens and audio. A game's interface is readable when its text, graphics, images, and videos are formatted to be easily viewed and understood. Readability is an indispensable aspect of any digital product,^[197] particularly one intended for seniors. The following guidelines, validated by experts and by older adults in our game trials, can help to make a game readable for older adults:^[198-200]

- Use a consistent, uncluttered text layout to aid reading and viewing.

- Use a clear font with few text effects.
- Use a vocabulary suited to older adults.
- Use only relevant illustrations and allow them to be enlarged for easier viewing.
- Ensure that display times are immediate to accommodate players with shorter attention spans.
- Include spoken texts so that players have the choice of listening rather than reading.
- Give players full control over sound by making controls always available and easy to use.

Example: Bingo Quiz Readability

Our Bingo Quiz educational game “Live Well, Live Healthy!” incorporated the following readability features to make it appropriate for our older adult audience:

- Text: the text is left-justified and uses only the Arial font (12 pts for regular text and 14 pts for headings). Upper case is only used for headings.
- Images: Players can enlarge images to full screen with a simple click of the mouse. Computer display time for low, medium and high speed internet connections is immediate. We used the inter-rater method to evaluate the usefulness of the images illustrating game questions.
- Sound: A virtual voice allows players with visual impairments to listen to the questions, rules and instructions. Players have full control over sound levels.^[181-184]

Game Equipment

Older adults are not always comfortable using game equipment such as a laptop, tablet, keyboard, or joystick. The following guidelines can make the equipment easier for them to use:

^[185]

- Avoid complicated physical actions, such as those that require a mouse double click or that force the player to precisely control a pointer on the screen while correctly pressing a button.
- Use mouse handling, which requires hand-eye coordination and increases cognitive load, only for essential actions. Use arrow keys, or a keyboard adapted for the game, instead.
- Avoid using double clicks.
- Avoid using technologies that require high skills to be used effectively. If a game controller is used, choose a one-handed device such as a computer mouse or the Wii Remote.
- Use tablets with screen sizes large enough to clearly display all game information

Example: SolitaireQuiz Game Equipment

From an equipment perspective, our SolitaireQuiz educational game includes the following design features to make it usable by older adults:

- No actions require a double click to be performed, whether to answer questions, to move cards in the game, to open the tutorial, to purchase a privilege, or to choose gaming options.
- To test the game with users, we chose computers with a mouse, 15” touchscreen laptops, and 10” tablets that allowed players to move game elements by touch.
- We used buttons with words and symbols to make their functions easier to understand for inexperienced players.^[185]

Game Utility

With respect to utility, older adults play games that they see as worthwhile in terms of the time and energy that they invest versus the benefits that they experience.^[80,145] Seniors are more likely to play games that they see as beneficial for cognitive exercise, social engagement, learning, connection with younger family members, familiarity from their earlier lives, and for the way they entertain and help players relax.^[133,145,166] For educational games such as the ones developed in our project, utility is linked to the value and amount of learning that occurs in the game. The following guidelines helps integrate learning content into a digital game to ensure effective learning:^[196]

- Arrange the learning content from simple to complex in order to offer multiple levels of difficulty and inform the players that the “Easy” level corresponds to their basic knowledge, thus encouraging everyone to participate.
- Use closed questions (ex. true/ false or multiple choice with one or more answers or objects to be matched) to facilitate the use of prior knowledge for progressing in the game and accumulating points.
- Analyze the learning content and to break it down into small units of information; this makes it possible to formulate simple questions in order to avoid cognitive overload in seniors.
- Limit the number of questions in a game to allow older adult players to recognize them and see them as useful for progression in the game.
- Use visual or audible feedback to reinforce the answers to the questions. For example, the face that accompanies each feedback comment, along with the sound emitted for a correct response, makes it easy to quickly tell whether or not the question was answered correctly.

