Older Adults' Perceptions About Commercially Available Xbox Kinect Exergames

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Abstract. Cognitive decline is one of the most feared aspects of growing older that may produce financial, personal, and societal burden and serious consequences on older adults' independence and quality of life. The findings of previous studies suggest that playing digital games can activate cognitive skills, while exergames can be beneficial both for physical activities and cognitive training. In this study, we used the Xbox 360 Kinect gaming console that employs advanced sensing technologies to allow players to interact with a game using body movements. The purpose of this research was to explore the gaming experience of older adults and to identify the benefits and obstacles they encounter while playing Xbox Kinect games. A total of ten older adults (an average age 82.8) were recruited from two senior centers in British Columbia, Canada. For five weeks, participants played mini exergames from collections: Kinect Sports, Dr. Kawashima Body and Brain Connection, Your Shape Fitness Evolved, Kinect Adventures, and Dance Central 3. Each session lasted for 30 to 60 min. Interviews were conducted after each session and at the end of the study. The findings show that older adults enjoyed most games they played, but preferred ones that are familiar to them. Also, they valued the exercise aspect of the games because they had to use their cognitive and physical abilities at the same time. However, they also report many obstacles while using the system.

Keywords: Exergames · Older adults · Xbox Kinect

1 Introduction

Modern society is aging. Statistical trends show an increase in the population of older adults aged 65 years and over [1]. If this trend continues by 2036 older adults "could constitute more than one-fourth of the population" [1, p. 59]. The problems of an aging population are seen in reduced mobility, raised the risk of falls and injuries [2], social isolation [3] and cognitive decline [4]. Accordingly, the number of older adults with mild cognitive impairment, Alzheimer disease, and dementia has been increasing in recent decades [5]. This increase in the aging population has as effects not only on the quality of life of these individuals and their families but on the world economy as well, mostly on the health care and pension systems [6]. To provide a better quality of life for older adults and their families and reduce burden on economy, researchers have been examining different types of cognitive training and "how technology and computing

might reduce [the] deficit [of physical and cognitive abilities] and problem of old age" [6, p. 4]. Some researchers are developing hardware, devices or small appliances, and others are looking at the possibilities of how existent technology can be used to prevent a physical, cognitive and social decline in older adults. A special interest developed over the years in gerontology research has been on the use of digital games and gamified applications for improving many aspects of older adults' lives. On the contrary to traditional cognitive training, digital games present a fun and enjoying activities that can enrich a person's life, regardless if they are played in groups or individually. Results from some empirical studies show that digital games are known to reduce depression [7], loneliness [3], and improve self-confidence while enjoying social interactions and engaging in cognitive and physical activity [7, 8], but the results of many studies are not evidence-based (see for example the review by Loos and Kaufman [9]). All these aspects contribute to the overall quality of life which is defined not only as the absence of disease but as "…a state of complete physical, mental and social well-being" [10].

The purpose of this research was to investigate the gaming experience of Canadian older adults and identify the benefits and obstacles they report with commercially available off-the-shelf (COTS) Xbox Kinect games with the following research questions:

1. What types of Xbox Kinect games are suitable for older adults aged 65 and over? What are the features of these games?
2. Which challenges do older adults aged 65 and over encounter when playing Xbox Kinect games?
3. What are the opinions of older adults aged 65 and over on using Xbox Kinect games?

1.1 Cognitive Training

The effects of cognitive training have been a subject of many discussions in neuroscience, gerontology, education, and human-computer interactions, and there are many controversies around this issue. Review articles that have been investigating the benefits of any type of cognitive training, traditional, computer or game based, concluded: "that training improves immediate performance on related tasks, but there was no evidence for generalization effects to overall cognitive functioning" [11, p. 263]. Several review articles were investigating the cognitive benefits of both physical and cognitive training in older adults using digital games. Some of the findings suggest that there are short-term beneficial effects of playing digital games "on older adults' balance, mobility, executive function, and processing speed" [12, p. 14] regardless of the health and living conditions of this group. However, more research is needed to determine the effects of cognitive training to untrained tasks, activities of daily life, with the follow-up data on the far transfer of the training [11].

On the other hand, neuroscience research found "the relationship between serum BDNF [brain-derived neurotrophic factor], IGF-1 [insulin-like growth factor type 1], and VEGF [vascular endothelial growth factor], and functional connectivity in healthy elderly adults" [13, p. 90]. By measuring the presence of these factors in human blood,

they determined "that aerobic exercise-related increases in circulating growth factors are related to temporal lobe functional brain connectivity in elderly humans" [13, p. 98]. This study provides evidence that exercise, even moderate, can influence changes in chemicals in our organism that are relevant for the age-related changes in the brain.

