Chapter 6
Can Mobile Digital Games Benefit Older Adults' Health?

Emmanuel Duplàa, David Kaufman, Louise Sauvé, Lise Renaud, and Alice Ireland

Abstract Aging adults face many challenges, including declining physical and cognitive abilities, loss of companions and social support, family changes, loss of professional identity, changing lifestyles, and increasing likelihood of developing chronic and debilitating disease. Evidence suggests that digital games can improve older adults' quality of life through improved physical, cognitive, and social health as well as general psychological wellbeing and emotional health. Benefits demonstrated in research studies have varied with game characteristics, study methodologies, and outcome measures, so generalising across studies is difficult, but our review highlights the potential for mobile digital games to improve older adults' lives as they increasingly appear on common, accessible mobile devices.

6.1 Introduction

The proportion of people aged 60 and older is increasing faster than other age groups and is expected to increase to two billion by 2050 (World Health Organization 2002). In the USA, one million people reach the age of 65 each year, and in 2020, almost 30% of the population will be over 65 (Allaire et al. 2013). In Canada in 2010, almost five million people were 65 years of age or more, and by 2036, there will be more than ten million (Human Resources and Skills Development Canada

E. Duplàa (✉)
Faculty of Education, University of Ottawa,
145, Jean-Jacques-Lussier, Ottawa, ON, K1N 6N5, Canada
e-mail: eduplaa@uottawa.ca

D. Kaufman • A. Ireland
Faculty of Education, Simon Fraser University, Burnaby, BC, Canada

L. Sauvé
Department of Education, Téléuniversité, Université du Québec, QC, Canada

L. Renaud
Faculty of Communication, Université de Québec à Montréal, Montréal, QC, Canada

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2011). Aging older adults face many challenges, including declining physical and cognitive abilities, loss of companions and social support, family changes, loss of professional identity, changing lifestyles, and increasing likelihood of developing chronic and debilitating disease.

Information communication technologies (ICTs) can offer ways to mitigate these challenges. Older adults increasingly use ICTs in their daily lives. ICTs, including digital games and mobile technologies, can help to improve older adults' safety at home, provide more access to information, increase family and social interaction, and increase older adults' life satisfaction and self-esteem (Fausset et al. 2013; Hwang et al. 2011).

Both digital games and mobile technologies are increasingly popular among older adults. In 2007, 27% of Canadian 45–64-year-olds and 36% of those 65 and over were playing digital games, positioning games as this population's third most common technology-related activity in that year, after email and online search (Statistics Canada 2007). In the USA, 78% of adults aged 65+ owned cell phones in 2015 and 30% owned smartphones, while the percentage of smartphone owners among all adults had increased from 35 to 68% since 2010 (Anderson 2015). In 2014 in Canada, 61% of seniors owned cell phones and 14% owned smartphones (Oliveira 2014). Thirty-two percent of Americans aged 65+ owned tablets in 2015, while 45% of all adults did so – an increase from only 4% in 2010 (Anderson 2015).

While their popularity has grown, digital games have become effective ways to enhance older adults' health and quality of life. They can engage players physically, mentally, and socially, educate them about health behaviors, support disease management and rehabilitation, and promote change to healthier activities and lifestyle choices (Wattanasoontorn et al. 2013). While research has documented benefits of digital gameplay on computers and game consoles, mobile games' potential in these areas is just beginning to be realized and studied.

This chapter reviews the potential benefits of mobile digital games for older adults' health and quality of life. Because research on mobile digital games is relatively new, the review relies on a qualitative meta-analysis (Bland et al. 1995) of research on digital games in general, summarizing areas in which evidence has been found for health-related benefits for older adults. This is extended to include game examples, whether or not rigorously evaluated, specifically for mobile games. The overall purpose of this chapter is to summarize key benefits of digital games for older adults' health and quality of life and to point to how these are likely to be realized in the near future.

6.2 Older Adults, mHealth, and Digital Games

Statistics Canada (2014) defines older adults as those aged 65 and older, but some reports distinguish a next generation aged from 55 to 64 years (Statistics Canada 2007). Definitions vary in the literature on digital games, with some studies

including adults starting at age 55. No studies have focused on the oldest old – adults aged 85 years or more (Marston et al. 2016).

The term "mHealth" has evolved from earlier terms describing applications of technology to health. Initially, the definition of "telemedicine" by Perednia and Allen (1995) was one of the most cited in the medical and paramedical literature, covering the use of communication and information technologies to deliver medical services remotely. The term grew to include clinical acts and the doctor-patient relationship, mediated by technology (e.g., Serafini 1995; Strode et al. 1999).

More recently, the concept of "eHealth" has appeared, based on the analogy with other e-domains such as eBusiness and eLearning. This combines medical computing with a business development perspective that views patients as clients who are actively involved in managing their own health, supported by technology (Alvarez 2002; Eysenbach 2001). It also extends medical training beyond students and medical staff to the general public through sites and applications including digital games (Raffelini 2005). Today, by extension, "mHealth" is defined as a component of eHealth: "mHealth or mobile health is the realization of medical and public health supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices" (Misha 2011, p. 6). mHealth extends telehealth in part by linking patients with medical personnel through convenient devices and improving medical data collection and patients' access to health care (Agarwal and Lau 2010). Several recent studies have documented mHealth applications for older adults (Baldwin et al. 2015; Kampmeijer et al. 2016; Silva et al. 2015). However, games are mentioned rarely in these reviews.

6.3 Older Adults and Quality of Life

Digital games are often cited as tools to improve quality of life for older adults. Although it has been difficult to build a consensus on what "quality of life" means (Kuyken 1995), the most widely used definition is that of the World Health Organization (1993). This provides a context for our review, defining quality of life as an individual's perception of their position in 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 interrelated dimensions including a person's physical health, psychological state, level of independence, social relationships, personal beliefs, and relationships with characteristics of their environment. Chen et al. (2012) similarly define quality of life as a multidimensional concept that includes individual subjective perceptions on physical health, psychological state, relationships, and interactions with the environment. Four dimensions of health-related quality of life that have been studied with respect to digital games and older adults are physical health, cognitive abilities, social connectedness, and subjectively reported psychological well-being.