Example: SolitaireQuiz Educational Game Utility

For utility in terms of learning, our SolitaireQuiz educational game includes the following design features:

- Closed questions (true/ false or multiple choice with one or more answers), to which we added feedback to be displayed when the player answers a question.
- Learning content divided into small units with three levels of difficulty (15 easy, 15 intermediate and 10 difficult) identified by one, two, or three stars.
- Enough questions (40) to ensure variety but so that each is used at least twice during a game.
- A balance of playing and learning that uses one question for each five card movements

during the game.

- Feedback in the form of a smiling or sad face as well as text and audible feedback to highlight and explain the correct or incorrect answer.

Seniors in our user-centred design process confirmed that the game's learning content (what to do after the death of a spouse) was important and that playing the game allowed them to increase their knowledge and be better equipped when the time comes.^[182-184,196]

Design for Intergenerational Gameplay

Intergenerational gameplay introduces additional design needs because a game for multiple generations must encourage communication among players and must be playable, fun, and challenging for players of different ages and abilities. Suggestions for doing this include:^[164]

- Base the game on fantasy and imagination rather than action and violence;
- Allow individuals to have their own gameplay settings, e.g. for speed and difficulty;
- Base the game on cooperation rather than competition, or on a blend of cooperation and competition, so that it will be fun for all players;
- To encourage player communication and mentoring, design gameplay to happen with all players in the same physical location, or have strong communications tools.

Example:-Design for Intergenerational Gameplay

The Bingo game design elements discussed in previous examples make the game useful and usable for older adults and also for younger players, particularly because the challenge elements, difficulty levels, and simple interface elements allow players of all generations and abilities to enjoy playing the game.^[201]

Exergame Design

Exergame design for older adults must ensure that gameplay is physically safe, accessible, and enjoyable for players with various capabilities. Seniors are often discouraged from playing by game aspects such as unfamiliar equipment, unfamiliar physical movements, awkward gesture or movement controls, confusing displays, unclear instructions, and too-fast play pacing.^[133,202-204] Inexperience with exergames is a major stumbling block for older adult players that needs to be overcome.^[202-205] One exergame study found that frail elderly often felt incompetent or too old to play without effective feedback and support for them to learn and enjoy the game.^[206]

With these issues in mind, researchers have identified specific exergame design guidelines that can help make these games suitable for seniors:^[133,202-205,207-209]

- Apply inclusive design principles to make games safe and enjoyable for a wide range of players.
- Allow the speed, physical effort, and gameplay gestures to be adjusted.
- Use gesture controls that accommodate reduced dexterity and motor control.
- Focus on simple interactions.
- Avoid large or sudden movements.
- Avoid leaning backwards or other movements that compromise balance.

- Allow interaction while sitting or standing (such as arm and hand movement in addition to foot movement) for play by those in wheelchairs or with limited mobility.
- Use a simple interface with clear screen information.
- Provide a “quick start” guide to help new players set up the game, understand its goals, and learn to play.
- Have help, tutorials, and feedback available throughout the game (e.g., to show what gesture to use at what point).

Example: iStoppFalls Exergame Design

iStoppFalls (www.istoppfalls.eu), the Kinect system built to predict and prevent falls, uses existing commercial technologies (a motion sensor, TV, Kinect game machine, and tablet), and players use voice, gesture, remote control, and tablets to interact with the game. iStoppFalls uses three games to train balance and strength through weight shifting, knee bending, and stepping.

In each game, exercises can gradually increase in intensity, as players grow stronger, by varying motions, speed, number of sets, step height, repetitions, added weights, and physical and cognitive tasks. Exercises begin at the lowest level for players to become familiar with the technology.

At the close of a game, players receive immediate visual, colour-coded feedback on their play time, exercise intensity, movement quality, task performance, and game scores. They can find additional feedback using menu options and can readily see their progression over time. Scores are compared to those of other players and achievement awards are given for exceeding personal best scores. Feedback is also used by medical personnel to identify those at high risk of falling and to identify factors contributing to this risk.