A new gaming technology that emerged in 2006, first used by Nintendo Wii, enabled a new form of physical activity using digital games called exergames [14]. As defined by Oh and Yang [15], an exergame is "a video game that promotes (either via using or requiring) players' physical movements (exertion) that is generally more than sedentary and includes strength, balance, and flexibility activities" [15, p. 9]. This new technology can detect movements of players body by either tracking of hand-held controllers [14] or by tracking the movements of player's body joints [16, 17]. The research shows that older adults are motivated to play exergames [18] and see them as fun and engaging physical activities that could be done indoors [19]. On the other hand, many older adults report issues with the use of new technologies which could be a consequence of the fact that digital games, including exergames, are usually created for a younger audience without the consideration of limitations that come with old age [18]. Exergames can range from light to vigorous physical intensity while at the same time being entertaining for users [14]. As neuroscience research indicates that physical activity is beneficial not only for physical health but also to age-related cognitive decline [13], these games could be valuable for improving both cognitive functioning and physical abilities in older adults. However, Loos and Kaufman [9] in their state-of-the-art paper about the impact of exergames on the mental and social well-being of older adults concluded that 6 out of 9 empirical studies they analyzed report some positive impact on the cognitive performance of older adults while others did not report any significant results, therefore, they advocate for more empirical research to be conducted.

1.2   Microsoft Xbox Kinect

In November 2010, Microsoft launched its new gaming technology named Kinect [16], which uses advanced sensing technologies [17]. To detect body movements, Kinect uses two cameras and one infrared projector that scan the environment to detect body joints and facial expressions [17, 20] with the ability to recognize different players. Also, Kinect uses voice recognition technologies that enable controlling a game with users' voice [17]. When tested, the Kinect sensor showed high sensitivity in both response time and accuracy [21], which is important when the game expects from a player to perform cognitive tasks and provides greater potential for adequate feedback on performance [22]. Besides Xbox Kinect, Nintendo Wii and PlayStation Move use motion tracking to control gameplay. However, Nintendo Wii uses Wiimote, a remote controller that requires users to push buttons on the remote during gameplay which can be challenging and frustrating for older adults. Features facilitated by Kinect present great improvement in the gaming experience especially for users with less experience in gameplay.

1.3   Usability of Xbox Kinect COTS Games

Research conducted using the Kinect system can be divided into two groups. One group that developed and tested their own applications/games, and the other that explored commercially available games. The development of new games is important for creating games that are suitable for older adults, especially concerning barriers of the user's interface [23], options for personalization and adaptation [24] and having dual-task activities included [25–27]. These applications are usually designed with the consultation of appropriate experts, but they still have to be tested for the usability of older adults and commercialized for broader use. On the other hand, there are numerous commercially available exergames developed for different gaming consoles [24].

To determine the usability of the Kinect system and COTS games for older adults, researchers have done several studies. Marinelli and Rogers [28] conducted a heuristic evaluation and hierarchical task analysis, using games from Body and Brain Connection and Your Shape Fitness Evolved, by decomposing large tasks into networks of nine sub-tasks and pre-requisites. Several studies explored the use of the Kinect games together with exergames for other platforms. Barenbrock, et al. [24] conducted a qualitative study with four participants aged from 71 to 86 years old "to investigate strengths and weaknesses of commercial exergames with regard to older people" [24, p. 1]. From nine games that were tested throughout three days in participants' homes only two were for Xbox Kinect, Dance Central games and one game from Kinect Adventures collection, 20,000 Leaks [24]. Harrington, Hartley, Mitzner and Rogers [23] conducted a qualitative study with 20 healthy older adults, aged 60–79, "to identify usability challenges of Kinect-based exergames for older adults" [23, p. 490] and provide recommendations for the design of the games for this population. They used Body and Brain Connections and Your Shape Fitness Evolved, recorded gameplay and conducted interviews after each session to analyze errors in starting and handling the system and to examine perceptions of the participants of the use of two game collections for older adults, especially in the personal home settings.

Difficulties in using gesture to control the game and navigate through the system were observed in all studies. When the system was placed in older adults' homes who were asked to play three games every day in for three weeks and to record their progress, participants expressed "difficulties adapting to the physical demands of Kinect play" [29, p. 18:16]. However, older adults did find ways to adapt to Kinect by developing strategies that will compensate their bodily limitations through anticipating required activities during gameplay, for example, starting required action few second in advance [29]. This finding suggests that for new technologies to be adopted by older users they should be present in everyday lives and practices so that the interactions can be modified based on personal abilities [29]. Also, it was noticed that initial errors were reduced when participants used another set of games due to the familiarity with the Kinect system [23].