6.3.1 Physical Health

Aging brings about a decline in physical capacity. Usually from age 75 (although this varies with the individual), older people require different levels of daily support services to maintain their independence in the face of chronic health issues and/or cognitive problems (Daniel 2012). Physically, older adults are at increased risk of falls and major health risk factors. These risk factors include impaired muscle strength and poorer postural balance (Jorgensen et al. 2013) as well as fatigue, exhaustion, slow gait, and unintentional weight loss (Daniel 2012). For example, in 2009, 8.3% of men and 9.8% of women aged 65 or older were injured seriously enough to limit their usual activities, and 63.7% of these injuries were due to falls (Statistics Canada 2015). To overcome this, physical exercise is often recommended for the frail elderly as an intervention to restore muscle strength and agility (Daniel 2012). Many interventions have been proposed, with varying degrees of success, to improve balance in older people (Bieryla and Dold 2013).

6.3.2 Cognitive Abilities

A number of dimensions link cognition and aging. According to Brickman and Stern (2009), aging increases a person's chances of developing a neurodegenerative disease such as Alzheimer's disease. Cognitive deficits associated with age have been identified in working memory (Bopp and Verhaeghen 2005), reasoning (Schaie 1996), and episodic memory (Salthouse 1996). Other research highlights dementia, which is a severe loss of memory, attention, language, and problem-solving ability (Bishop et al. 2010; Salthouse 2009), and identifies less serious deficiencies in the operation of attention, problem-solving, information processing speed, spatial orientation, and divided attention (Basak et al. 2008). Cognitive function is an important indicator of the ability of older adults to maintain their independence, engagement, and health (World Health Organization 2002).

6.3.3 Social Connectedness

Social connectedness and relationships are significant influences on health-related behaviors and health outcomes (Christakis and Fowler 2007; Elwert and Christakis 2008; Stowe and Cooney 2015). For example, Christakis and Fowler (2007) found that the influence of social networks extends up to three degrees (i.e., friends, friends of friends), and certain health conditions are more influenced by friends than by closer relationships, including spouses. Gorin et al. (2008) showed that when one partner is enrolled in a weight reduction program, the likelihood of weight loss also increases for the non-registered partner. Putnam (2000) found that people who have

close social networks experience lower rates of sadness, loneliness, low self-esteem, sleeping problems, eating problems, and likelihood of death.

Social isolation is a lack of social connectedness or the objective state of having minimal contact with others (Wenger et al. 1996). Social isolation is associated with health because isolation can be caused by mental disorders, distress, or poor health (Ellis and Hickie 2001) and can lead to loneliness, sadness, and boredom (Grenade and Boldy 2008). Loneliness (defined as distress about the quality of one's social relationships) is related to numerous psychosocial risk factors including increased blood pressure, depression, impaired mental function, nursing home admission, and mortality (Hawkley et al. 2010).

6.3.4 Psychological Well-Being

Overall psychological well-being is linked to physical and cognitive health and social connectedness. Depression, poor coping skills, and a weakened sense of self-efficacy all appear to contribute to older adults' dependence, development of disease, and early mortality (World Health Organization 2002). The complex phenomenon of well-being for older adults has both objective and subjective aspects (Jeste et al. 2010). Psychological health is crucial for older adults' quality of life, and aspects such as optimism, sense of purpose, and positive attitudes are linked to longer life spans (Jeste et al. 2010; Maier and Smith 1999). However, it is important to note that subjective well-being is not synonymous with objective health but is, instead, a reflection of a person's inner satisfaction with their life situation (Stowe and Cooney 2015, citing Havighurst 1963).

6.4 Benefits of Digital Games for Older Adults

Digital games are becoming accepted as tools for improving health, and research is providing increasing evidence of their effectiveness, although reviewers have questioned the quality and consistency of many studies (Bleakley et al. 2015; Primack et al. 2012). Primack et al., in a review of the literature up to 2010, found evidence from randomized controlled trials for positive outcomes of digital game applications to physical therapy, psychological therapy, physical activity, health education, pain distraction, and disease self-management. Eight of the 38 studies that the authors reviewed targeted adults aged 50–80. Bleakley et al. reviewed literature up to 2011 for the effects of exergames on adults older than 65 years and found some evidence for a range of physical and cognitive benefits.

Although this book focuses on mobile eHealth, our review has not been limited to mobile applications because research on these specifically for older adults is new and limited and tends to address design issues rather than evidence of effectiveness. However, mobile devices, tablets in particular, are often recommended for older

adults due to their simpler interfaces, and migration to mobile devices of the types of applications described here will naturally happen over the next few years. Therefore, these examples are good indicators of the future direction of mobile, game-based eHealth for older adults.

6.4.1 Physical Benefits

"Exergames," which are video games that combine play with significant physical exercise using physical input devices (e.g., Nintendo Wii, Microsoft Xbox 360 Kinect), have been suggested as an innovative approach to improve physical activity among older adults (Larsen et al. 2013). Exergames rely on motion tracking to translate players' physical actions into game actions (e.g., bowling, dancing) and scores on a screen. Exergames' popularity has grown rapidly within the older adult population (Maillot et al. 2012). The health benefits of exergames have been widely researched. Larsen et al. (2013) analyzed four electronic databases on exergames and found positive effects of exergaming on older adults' physical health, although they could not easily compare the studies due to methodology variations.

Wiemeyer and Kliem (2012) surveyed the scientific literature on the impact of "serious" exergames aimed at disease prevention, injury prevention, and rehabilitation for older adults. They found at least partial support for using these games to improve energy expenditure, strength, basic motor control, and various nonphysical measures of well-being. The games also increased patients' motivation to adhere to their recommended chronic disease treatments over time.

In a randomized controlled experiment comparing no exercise, seated exercise, and Wii Fit gameplay for systematic Progressive Functional Rehabilitation (PFR), Daniel (2012) examined the effectiveness of 15-week interventions on indices of physical frailty among 19 older adults. Their Wii Fit group showed improved physical function and strength equivalent to the seated-exercise group, and the Wii Fit group showed higher caloric consumption relative to the other groups. Daniel concluded that a physical activity program based on exergames offers advantages over seated-exercise programs and is an option for older adults with limited access to organized exercise programs. Additionally, she noted that Wii games are varied and interactive, providing older adults at home with a wider variety of exercises than the standard exercise protocol.