The game is supported by learning content in the form of fact sheets about fall risk and best practices for fall prevention. To support social interaction, the system has an integrated social media platform for players to upload their exergame scores and post short messages.^[90,210]

In Practice: Supporting Older Adults’ Digital Gameplay

For seniors to benefit from and enjoy playing digital games, they often need help overcoming obstacles.^[211] We have seen that perceived benefits, relevant learning content, good design, and easy-to-use equipment can help, but these are not always enough to motivate and support older adults to try something new and establish digital gameplay as an ongoing activity. Older adults who see themselves as unable to learn to use new technology or who have a frustrating early experience with a game may just abandon it, missing out on the game’s potential benefits.

^[133,188,212] However, those who overcome initial difficulties, develop at least minimal technology skills, and come to enjoy gameplay are likely to continue playing and realize greater gameplay benefits.^[213,214]

Researchers consistently note the need for support for both the digital game technology and for learning and playing a game, whether it is to be used at home, in a seniors' centre, or in an independent living or care facility. Help, in setting up and learning to use game equipment and fixing technical problems, can come from a relative (such as a technology-literate grandchild), program staff, a help line, volunteer peer group support (as from experienced players in a care home), or community volunteers; the important thing is that they are available to quickly help new players overcome technical issues and issues with how to play.^[90,133,204,210]

A review of studies of home-based virtual reality and gaming for older adults found that their training typically used orientation sessions, user manuals, or supervised sessions to familiarize the participants with technology setup and gameplay. Standby assistance and monitoring was often required to assure players' safety, at least initially, and home visits were needed to help participants progress.^[215]

Example: Supporting iStoppFalls Use At Home

For games to be used as part of a health intervention, such as fall prevention or rehabilitation, adherence to a game-based training plan determines whether the intervention will or will not be successful. In an unsupervised, home-based exercise experiment testing the iStoppFalls fall prevention system, trained research staff installed the system in participants' homes and taught them how to control and navigate through the games. Staff members checked on each player's progress in a second home visit. Throughout the 16-week intervention, players could request phone support and additional home visits.^[90]

It is also important to facilitate social interaction when games are intended to boost older adults' social connectedness. This can be done by playing games in teams, playing individually in group settings, playing multiplayer games online, or by setting up tournaments or team-based competitions. For example, in our Bingo experiment we found that social connectedness increased when players played in group sessions where they could collaborate and encourage each other, and our eight-week Wii Bowling tournament across 14 seniors' centres was found to increase social connectedness and decrease loneliness among participants. The tournament drew in spectators and supporters in the centres to create a more entertaining and social atmosphere in the centres during the tournament.^[70,117,120,121] By engaging players through a familiar activity (bowling), team competition, social and emotional support, and a tournament structure supported by centre coordinators, it created a positive gaming experience for players and improved their attitudes toward playing digital games in the future.^[216]

Gameplay benefits are more likely to continue in a sustainable way when social gameplay is supported by seniors' centres through structured programs and schedules and through ongoing support and encouragement by staff. Relying on volunteer organization to continue these activities is less likely to be effective in the long run.^[120]

Looking Into the Future

As we move into the future, we will be called on to support (or be part of) a growing population of older adults with age-related physical, cognitive, and social challenges. Compared to today's seniors, in the future more will be comfortable with technology from their earlier work and personal lives. More of them will be likely to already play digital games.

As we have seen, digital games can contribute in many ways to managing these challenges and helping our seniors to maintain and enhance their health and quality of life. Game technology will evolve with more realistic graphics, virtual reality, augmented reality, more sensitive speech and gesture recognition, new interfaces, and other improvements that will make digital games easier to use and more engaging for older adults. However, today's digital game industry seems to largely ignore the older adult market. As this population grows, we hope that more games will be offered by commercial game companies specifically for this audience, both for educational and entertainment purposes.

We envision digital games as supportive activities for seniors at home, in residences, and in community programs aimed at recreation and fun as well for their physical, cognitive, and social benefits. This paper has been an overview of where we are now; we look forward with excitement to the future.

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