Moreover, researchers proposed the recommendations for future game developers to follow: design less complex and dense environment, minimalize information presented on the screen, develop user-friendly interface, provide "on-screen instructional gestures … to serve as guidance and reinforcement" [23, p. 497], put the importance on progress in contrary to challenge, allow additional time for reactions, and create

environments that support adaptability and realistic scenarios over fantasy settings [24]. While others concluded that "game redesign based on principles of universal accessibility would be ideal" [28, p. 1251] or the use of supplemental materials, complemented with guidelines or training, to accommodate knowledge and skill transfer from familiar games to the new ones.

We often speak about technology specifically designed for the use of a certain group. Similarly, researchers are developing special games or digital training targeted at older adults. While such an approach is innovative and creative, it takes time to produce, test and put into use these technologies. On the other hand, there are plenty of COTS games that are sporadically tested for the usability of older adults, often excluding participants with some physical or cognitive impairments. With that in mind, we conducted a study to explore older adults' perceptions about commercially available Xbox 360 Kinect games, especially in the context of physical and cognitive training.

2 Methods

2.1 Research Design

The research instruments for this study included a background questionnaire, post-session interview protocol, and post-intervention interview protocol. Also, about 40% of the gameplay was video-recorded. This paper will present only the results of the post-intervention interviews with some information taken from the background questionnaire, while the results of gameplay analysis and short post-session interviews will be the focus of another report.

2.2 Participants

We recruited ten older adults from two senior centers to participate in this research. Eight participants were female, and two were male. The average age of participants was 82.8 with the age span from 74 to 89. As we wanted to explore how COTS Xbox 360 Kinect games can be used in any situation where Xbox 360 with the Kinect sensor is available (independent living facilities, retirement communities, seniors' private homes, or the homes of their families), we decided not to exclude any participants with physical or cognitive limitations. Therefore, all participants that were willing to participate in two selected locations were included in the study. Both locations provided independent living arrangements, so most participants were able to take care of themselves independently. Nine participants lived alone, while one was living with his spouse and had an early stage of Alzheimer disease. However, their physical abilities did vary.

There were multiple physical challenges that participants were facing which interfered with their gameplay. Some of them reported having issues with balance and strength in lower extremities, or pain in legs, back and shoulders. A couple of participants had to use a walker, and one of them could not play any of the games that required extensive standing. One participant reported having heart conditions, and one was diagnosed with Alzheimer disease. Table 1. provides detailed information for each participant.

The level of education of participants also differed. Three of them had less than a high school, four finished high school, one was college and two university graduates. Experience with digital games was equally distributed. Five were non-gamers, and only one of them plays non-digital games (such as card games or puzzles) once a day.

Table 1. Characteristics of participants

Participant' code	Experience with digital games	Non-digital games or puzzles	Physical activities	Self-reported and observed physical limitations
AL87f	Never played	Never played	Light walking, stretching (a few times a week)	Severe back and legs pain, issues with balance.
RN87f	Plays once a week	Plays once a week	Other - bowling (a few times a week)	Generally, no issues, feels strong, sometimes may lose a balance. Considers herself active.
MP89f	Plays twice a week	Plays once a day	Light walking (once a day)	Uses walker, had to sit all the time, but was able to stand up to initiate the game with a help of a chair.
TD85mA	Never played	Never played	Stretching, fast walking/hiking, other - played soccer (once a day)	An early stage of Alzheimer disease, no physical limitations.
RT89m	Never played	Plays once a day	Light walking, stretching, fast walking/hiking (once a day)	Light shoulder pain. Considers himself active.
TA84f	Never played	Never played	Light walking, stretching, balance exercise, fast walking/hiking, gym exercise (once a day)	Low strength in lower extremities, had to sit frequently.
BD77f	Plays three times a day on her cell phone	Plays a few times a week	Light walking, other - shopping (once twice a month)	Back and shoulder injuries, heart diseases.
AM74f	Plays twice a week	Plays a few times a week	Light walking, yoga (a few times a week)	Some pain in legs, couldn't stand for too long.
AL82f	Never played	Never played	Other - yoga (once in two weeks)	Uses walker, wanted to sit down and play games, however, played them standing up. Did not report any physical limitations but said that she couldn't jump if needed.
RM74f	Plays once a day	Plays once a day	Light walking, square dancing (once a week)	No physical limitations reported or observed. Considers herself active.

Note: The first two letters in the participant's code represent their initials, the number represents the age of a participant, while "f" and "m" letters represent female or male gender, respectively. One participant is assigned with the letter "A" for Alzheimer disease.