Three other Wii Fit studies add to positive results for exergames. Singh et al. (2013) measured improvements for 36 elderly Malaysian women in flexibility, balance, and functional mobility, comparing six-week-long therapeutic balance exercise group to a digital gaming group using the Nintendo Wii Balance Board. They found that the older women who regularly played with the Wii improved on all three measures identically to the comparison group. Jorgensen et al. (2013) found that biofeedback-basic Nintendo Wii training resulted in significantly higher maximal voluntary contraction strength and high motivation, compared to a control group, among the 58 participants who completed the trial. Similarly, Bieryla and Dold

(2013) conducted an experiment with 12 healthy older adults and found that their Wii Fit experimental group significantly increased their BBS measure of balance after one month of training, compared to the normal activity control group. However, 3 other tests showed no significant changes.

Kinect exergames are a key part of a system developed by Gschwind et al. (2015) (www.istoppfalls.eu) to deliver an unsupervised exercise program to older adults at home. Results from their international multicenter randomized controlled trial, which included 153 participants aged 65-plus years, show that use of the application led to significant reductions in measures of physiological fall risk and postural sway, along with improved stepping reaction time. The authors conclude that more work is needed to optimize adherence to the program.

Taken together, these studies confirm that exergame-based training can lead to improvements in physical strength and balance, as measured by certain types of tests, even if additional research must be conducted to understand how. Strength and balance are crucial for maintaining daily function and preventing debilitating falls in older adults (World Health Organization 2016). However, the games in these studies are far from mobile in that they require a dedicated game machine anchored to a single location.

Moving to an exergame only available on mobile device, Kerwin et al. (2012) developed the mobile game prototype *Dance! Don't Fall* to encourage physical activity and monitor gait and fall risk in older adults. Based on a smartphone sensor worn against a player's lower back that communicates with a video display, the game teaches a single-person dance routine and gives feedback on a player's performance. Although Kerwin et al. have not done a controlled evaluation, their initial user evaluation results for the game were positive, and the project has expanded into a larger "Active@Home" fall prevention initiative (Fraunhofer Portugal 2016).

Konstitinidis et al. (2015) point to another form exergaming on mobile devices, citing examples of GPS-based mobile apps with city visualizations to encourage players to walk, run, or exercise outdoors. The commercial game *Pokemon Go* (http://pokemongolive.com/en/) adds to this approach by augmenting reality to include virtual creatures to track and capture. These examples rely on increasingly powerful web-based game engines. Although they are not so far aimed at older adults, it is not hard to imagine physical games and activities directed by mobile devices designed especially for this group to maintain and improve physical health and fitness.

6.4.2 Cognitive Benefits

As with physical benefits, the cognitive effects of digital games for older adults have been widely studied. A survey by Kaufman et al. (2016b) of 463 older Canadian adults found that mental exercise, fun, and several specific cognitive improvements (attentional focus, memory, reaction speed, problem-solving, and reasoning) were the most frequently self-reported benefits experienced from digital gameplay.

Several types of games, including some not specifically designed for cognitive training, have been shown to enhance cognitive function, although evidence is inconsistent due to variations in study methodologies (Zhang and Kaufman 2016b).

Traditional Digital Games In an early controlled experiment, Goldstein et al. (1997) studied the effects of video games like *Tetris* on older adults' reaction time, visual/cognitive adaptability, and emotional well-being. After 25 h of gameplay, the authors found a significant improvement for the experimental group in reaction time as well as a weak increase in emotional well-being; however, no difference was found in post-gameplay visual/cognitive adaptability between the two groups. Goldstein et al. warned that the relative increase in well-being could have been associated with other experimental factors such as the presence of the attendant, weekly visits, or voluntary participation in the study.

Belchior et al. (2013) examined the comparative effect of four types of training on useful field of view (UFOV) performance (processing speed, divided attention, and selective attention) for 58 older adults. Experimental groups played *Medal of Honor* or *Tetris* or had clinically validated UFOV training over 2–3 weeks. The three experimental groups all increased their visual performance significantly over the control group. The *Tetris* group also increased selective visual attention among the older adults, which was not the case for the same experiment with young adults (Green and Bavelier 2003). The authors interpreted this result to suggest that the *Tetris* game challenged their cognitive, perceptual, and motor skills more than it would have for young adults who are already familiar with digital games.

Using a game that required visualizing movement in three dimensions, Whitlock et al. (2012) studied improvements in 39 older adults' of multitasking, reasoning, and spatial memory during 2 weeks of 1-h play sessions with *World of Warcraft*, in which they completed specific challenges. They found improvements in attention control, orientation and mental rotation, recognition memory, and reasoning, and those with weaker computer skills benefited most from the game.

The games *Tetris* and *Medal of Honor* are available in mobile versions, suggesting that the cognitive benefits identified in these experiments could also be achieved on smartphones or tablets once usability issues are addressed that might deter older adults from playing on these devices.

Brain-Training Games Various games have been widely marketed and tested as tools for maintaining cognitive capacities such as memory, focus, and processing speed, with mixed results. In a significant study, Wolinsky et al. (2013) found that healthy adults over age 50 improved their concentration, speed, and agility in task switching after training for an average of 9.2 h with the game *Road Tour*, as compared to solving crossword puzzles. In Japan, Nouchi et al. (2012) examined the positive effects of the use of brain-training games on 32 older adults in Japan who played *Brain Age* or *Tetris* at home on a Nintendo DSi game console for 15 min per day, 5 days per week for 4 weeks. Effects of playing *Brain Age* were higher than those for *Tetris* for all measures of executive function and for two measures of processing speed.

Using an electrophysical test after 20 1-h training sessions with the commercial brain-training game *Lumosity*, Mayas et al. (2014) found significantly reduced distraction and increased alertness in their experimental group of healthy older adults with no previous video game experience, compared to their control group.

However, some results have been less conclusive. Miller et al. (2013) found only a gain in delayed memory function, but not in immediate memory or language, in 133 dementia-free older participants that used a computerized brain-training program for 20 min per day, 5 days per week for 2–6 months. Ballesteros et al. (2015) found that after playing brain-training games (*Speed Mach*, *Memory Matrix*, and others) for 3 months, there were significant improvements in their experimental group's attention, processing speed, memory, and subjective well-being, but the cognitive improvements disappeared after 3 months without play. Finally, Boot et al. (2013) found no significant improvements in cognitive abilities for groups playing *Brain Age 2* or *Mario Kart DS2* for 1 h per day, 5 days per week for 12 weeks, compared to their control group.