For example: TD – initials, 85 – age, m – male, A – with Alzheimer disease.

The other five participants had some experience with digital games. Their involvement with digital games varied from a couple of times a day, once a day, once a week to a couple of times a week. Participants who played digital games, also engage in non-digital games activities from once a day to a couple of times a week. On the other hand, all participants practice light walking and stretching, while some engage in other physical activities such as yoga, hiking and fast walking, balance and gym exercises, and square dancing.

2.3 Games and Game Sessions

As the literature review showed a need for more research conducted on the evaluation of COTS games since only a small number of games were explored with older adults [23, 24, 28], this study aimed to expose older adults to a variety of games. It was also important to explore perceptions of participants about these games in the context of cognitive and physical training. Based on the previous research done on the usability of digital games with older adults [23, 24, 28] criteria for game design suitable for older adults were used. These criteria included: giving importance to the progress instead of a challenge, taking care of health risks during gameplay, the complexity of the game, and moderate visual and audio stimulations. After a thorough investigation of both gameplay and previous research, following game collections were selected: Kinect Sports, Body and Brain Connection, Your Shape: Fitness Evolved, Kinect Adventures, and Dance Central 3. These collections were also used in previous research. The most popular collection of games in the research with older adults is Body and Brain Connections that was used in at least three studies with older adults [24, 28, 30]. The reason for that popularity may be in the fact that games in this collection were developed under the supervision of a neuroscientist Dr. Ryuta Kawashima [31]. However, not all games of this collection were available for older adults to choose in these studies. For example, Chiang et al. [30] used only three games from this collection: Follow the arrow, Matchmaker and Mouse mayhem. Aside from this collection, Marinelli et al. [28] and Harrington et al. [23] explored the Kinect fitness games under the title Your Shape, while Barenbrock et al. [24] explored usability challenges of older adults while playing two Kinect games: Kinect Adventures and Dance Central 3. In this study, we decided to explore all these titles, but we also included the Kinect Sports games, as a collection with potentially familiar and fun activities for older adults.

Table 2 shows a schedule of games offered to older adults in the period of five weeks. Seniors were asked to play a specific list of games each week, but in later weeks, they were offered both games assigned for that week and games that were played in previous weeks. Also, participants were able to choose any game from available collections after they played required games to see if the motivation for play would help them overcome challenges they experienced with the system.

Each session lasted for 30 to 60 min. The reduced time of gameplay was noticeable for seniors who have less interest in gaming activities as seen in their background profile. For example, TA84f never played digital games, nor she engages in non-digital gaming activities, so her sessions were usually shorter as she reported not feeling motivated to play.

On most sessions, there were two research assistants present. One would observe gameplay, asking questions about games and video or audio record sessions, while the other one would assist older adults in their play.

Table 2. Game sessions

Session	Must play	Optional
Week 1: Sports	All mini sport games	Any other sports games under the Main Event Model
Week 2: Body and Brain Collection	Traffic control, What time is it?, Match Maker, Perfect 10, Math Jock, Balloon Buster	Other body and brain games, any sport games
Week 3: Your Shape	All body shape games	Any sport and body shape games
Week 4: Kinect Adventures	All adventure games with and without stories	Any sport, body/brain collection, and body shape games
Week 5: Dance Central 3	Any dance games participants choose	Any other game

2.4   Interviews

For this study, we collected data using two interview protocols. We interviewed participants after each session to collect participants perceptions about games right after gameplay. In addition, we conducted a final interview after participants completed the last session to understand their overall experience and opinions about games and the Kinect system. Questions for the final interview can be divided into three sections: opinions about games (most liked and least liked game and features of these games), experiences with the Kinect system (challenges in using the system, comparison to other consoles if applicable), and opinion about the usability of games and the system for cognitive and physical training of older adults (including observed changes in their abilities after the intervention).

2.5   Data Analysis

Data collected in this study were audio recorded and transcribed. Transcribed documents were uploaded to a qualitative data software, NVivo 12, to identify emergent themes using in-vivo coding method. These themes were then compared and organized using axial coding into higher categories [32].

3   Findings

In that sense, findings are organized in three sections: types of games and their features preferred by older adults; challenges experienced with games and the Kinect system; and opinions about games, the system and the potential of both for cognitive and physical training of older adults.

3.1   Game Preferences of Older Adults

Many participants highlighted that they *liked all games* "because they were different and gave a variety" (TA84f). However, the most popular games among older adults were games from *the Kinect Sports collection:* Bowling, Boxing and Soccer. Next in line were the Kinect Adventure games and Dance Central 3 games, while only two participants mentioned liking the best games from Body and Brain Connections and Your Shape, respectively.

The familiarity of games including the connection to previous experiences and *challenges* were reported equally as highly desirable features of games played. Participants felt a closer connection to the games which they played in real life and for some of them that brought up old memories:

> "Bowling was good, yeah. I liked them all actually, because I have three sons that I brought up, so we did a lot of sports because their dad was… I was divorced so we always went with them… So, it was fun, three boys." - BD77f

For others, it was a matter of knowing the rules of the play and having personal interests in these activities:

> "The boxing would be my favourite. [Why?] Possibly 'cos I did all that before: tennis, boxing, soccer." - RT89m

Even though seniors reported challenges that prevented them on playing and enjoying some games, like a game being too fast, most of them *like being challenged a bit*. They regard challenge as a motivation to engage with the game further and having fun in that process:

> "I like to figure how things go, and I want to do the best I can so, yes, the challenge. No matter which one I do I'm going to try it and beat what I can…the astronaut games [Space Pop game from Kinect Adventures] where there's a bit of a challenge, but it's not overwhelming challenge. Like if you can laugh at yourself, that helps." - RM74f

Another important feature of games that emerged from the interviews was *enjoyment and fun*:

> "It was a lot of laughs because I kept getting banged. [Kinect Adventure]" - BD77f
> "Even if you don't make it. You know, if you don't… if you can't do it, it was still enjoyable… I had fun, yes." - MP89f

Reasons that made seniors dislike a game are usually *difficulties they experience playing*, such as a game being too complex or fast. Some participants disliked certain games as they perceived them "kind of childish" (AL87f).

When asked which games they would play again and potentially buy, opinions differed. Most participants still preferred sport games, while others liked adventure games and dances; some of them would like to play these games again and others would not. Reasons for that might be in personal preferences, the perceived difficulty of a game and even inabilities to play some games due to their physical limitations. One of the quotes describes the issue well:

"If the dances were more in line with the age group, I'd probably go for the dances. I like the Macarena, and I like the YMCA one, the Hustle, and probably the other ones, I wouldn't have even attempted. I won't even attempt them with my grandson. Because these are all the young ones and I like the adventure ones myself. But I'm a go, go, go type of person." - RM74f

This quote also represents mixed perceptions about dance games. On the one hand, many older adults like dancing and would love to be able to play games from Dance Central collections. However, they find them too fast and challenging, or how seniors would put it "Not the dance. [You didn't like dance?] Because not that easy. Just the leg or the hand but both you… maybe the younger will be okay" (AL82f).

3.2   Challenges

Exergames that are available on the market are usually created for a younger audience, people who are physically able to complete moderately complex physical and dual-task activities. Also, previous research tended to exclude people with physical limitations [24], unless the goal was to develop a game or application targeting this population [25–27]. However, the availability of gaming consoles in senior centers and homes is increasing, so the accessibility of these games to older adults will be increasing as well. Having that in mind, we wanted to see what kind of challenges seniors experience when playing commercially available titles and what would be needed for them to enjoy gaming activities at their own home.

Fig. 1. Gameplay supported by objects from the environment

Since the background survey had shown the lack of experience of our participants with games and gaming consoles, we decided to set up the system each week ourselves. The first couple of sessions started with a research assistant navigating the interface and doing all necessary preparatory activities. After that, the game tutorial would be shown, and in some cases, the research assistant had to play the game before a participant would start playing. Some participants learned how to navigate the system easily, but for some others, we had to initiate the game each time. One participant especially had difficulties in navigating the system, as she had to sit all the time and was not able to use her body to control the system. As she had to stand up to initiate the game, we

Fig. 2. Math Jock screenshot of gameplay [33] and a photo of the actual play

provided support in the form of additional chairs that she could hold on to be able to stand up (Fig. 1). We used the same adjustments in several cases. However, a chair on which a player would sit during gameplay presented an obstacle in some games. For example, in the game *Math Jock* from Body and Brain Connections, a mathematical equation is displayed at the top of the screen, and the player is supposed to kick the ball with the correct result of with their foot (Fig. 2). If the player had to sit and play, the system would detect a leg of the chair, which interfered with the ability of the Kinect sensor to respond to the player's actions correctly.

Challenges that participants reported as interfering with their gameplay can be grouped into several themes: their own physical limitations and injuries, the complexity of games or games being "fast and hard" (BD77f), inability to focus on dual-task activities, defined as "simultaneous locomotive and cognitive performance activity" [26, p. 348], issues with the Kinect sensor response, and learning new thing.