In a comprehensive study, Simons et al. (2016) reviewed all available research and company evidence about brain-training applications that use cognitive training or games to enhance performance on other tasks. They concluded that many studies have shown benefits of training on closely related tasks, but few studies have provided evidence for transfer from one cognitive domain to another. None of the studies in this review provided compelling evidence consistent with broad-based, real-world cognitive benefits from brain-training interventions. The reviewers judged this difference between hypothesized benefits and results to be due to methodological weaknesses, since few of the studies conformed to best practices for the design and reporting of intervention research.

Mobile brain-training games (apps) are widely available; for example, see Dredge (2016). Dredge points out that evidence about their effectiveness is indeed questionable and that at least one company has been fined for unproven advertising claims. He does note, however, that these games can be entertaining and appealing to older adults.

Experimental Games In addition to commercial brain-training games, some researchers have developed their own games to measure specific effects on older adults' health. ELDERGAMES (Gamberini et al. 2006, 2009) and HERMES (Buiza et al. 2009) have used custom-built games for older adults' cognitive training, although they have not provided evidence of their effectiveness. The SAVIE group at Téléuniversité, Université du Québec, has a long history of developing "frame games" for playfully delivering learning content; several of their games have been redesigned to meet older adults' usability needs and are now being converted to tablet format (Kaufman et al. 2016b; Sauvé et al. 2015; Seah 2015).

Zviel-Girshin et al. (2011) built a gaming platform specifically designed for older adults, the *Play System for Elderly Therapy (PSET)*, containing several games and diagnostic tests. The system could diagnose and treat cognitive problems by allowing the patient or the therapist to select a specific game, a program of tests, or treatments. Evaluation results showed that patients who used the system had fun

supplementing their therapy sessions. Therapists, for their part, appreciated the opportunity to work with several patients simultaneously. Although no specific results were reported in terms of cognition, the project enhanced work on the therapeutic process.

To support a set of studies, Anguera et al. (2013) developed the three-dimensional game *NeuroRacer*, with challenge levels customized to individual players' abilities. It was used to test whether older adults' multitasking performance could be improved through training. First, using the game with a sample of 20–79-year-olds, they found that multitasking performance declines linearly with age. Second, they tested the impact of the game on adults aged 60–85. After playing for 1 h, three times per week for a month, tests showed that the multitasking group had significant reduction in multitasking costs compared to the single-task and control groups. In addition, electroencephalography tests showed that they had returned their key neural indicators of cognitive control to levels normally seen in 20-year-olds, and these gains persisted for 6 months after training. The authors concluded that these results provide evidence that a custom-designed video game can be used to assess and improve cognitive ability and its underlying neural mechanisms throughout life.

In a project aimed at cognitive diagnosis and monitoring, a team from two Canadian universities has produced a tablet-based *Whack-a-Mole* game to remotely monitor inhibition and processing speed for patients with moderate dementia (Guana 2016). This combines mobile monitoring technology with a game that is simple and familiar to older adults.

Physical Games Exergames have been shown to produce cognitive, as well as physical, benefits for older adults. Maillot et al. (2012) found that a 12-week Wii-based physical training program for sedentary older adults, using a variety of games that challenged different physical and cognitive abilities, significantly improved game performance, physical function, executive control, and processing speed compared to the control group. The players did not, however, improve their visuospatial functions.

Avoiding cognitive decline allows older adults to continue to function effectively in everyday life and to safely carry on activities that they enjoy. There is at least some evidence that conventional digital games, brain-training games, experimental digital games, and exergames can all enhance older adults' cognitive function, and many of these are now or will be available on mobile devices, contributing to the health of the aging population.

6.4.3 Social Benefits

Digital games can also offer older adults benefits in terms of social contact and support. Because it is more difficult to carry out controlled experiments to confirm these benefits, researchers have tended to rely on qualitative research and observation. For example, McLaughlin et al. (2012), using focus groups and qualitative

analysis of players' comments while playing an exergame, found that these games are increasingly social activities for older adults. In an experiment using exergames with older women, Wollersheim et al. (2010) studied both the physical and psychosocial aspects of gameplay for 11 older women who played *Wii Sports* games twice per week for 6 weeks.

Interviews highlighted that the participants were forced out of their comfort zones by the game. The game also challenged their perceptions of themselves; before playing, they saw themselves as old and disconnected from the world, but after the experiment they felt younger and less disconnected. They also self-reported improved physical and social well-being and deeper social connections and shared experiences with younger family members. The authors concluded that the digital game helped to break players' isolation and decreased their feelings of loneliness. However, they cautioned that their gameplay environment, with regular technical support from researchers and constant verbal encouragement for the players, could not be generalized to independent home gameplay.

Theng et al. (2012) studied the use of Wii-based exergames for enhancing attitudes of younger and older generations toward each other. For this study, 14 teams of older adults paired with 17- or 18-year-olds participated in 6 recorded game sessions, with data gathered through pre- and post-surveys and post-gameplay individual interviews. Their results showed that the gameplay had positive results for participants' social activity, intergenerational social ties, and attitudes toward other generations, although design issues limited the games that the older adults could comfortably play.

In a controlled experiment, Chen et al. (2012) examined the benefits from the use of Xbox 360 Kinect SVG exergames on the physical and mental health of institutionalized older adults with disabilities. Sixty-one participants were divided into an experimental group, who played for three 30-min sessions per week for 4 weeks, and a control group that continued regular activities. Study results found that social functioning showed a significant increase after the experiment. However, there were no significant differences between groups in vitality, general mental health, or role limitations due to emotional problems.

In another study, Mubin et al. (2008) developed an interactive mobile social game, *Walk 2 Win*, incorporating older adult feedback gathered throughout the game's design, construction, and testing. *Walk 2 Win* is a memory game that can be played individually or in teams using smartphones. Evaluation results for both types of play, by eight older adults in 2-h sessions, showed that older people are eager to play simple games with simple rules but are not confident in their skills for playing fast games. On the social level, the study participants expressed a strong preference for more social team play, especially with their grandchildren.

Al Mahmud et al. (2010), testing their tabletop card-guessing game with older adults at a community center, concluded that the rules of the game greatly influenced social interaction among players. They recommended that game rules encourage cooperation among team members and social interaction with members of other teams. They also found that the older adults in their study appreciated opportunities to play with younger family members.

Schell et al. (2016) found that for 73 players, levels of social connectedness increased significantly, and loneliness decreased significantly, after playing in a team-based *Wii Bowling* tournament for eight weeks. Qualitative evidence from this study described how players built new friendships and continued new social interactions after the tournament. Schell et al. concluded that digital games are an enjoyable leisure activity that can help older adults to maintain and enhance their social contacts, offsetting possible increased isolation as they grow older.

Combining social interaction and health-related learning, Seah (2015) found that social interaction while playing an online *Bingo* game significantly improved 50 older adults' self-reported social connectedness. In this game, older adults were also able to learn about healthy living and nutrition through questions and answers built into the game. The combination of social interaction and learning was highly valued by subject participants.

Games played online or on social networks link players to enable socializing along with gameplay (Kirman et al. 2011). In one example, Cornejo et al. (2012) found that an older adult and her relatives who tested a Facebook-based social digital game for 5 weeks were enthusiastic about its potential to reduce loneliness and increased social interaction with their family networks during and after the research project.

Massively multiplayer online role-playing games (MMORPGs) such as *World of Warcraft* (*WoW*) offer immersive worlds that are based on social interaction with other players in persistent, online virtual environments. In a questionnaire-based study of older adult *WoW* players, Zhang and Kaufman (2015) found a link between enjoyment of relationships within the game and the development of online bridging and bonding social capital that built and sustained their social networks. Zhang and Kaufman (2016c) reported that playing MMORPGs offered older adults ways to nurture off-line relationships with family and real-life friends and to construct new meaningful and supportive relationships with friends in the game. Zhang and Kaufman (2016a) highlighted the importance of intergenerational digital gameplay for forming stronger relationships and more favorable opinions across younger and older generations.

These studies illustrate the social benefits of digital games usually played on computers or game consoles. Some of these are now, or will soon be, available on mobile devices; for example, the *Bingo* game cited above is being rewritten as a tablet application to make it more easily accessible to older adults, and Facebook games are readily available online through smartphones and tablets. By supporting social interaction and social networks for older adults, these digital games promise to help to increase their enjoyment of leisure time, sustain relationships that mean so much for their quality of life, and so contribute to their health and well-being.

6.4.4 *Benefits for Psychological Well-Being*

Psychological well-being encompasses mental and emotional health and subjectively perceived well-being. Several types of games have been shown to contribute to these.

Exergames Wiemeyer and Kliem (2012) reviewed exergames for health using Mueller et al.'s (2011) framework, which emphasized positive effects on psychological, behavioral, and social health in addition to physical condition. Wiemeyer and Kliem's conclusions highlighted exergames' positive effects on intrinsic motivation, attitude, self-control, and self-efficacy.

In another study of exergames, Rosenberg et al. (2010) assessed the feasibility, acceptability, and short-term effects of Nintendo *Wii Sports* exergames practiced by 19 American older adults with subsyndromal depression. Their results after 12 weeks of play showed significant improvements in depressive symptoms, mental health, and cognitive functioning, as well as the absence of major side effects, although there were no significant changes in physical health or anxiety. They concluded that these games are likely to be a new way to improve symptoms of older adults with subsyndromal depression.

Participants in the Wollersheim et al. (2010) study reported that, in addition to improved physical and social well-being, they experienced a sense of empowerment and improved psychological well-being as they learned to play the games despite physical frailty and shared new social experiences and connections.

Advergames Digital "advergames" – a "persuasive technology" designed to change attitudes or behaviors (Fogg 2003, p. 1) – are widely used in health promotion. The literature is sparse to date on advergames aimed specifically at older adults, but there is evidence that they are effective across a range of age groups (DeSmet et al. 2014). Lieberman's (2001) experiments with advergames for children found that they positively affected self-esteem, self-efficacy, knowledge and competence, communication, and social media; although this study was not directed at older adults, it confirms Wiemeyer and Kliem's argument that games are likely to have a role to play in maintaining and enhancing older adults' motivation and emotional health.

Brown-Johnson et al. (2015) demonstrated the power of an iPad-based learning game, *mHealth TLC*, to improve patient-physician communication using virtual clinical visits. Although they were concerned about its emotionally charged content, eight users rated the game engaging, believable, clinically appropriate, and helpful for supporting lung cancer patients, its target audience. While this game was not aimed at older adults, the study suggests that learning through mobile games may have the potential to positively affect older adults' medical communication and care.

Other Games Beyond advergames, various studies have analyzed the impact of games on emotional health when they are primarily intended for other purposes. Boot et al. (2013) and Chen et al. (2012) found no significant impact on emotional

well-being, although both studies measured this outcome. However, Goldstein et al. (1997) noted that their participants experienced greater emotional well-being than the control group after the study, either as a result of playing *Tetris* or of being part of a game experiment. In their experiment with brain-training games, Ballesteros et al. (2015) found significant improvements in the affection and assertiveness components of self-reported well-being that remained after three months without play.

In a study focused on socio-emotional functioning, Allaire et al. (2013) surveyed overall wellness, positive emotion, negative emotion, and depression among 140 older adults divided into three groups: non-players (40%), casual gamers (25%), and regular players (35%). They found that casual and regular gamers reported significantly greater well-being than non-gamers as well as lower levels of negative emotions and, to some degree, lower levels of depression. The three groups did not show any difference in their level of positive emotions, social functioning, or self-rated health. The researchers suggest that their results might indicate that digital games serve as a source of entertainment, similar to other leisure activities, which can increase older adults' well-being and reduce depression.

The game types studied here are all moving to mobile devices, as noted earlier in this chapter. This section has shown that psychological well-being promises to be an important benefit (or side effect) of these mobile games, enhancing older adults' health and quality of life.