Physical abilities tend to decrease with age in some people [34]. Most participants in our study reported some *physical limitations* and *previous injuries* that prevented them from completing tasks in games:

> "The basic challenge was speed because I was having a hard time standing. I'm in pain all the time. You know, I shouldn't have signed up for this because I'm a disappointment to you." - AL87f
> "Just a sore back and bad shoulder, broken shoulder that's still not healing properly. So, it's just some injuries that can limit my activities or exercise." - BD77f

Although participants appreciated dual-task activities in games, they also found them *fast* and *challenging*. The fact that they had to process information cognitively and the same time thinks about physical movements made some activities too complex. Also, the time available to complete these activities was too short. Some participants suggested that time given in games (for example, 10 seconds to resolve an equation and kick the correct ball) is more suitable for younger people and felt that they needed either more time, less complex activities or activities involving only one section of the body in combination with cognitive activities. Here are some quotes from the participants:

> "Well, you're watching what is she [the virtual trainer] going to do next. I've done the Macarena before, but I have a hard time to follow. [Why?] Why, it's just so fast. Like you're standing there, there, there, this way and that way." - TA84f

While previous quotes illustrate participants highlighting physical challenges, some participants reported *an inability to focus on dual-task activities* regarding cognitive processing.

> "Coordinating and focusing. Learning to really keep focused. In my mind it's like this is just a game so I had to learn to really concentrate and focus so I could do it properly and get the little bit of points that you can get." - BD77f

For some participants, the biggest challenge was *being recognized by the system.* The Kinect sensor was not able to recognize and connect to the body joints of two female participants that had to sit most of the time. This resulted in the limited scope of games they could play.

> "What challenges? Just trying to be recognized on the TV, I guess." - AM74f

Another participant was upset that the system was responding late to his actions:

> "I didn't really dislike any of it, but I was disappointed in some of them. The technology isn't quite there to respond to my responses. And I dislike them on account of that but not because… [Of the game.] It was quite good. Concept is excellent, but it could be quicker response to my actions. Like for instance when I was trying to kick the ball there if that was a real ball, I knew a real ball I know what to kick. And they were on the machine I was missing them." - RT89m

The last statement can be linked to another challenge seniors experienced *learning new things.* Some of them had to put a lot of energy into playing game and understanding its rules. It should be also noted that half of participants never played digital games before.

> "Well, I really… let's put it this way. I had to put all my energy into it. I think this type of a game maybe 30 years ago then you're going to say, yeah, okay, this is a kiddie's game, right? But I won't say that now anymore. I really have to follow exactly what it says." - TD85mA

3.3   Opinions

Aside from exploring the experiences of older adults with the Kinect systems and selected game collections, we wanted to hear seniors' perceptions about the value of the system and games for older adults especially in the context of dual-task training and the perceived benefits of engaging in these activities. Several themes emerged in the analysis.

Value of the System and Games and Perceived Benefits
When asked if games and the system would be useful for seniors, participants see their *value as physical exercise and cognitive training*, *having fun while exercising, for learning new things,* and *making them feel better.* However, they believe that *some adjustments* should be made so older adults could play them.

Most participants believe that the system and games could be used in dual-task training:

> "I think it's good if you can get people to take, use it, because when you're using it you're using your brain and what mobility you have. So, it's to keep everything working and because you use it, or you lose it." - RM74f

In addition, participants expressed belief in the high value of games played to make seniors *enjoy physical activities while having fun*. For some "time went very fast" (RT89m), while others appreciate exercising without knowing it:

"I enjoyed the games. It gave me exercise that didn't feel like exercise. I have never done exercise for the sake of doing exercise. And if you want people to do exercise without them knowing they're actually exercising, this is the way to get it… As far as I'm concerned, I never, I don't go for walks unless I've got to go somewhere. Okay. It's my own way, I've got a destination, I'll go. Am I going to walk around the corner just to say I walked? No… [So, you want to say that these are more fun activities than regular exercise.] Correct. These are fun activities that actually count as an exercise." - RM74f

Having fun while exercising made some of them *change attitude towards exercise*:

"Yeah, in general, I have a better attitude towards exercise… That's amazing because I don't want to do exercise, but this is showing me that it can be a lot of fun and very helpful." - BD77f

Some people think that these types of games would provide seniors ways to *learn something new*:

"Well, I was happy to try them all because it's something new and it gives… we're seniors. We don't do them. I go to the gym three times, but we do different ones and I do the step thing and then I practice standing a lot, you know, about 20 times. Then you can just get up. A lot of people can't get out of their chair if they don't have the strength in their legs." - TA84f

Or make them *feel better*:

"Usually when we all have sicknesses, when you get sick you start feeling miserable and get a headache or whatever. Here you don't notice nothing." - TD85mA

However, *some adjustments* are required:

"They could be very beneficial in like you're going to have to figure out which… how to moderate some of them a bit probably. [They would need some adjustments?] Some adjustments, I would say. Like the Hustle. I mean, there are some that are here that will try to learn something new but most of them it's not what they want to do. Have you seen that yourself? Yeah." - RM74f

The majority of older adults believe that their gaming skills improved during the five weeks of the study. They report learning how to play games and how to use the system, as illustrated in the following statement:

"Well, the gaming skills you got used to what was happening, so you get better at it." - AM74f

Some participants even reported seeing certain abilities improved during the study:

"I think it's improved my reaction. [We are interested in using these games to improve the physical and also the cognitive function of older adults. What's your opinion on this?] Oh, I think it helps." - AL87f

On the other hand, some of them think they would need more practicing time to improve their gaming skills:

"No, because I didn't do them that much, although they did improve while I was doing them. But if I had access to the machines all the time they would definitely go way up to what I did

there for the first time. You just bring in the game and spend a… your real reaction to things." - RT89m

"That they're too short to indicate that with. I think if you play this game let's say four hours a day, every day, every single week you will do a lot better but that's not the idea." - TD85mA

Difference Between Digital Games and "the Real Thing"

Since only five participants played digital games before, they tend to compare games played during the study with activities like walking, playing sports, doing yoga, and dancing:

"[Well, do you think that these… you can replace your dancing courses with some of these games, dancing games?] Not even close. [Why? Just be honest.] Because I've always been extremely active and when I dance I love the fast… I don't know if you know what a polka is but that's one of the faster ones. And the jive, maybe you know that. And western dancing. And they're all very, very lively dances and they use every muscle in your body, your neck, your arms, your legs. 100% exercises. [And these are not like that?] They are trying to be, but they're still machine and…" - RT89m

Some participants even considered the Kinect games easier than real life activities:

"I did the hula hoop. That wasn't too bad. I didn't think I was going to do it because I haven't been able to do the hula hoop in like I can't remember. I think I got a daughter hula hooped and I tried it to show her, I couldn't do it anymore. But because it's animated it did work." - RM74f

Comparison to Wii Console

A couple of participants had some experience with the Nintendo Wii console and its remote controllers. We asked them whether they preferred using their body to control gameplay or controllers as used in the Wii system. Again, they had different opinions. Two female participants that had the biggest challenges with being detected by the Kinect sensor reported preferring Wii over the Kinect system:

"[And this system is… how different is this system from Wii?] It's quite a bit different. But yeah, it's quite a bit… well, it's similar. It's similar enough but you have to pick up the ball. And you're playing bowling and… [Which one would you choose?] I would still choose Wii bowling because it's less… you don't have to detect the person. [And it's not challenging for you to hold the remote?] No, no." - AM74f

On the contrary, some people feel more freedom without having to use the Wii controller:

"I like that. I like the bowling better than the Wii bowling because you don't have that… [remote]… on your wrist and because you go like this here, but that thing could turn a different way. So, this here it's your own hand that…" - RM74f

Lack of Interest in Digital Games

On the question whether they would use the system if it becomes available in their center, seniors had split opinions. Some see the opportunity to play these games as a new and exciting activity, or as a way to exercise and have fun at the same time. However, others are just *not interested in digital games*:

"I don't think I'll play. [Why?] Well, it just doesn't interest me. There's no real interest." - AL87f

Participants in this study lived in two senior communities in which there are many activities organized during a week. This means that they are usually surrounded by their peers with whom they can connect on a personal basis:

> "Will I use it? Probably not… For me if they're happening at a game night or something, then I might go and do something. But it's called a game night a fun night or something like that. And what machine is not going to generate a fun night, you know… Yeah. Like if you start all machines at the same time two players on each one or something then, okay, let's see who gets the best score, the best time or… [Actually, RT89m and TA84f danced together this morning, so that was fun.] Yeah. And that would make it more fun because you're not feeling like you're exercising." - RM74f

Personal Value for One Participant

Even though we had no aim in elaborating experiences of individual participants in this study, experiences with the system and games had a special significance to one participant. The biggest value of the system and games for the participant with Alzheimer disease was, in his perception, that these games could be a good assessment tool for tracking his decline. He emphasized this on several occasions:

> "I find all these games it's like a little challenge in itself. It's what I like about something like that, if you had these games you could test yourself and really do some of these things and really assess how far you go down." - TD85mA

One of the reasons for this belief may be in the description of the collection and an option for initial assessment present in Body and Brain Connections. Before selecting games, in this collection, there is an opportunity to be evaluated by playing sample games which will give an initial assessment of dual-task activities. Later on, games would provide an assessment based on the progress. TD85mA might have perceived that this option would be valuable for him:

> "I have nothing to hide or anything like that. Then the more I learned about myself that way, and I know better off I am. I know you're on a decreasing light, but it is always hard to find out exactly where you are on… So, I think even games like this remind me again, and I can assess a little bit where I am at." - TD85mA

However, he did indicate that in some games you can track your progress by tracking the amount of energy you put into gameplay, which could be seen as a self-evaluation:

> "Well, I think I like the idea of it. And I think also it's probably a good way, I don't know. I have so far on my journey I have never learned of a systematic way of assessing well, like noticing such… But games like this are actually very good because it shows in a practical way I think, how, where you are at on the whole thing… Well, I, for instance, assume I think he would know it by let's call it the energy you can produce in the…[game]…to set the same results." - TD85mA

3.4   Suggestions

While suggestions for designing the dual-task training will be derived from the analysis of the actual gameplay of participants and presented in a separate report, some valuable suggestions came from the interviews with participants. For example, since one of the

challenges experienced by participants was speed and time allocated to complete game tasks, one of the suggestion was to make games easier or less complex:

> "Comfortable would be easy game… Because, just as I said, if it's just hand or just leg will be easy. But if you want both leg and hand, move and match, they have the beat slowly." - AL82f

However, the certain degree of challenge should be present, enough to make it exciting and still be able to complete it successfully:

> "I don't like being beat. I don't mind being not good at it, but I don't like not being able to get it." - RM74f

For some seniors having assistance in setting up the system and navigating the interface would be highly preferable:

> "[Why is assistance from another person important?] Well, I didn't understand it [how to play those games] to begin with." - AL87f

In addition, providing more themes related to older adults' younger age and previous life experiences would provide more entertainment and motivation:

> "Bring in some old-type dances. The hustle…There's the Bunny Hop. Just the fun… you know, just simple type moves that we can grasp and enjoy…So, if you're enjoying it and you're going to do it a little bit longer personally, I think that." - RM74f

4   Discussion, Conclusion and Limitations

While exploring the usability of commercially available titles, researchers suggested more empirical studies to determine the benefits of COTS games and to provide recommendations for the use of the Kinect system at homes. Additionally, they were discussing reasons for the small number of games designed for older adults and the lack of knowledge about gameplay preferences of this population, as well as challenges of game designers with age-related declines in sight, hearing, reduces motor and cognitive abilities [23, 35, 36]. Moreover, the research explored only several titles of COTS games [23, 24, 28], leaving the huge number of titles to be further explored [22]. After exploring five different Xbox COTS gaming collections with ten Canadian older adults, we can derive the following conclusions and provide answers to our research questions:

1. What types of Xbox Kinect games are suitable for older adults aged 65 and over? What are the features of these games?
   Older adults like games with familiar activities such as sports games, adventures and dances. They prefer games that can bring up old memories and provide a connection to previous life experiences and interests. Games that are fun and challenging are also valued more than games with simple activities that they regard as childish to some extent. They see the challenge as a motivation and a way for deeper engagement in gameplay.

2. Which challenges do older adults aged 65 and over encounter when playing Xbox Kinect games?

Older adults without physical limitations can use the Kinect system with some support, while people who have issues with their balance or extremities face challenges being properly detected by the Kinect sensor. In addition, seniors find most of the games too fast and complex. Although they appreciate dual-task activities in some games, they report having issues with focusing on both cognitive and physical activities at the same time and in a limited timeframe.

3. What are the opinions of older adults aged 65 and over on using Xbox Kinect games?

   Doing physical activities while playing games and having fun participants saw as one of the strengths of exergames. Many report the lack of physical activities in their lives and believe that these games would motivate them in being more physically active. They also believe that games with dual-task activities could be useful for cognitive training.

The limitations of this study come from a small number of seniors who participated in the research, limited time for gameplay, and the broad scope of games tested. Even though we wanted to explore the usability of the wide variety of exergames, this broad scope also prevented us from gaining more precise knowledge of the features of games that are suitable for older adults. Exploring many games during one session could have also affected older adults' opinions on different games due to their similar content and activities. Lastly, exploring the experiences of a larger number of older adults could have provided deeper insights into seniors' perceptions and experiences in exergaming.

The potential of commercially available exergames exist, and while researchers should make more efforts in finding ways of using them in their current form, game developers and designers should be encouraged to create more fun and adventurous games that would include adjustments appropriate for older adults and other people with some physical limitations.

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