6.5 Health Benefits by Type of Game

Digital games in several categories, some now available on mobile devices, have been shown to benefit older adults' physical, cognitive, and social health as well as their general psychological well-being and emotional health. The benefits that have been demonstrated in research studies have varied with game characteristics, study methodologies, and outcome measures; it is difficult to generalize across studies even when they use randomized, controlled research design (Bleakley et al. 2015). Tables 6.1, 6.2, and 6.3 summarize by type of game the studies and benefits covered in this review.

Exergames (Table 6.1) have been widely studied and have produced benefits in all categories: physical, cognitive, social, and psychological. Documented results sometimes depend on the test used (e.g., for physical balance), the health profile (e.g., depression for non-symptomatic people), or rules that encourage particular types of interaction (e.g., for social games). Some exergames are available on mobile devices, while others are not. With many potential benefits, these games can reduce treatment costs while minimizing the risk for older adults of physical accidents and can support maintenance of all aspects of health discussed here. Finally, these types of games can support mobility in the present and future; for example, Daniel (2012) argues that older adults should invest in personal game consoles to support their own exergame regimes. This brings us to a view of exergames as evolving mobile tools for physical and cognitive support as well as for social connectedness (Crompton 2013).

Table 6.1 Summary of studies and outcomes: exergames

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Physical health					
Larsen et al. (2013)	Electronic database review	Seven studies	311 older adult (OA) participants	Positive impact on *physical health* in six of seven studies	Methodological differences made comparing studies difficult
Wiemeyer and Kliem (2012)	Literature review	Serious games (SGs) for health and rehabilitation	80 references	Partial support for using SGs to improve *energy expenditure*, *strength*, *basic motor control*, and some *nonphysical measures of well-being* Increased *patient motivation* for treatment adherence	Found few good-quality studies with OAs. Need work on how to achieve long-term motivation and engagement
Daniel (2012)	Randomized controlled trial (RCT)	*Wii Fit*	19 OAs: 15 weeks, 3x/week for 45 min	*Physical function* and *strength* improvements; higher *caloric consumption* than control group	Variety of Wii games makes them attractive to older adults
Singh et al. (2013)	RCT	*Wii Balance Board*	36 older women: 6 weeks, 2x/week for 40 min	Improved *flexibility*, *balance*, *functional mobility* equivalent to control group	
Jorgensen et al. (2013)	RCT	*Wii Fit*	58 OAs: 10 weeks, 2x/week for 35 min	Higher *maximal voluntary contraction strength*, high *motivation*	
Bieryla and Dold (2013)	RCT	*Wii Fit*	12 OAs: 3 weeks, 3x/week for 30 min	Improved BBS *balance* measure	No significant change in three other balance measures

(continued)

Table 6.1 (continued)

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Gschwind et al. (2015)	RCT	Kinect custom balance- and strength-training games	153 OAs: 16 weeks, 180 min/week	Significantly improved *physiological fall risk*, *postural sway*, *stepping reaction time*	Improvements were associated with better adherence to the training program
Kerwin et al. (2012)	User testing	*Dance! Don't Fall* mobile game	10 OAs completing 5 tasks	Positive user response with feedback on suggested improvements	Needs more variety and higher levels to engage users over time
Konstitinidis et al. (2015)	Review/position paper	GPS-based mobile games		Reviews newer technologies for mobile exergames	
Wollersheim et al. (2010)	Experimental study (ES)	*Wii Sports* games	11 older women, 6 weeks baseline period +6-week intervention period, 2x/week for mean time of 51 min	Participants perceived improved *physical well-being*	Support and encouragement from other players and researchers maintained player engagement
Cognitive health					
Maillot et al. (2012)	RCT	Cognitive effects of Wii training with Balance Board	32 OAs: 24 1-h training sessions	Significant improvements in *executive function* and *processing speed tasks*	Exergames found to be more engaging, which may partly explain improvements compared to other exercise

Social health					
McLaughlin et al. (2012)	Observation and focus group study	*Boom Blox* (Wii exergame)	13 OAs	Identification of OAs' costs and benefits associated with playing a digital game. *Social interaction* is an important benefit	Usability issues and cognitive challenges from poor game design can discourage play and negate potential benefits
Wollersheim et al. (2010)	See above	See above	See above	Deeper *social connections*, *shared experiences* with younger family members, *decreased loneliness*, *improved sense of social well-being*	
Theng et al. (2012)	ES	Wii games	14 teams of OAs and teens, playing for 6 sessions	Positive results for social *activity*, *intergenerational social ties*, *attitudes toward other generations*	Older adults' play was limited by playability issues
Chen et al. (2012)	ES with control group (CG)	Xbox Kinect games	61 institutionalized OAs with disabilities: 4 weeks, 3x/week for 30 min	Significant increase in *social functioning*	No difference in vitality, general mental health, or role limitations
Schell et al. (2016)	Mixed-methods study	*Wii bowling*	73 OAs in teams in an 8-week tournament	Significantly *increased social connectedness*, *decreased loneliness*, *new friendships*, *continuing new social interactions*	

(continued)

Table 6.1 (continued)

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Psychological well-being					
McLaughlin et al. (2012)	See above	See above	See above	*Self-esteem*, *fun*, *positive emotions*, *learning* observed as benefits	See above
Wiemeyer and Kliem (2012)	Literature review	Serious games for health and rehabilitation	80 references	Found positive effects on *intrinsic motivation*, *attitude*, *self-control*, and *self-efficacy*	
Rosenberg et al. (2010)	ES	*Wii Sports* games	19 OAs with subsyndromal depression: 12 weeks, 3x/week for 35 min	Significant improvements in *depressive symptoms*, *mental health*, *cognitive functioning*	No major side effects. No significant changes in physical health or anxiety
Wollersheim et al. (2010)	See above	See above	See above	Improved sense of *empowerment*, *psychological well-being*	

Table 6.2 Summary of studies and outcomes: brain-training games

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Cognitive health					
Wolinsky et al. (2013)	RCT with training groups on site or at home	*Road Tour* game	207 adults aged 65+, 413 aged 50–64: 9–13 h play	Improved *concentration*, *speed*, *task-switching agility* that held or increased at 1-year follow-up	Comparable effects for both age groups
Nouchi et al. (2012)	RCT	*Brain Age*, *Tetris*	32 OAs: 4 weeks, 5x/week for 15 min	Improved *executive function*, *processing speed* for *Brain Age* players compared to *Tetris* players	
Mayas et al. (2014)	RCT	*Lumosity*	27 OAs: 10–12 weeks, 20 × 60 min	*Reduced distraction*, *increased alertness*	
Miller et al. (2013)	ES	*Brain Fitness*	Convenience sample of 69 OAs: 5x/week, 20–25 min. Evaluated at 2 and 6 months	*Improved delayed memory function*. No improvements in immediate memory or language	Those who played at least 40 sessions over 6 months improved in all 3 domains
Ballesteros et al. (2015)	RCT	*Speed Mach*, *Memory Matrix*, others	30 OAs: 10–12 weeks, 20 × 1 h play sessions	*Improved attention*, *processing speed*, *memory*	Cognitive improvements disappeared after 3 months without play
Boot et al. (2013)	RCT	*Brain Age 2*, *Mario Kart DS2*	62 OAs: 12 weeks, 5x/week for 1 h	No improvements in cognitive abilities	Action game viewed as less enjoyable

(continued)

Table 6.2 (continued)

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Simons et al. (2016)	Literature and company information review	Brain-training tasks and games	Info on games and training programs for cognitive improvement	Found extensive evidence of improvements in *train task performance*. Less or no evidence that improvements transfer to related or non-related tasks	Found significant deficiencies in study design and implementation. Recommends best practices for evaluating brain-training claims
Psychological well-being					
Ballesteros et al. (2015)	See above	See above	See above	Increases in the *affection and assertiveness component subjective well-being* that persisted after 3 months without play	

Table 6.3 Summary of studies and outcomes: traditional digital games

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Cognitive health					
Kaufman et al. (2016b)	Survey	Perceived benefits from digital gameplay in general	463 OAs	*Mental exercise*, *perceived improvements in attentional focus*, *memory*, *reaction speed*, *problem-solving*, *reasoning*	
Zhang and Kaufman (2016b)	Systematic literature review	Cognitive impacts of digital gameplay in general, including exergames	26 studies on OAs	Some evidence that games can *mitigate cognitive decline*	Few rigorous studies found; inconsistent evidence due to methodology variations
Goldstein et al. (1997)	RCT	*Super Tetris*	22 OAs: 5 weeks for 5 + h/week	Significant improvement in *reaction time*	No significant improvement in cognitive/perceptual agility as measured by the Stroop Color and Word Test
Belchior et al. (2013)	RCT	*Medal of Honor*, *Tetris*	58 OAs: 2–3 weeks, 6 × 90 min	Improved *visual performance* (unified field of view), *selective visual attention*	
Whitlock et al. (2012)	ES	*World of Warcraft*	39 OAs: 2 weeks, 14 h	Improved *attention control*, *orientation and mental rotation*, *recognition memory*, *reasoning*	Greater benefit for those with weaker computer skills
Psychological well-being					
Goldstein et al. (1997)	See above	See above	See above	*Greater emotional well-being*	This outcome might be the result of study participation rather than from the game
Allaire et al. (2013)	Survey		140 OAs	Casual and regular gamers reported significantly greater *well-being* and *lower negative emotions and depression*	No differences in levels of positive emotions, social functioning, or self-rated health

Brain-training games (Table 6.2), which address cognitive health, have also been widely researched and are widely available on mobile devices. However, many study outcomes have been limited to capabilities targeted in the gameplay, and there is only limited evidence for transfer from brain-training interventions to real-world outcomes. This stands in stark contrast to the marketing claims of many companies (Simons et al. 2016). Time spent training seems to be important (e.g., at least 10 h, as Seçer and Satyen (2014) suggest), and it is important to assess cognitive benefits in the long term (e.g., some seem to fade after three months, as found by Ballesteros et al. 2015). Simons et al. (2016) point out that in order to measure the utility of a brain-training game, you must consider not only the relative benefits of different interventions but also their opportunity costs; training with a game yielding 10% better performance that takes twice as long to complete might not be worthwhile. Finally, it is important to consider that these games could also have benefits in terms of entertainment and enjoyment that outweigh their opportunity costs, even if they provide no cognitive benefits.

Table 6.3 summarizes studies on traditional digital games. There is evidence that traditional non-immersive games can improve emotional well-being along with some aspects of cognitive health, and there are indications that games with immersive environments, such as *Medal of Honor* and *World of Warcraft*, provide benefits related to cognitive and visual processing. However, today, immersive environments remain more difficult to use on mobile devices because of their size and power limitations.

Various digital games built as research projects (Table 6.4) have been shown to be effective in improving aspects of cognitive and social health. It is particularly interesting that two mobile experimental games, *Whack-A-Mole (WOW)* and the exergame *Dance! Don't Fall*, have incorporated monitoring of physical or cognitive functions, blurring the line between games and the growing group of mobile applications designed to collect data and provide health feedback to individuals and their physicians. The *Play System for Elderly Therapy (PSET)* game continues this approach by providing a playful system for facilitating the therapeutic relationship.

As online digital games (Table 6.4) increasingly become venues for socializing, either through group play or through online communities, evidence is mounting for their contributions to older adults' social health, although randomized controlled trials are limited in this area. Specific benefits, usually self-reported, include increased social interaction, reduced loneliness, feelings of social connection, general psychological well-being, and others including motivation for learning when a game includes learning content. Intergenerational exchange is often cited as a benefit for these types of games.

In addition, there is some evidence for psychological benefits arising from advergames (Table 6.4), when they improve health-related knowledge, attitudes, and/or behaviors. Researchers have also suggested that digital games in general might enhance older adults' feelings of well-being by providing new entertainment and leisure activity choices (De Schutter and Brown 2016).

Table 6.4 Summary of studies and outcomes: experimental games, online social games, and advergames

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
EXPERIMENTAL GAMES					
Cognitive health					
Gamberini et al. (2006, 2009)	Prototype development, user testing	ELDERGAMES project	107 OAs: 12 weeks of testing	Prototype measures cognitive function accurately compared to accepted scales. No cognitive improvement evaluation	
Buiza et al. (2009)	Prototype development, user testing	HERMES project	Usability testing	Usability evaluation only	
Sauvé et al. (2015); Seah (2015)	Game descriptions and user evaluations	SAVIE learning games (*Live Well, Live Healthy!*, *Bingo*, others)	Various user evaluations of PC and table-based prototypes	Ergonomic evaluations; positive user feedback about *learning experiences*	
Zviel-Girshin et al. (2011)	System description	*Play System for Elderly Therapy (PSET)*	Patient and therapist evaluations	Patients enjoyed supplementing therapy sessions. Allowed therapists to work more effectively with multiple patients	
Anguera et al. (2013)	RCT	*NeuroRacer*	174 participants aged 20–79 OAs trained for 1 h 3x/week for 1 month	Multitasking group had significant *reduction in multitasking costs* compared to the single-task and control groups. *Key neural indicators returned to 20-year-old levels* and remained after 6 months	

(continued)

Table 6.4 (continued)

Reference	Study method	Games/articles/topics studied	Sample/study duration	Outcomes/conclusions	Limitations and notes
Guana (2016)	Game prototype	Mobile *Whack-A-Mole* dementia-monitoring game	Prototype demonstration	Designed to facilitate *monitoring progress of cognitive functions*	
Social health					
Mubin et al. (2008)	Game prototype	*Walk 2 Win* mobile social memory game	Eight OAs playing in 2-hour sessions either alone or in teams	Participants had strong *preference for team play, especially with grandchildren*	Players preferred simple games and were not confident about their abilities for fast-paced play
Al Mahmud et al. (2010)	Game prototype	Tabletop card-guessing game	User testing	Rules of game influenced cooperation and social interaction; OAs *appreciated play with younger family members*	
ONLINE SOCIAL GAMES					
Social health					
Cornejo et al. (2012)	User test	*GuessMyCaption*	One OA, 12 relatives for 5-week test	*Increased social interaction within family*. Participants were positive about the game's potential to increase social connections online and off-line	

Zhang and Kaufman (2015)	Online survey	*World of Warcraft*	222 OAs	*Enjoyment of online relationships was associated with greater bridging and bonding social capital* for stronger social networks	
Zhang and Kaufman (2016c)	Online survey	*World of Warcraft*	176 OAs	Playing offered older adults ways to *nurture off-line relationships with family and real-life friends* and to *construct new meaningful and supportive relationships with friends* in the game	
Zhang and Kaufman (2016a)	Literature review	Digital games, intergenerational play	19 studies	Intergenerational digital gameplay facilitates *forming stronger relationships and more favorable opinions across younger and older generations*	
ADVERGAMES					
Social health					
Seah (2015)	Mixed-method study	Multiplayer *Bingo* learning game about nutrition and health	50 older adults playing for 30–45 min twice per week for 4 weeks	Significantly increased self-reported social connectedness; new learning about nutrition and about computers	
Psychological well-being					
Brown-Johnson et al. (2015)	User test	*mHealth TLC* iPad health game prototype	Eight health professionals (not older adults)	The game was rated as engaging, believable, clinically appropriate, and helpful for supporting lung cancer patients	mhealth game example; did not involve older adults

In terms of mHealth, mobile digital games provide a huge opportunity to increase digital health management. This chapter has noted some early mobile games that link older adult play with diagnostic data collection to detect or monitor health conditions. Older adults continue to enjoy, and find benefits from, playing commercial digital games alone and with family and friends. Finally, the development of specific mHealth games for older adults continues. All of these point to a future in which older adults can enjoy mobile games while managing and monitoring physical abilities and cognitive skills, supporting and developing their social networks, and maintaining their general well-being and quality of life.

6.6 Limitations and Conclusions

There are several limitations to the work presented here. First, it is difficult to untangle the heterogeneity of protocols used in digital game research. For example, several variables that may be important, such as age or differences in the types of digital games, were not fully considered in the reviewed studies. Limitations also lie in the isolation of variables: in fact, in the experiments the researchers clearly separate types of digital games, sometimes comparing them. They often separate the effects in the psychological tradition, e.g., cognition, emotion, and socialization. Several studies dissociate variables when they are often linked, for example, Wollersheim et al. (2010), who mention the social support of the game experience or the novelty of the game as confounding the results. As has been pointed out by other reviewers, therefore, differences in experimental protocols make it impossible to rigorously summarize and compare experimental results.

We suggest several areas for further research. The most important one relates to the theme of this article, i.e., the gameplay process and outcomes of mobile digital games. Also, studies on the duration of any benefits found would be useful. Many authors mention the need for work concerning the adaptation of successful digital games to the needs and capabilities of older adults. Whitlock et al. (2012) showed that the participants' backgrounds and gameplay expertise have major impacts on realized benefits; therefore, more research should be conducted on individual differences in older adult players. Miller et al. (2013) also mention that for cognitive outcomes, slight individual deficiencies can vary the results. All these results show the complexity and tremendous diversity inherent in older adults in any digital game context and research protocol. It is important for researchers to work closely with participants in the design and implementation of research studies and to employ a situational epistemology that promotes health and successful aging.

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Emmanuel Duplàa is a professor in the Faculty of Education at the University of Ottawa, specializing in information and communication technologies (ICT) for learning. He has participated in projects on design ergonomics and planning, distance education and training in eHealth. He is currently conducting research on educational video games, digital literacy, and e-learning design processes.

David Kaufman is a professor in the Faculty of Education at Simon Fraser University, Canada. He has published extensively with more than 120 published articles and 3 books to his credit; serves as a reviewer for many journals, granting agencies and professional associations; and has received more than $3 million in funding. His current research focuses on digital technologies to support ageing well.

Louise Sauvé is a professor of Educational Technology at TÉLUQ University in Quebec City, Canada. She has worked for many years as a distance education specialist, has developed many digital games and has published extensively on games and simulations for learning.

Lise Renaud is a professor at the University of Quebec at Montreal and director of ComSanté, a research centre on communication and health. She has more than 20 years of experience doing research and conducting interventions in public health in Montreal. She has 6 books and many articles to her credit.

Alice Ireland is an educational consultant in Vancouver, BC. She was formerly an executive director of Simon Fraser University's Simulation and Advanced Gaming Technologies (SAGE) for Learning Project and an associate professor of Management Information Systems at the Dalhousie University School of Business. She is currently a work package coordinator for AGE-WELL NCE Inc.