Review

A review of intergenerational play for facilitating interactions and learning

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F. Zhang, D. Kaufman. A review of intergenerational play for facilitating interactions and learning. Gerontechnology 2016;14(3):127-138; doi:10.4017/gt.2016.14.3.002.00 Researchers have recognized the potential of digital games to facilitate intergenerational connections and learning in diverse contexts. To understand the extent to which digital games can be considered as powerful tools for connecting different generations, this study reviewed nineteen published intergenerational interventions supported by digital games. Collectively, these studies highlight some features of intergenerational play such as short duration, flexibility, the new roles of young and older people, and the importance of intermediary generations on supporting intergenerational play. This study also reviewed seven games specifically designed for intergenerational play. A number of design ideas have emerged from reviewing these games, but the most important design consideration is emphasizing relationship formation. Previous empirical studies have shown significant effects of intergenerational play on positive perceptions towards the other age group. Finally, a number of recommendations are given for future research in this area.

Keywords: intergenerational play, digital games, social interaction, IGL

Intergenerational segregation has become a social issue as many older adults enter seniors' facilities and communities, or live alone due to the death of a partner[1]. Researchers have recognized the potential of digital games to facilitate intergenerational connections and learning[2,3]. The purpose of this review is to better understand the nature and role of intergenerational play, the design elements of intergenerational digital games, and the impacts of intergenerational digital gameplay on the lives of young and older people. The first step in understanding intergenerational play is to recognize the meaning of 'being old', the importance of social interaction and intergenerational relationships for young and older people, and the potential of digital games to promote intergenerational connections and intergenerational learning (IGL).

OLDER ADULTS AND SOCIAL INTERACTION

Older people represent a growing proportion of the world population. Between 2000 and 2050, the proportion of the world's population over 60 years will double from about 11% to 22%[4]. Being old is typically associated with negative connotations (e.g., frail, impaired and dependent) and comprises a number of physical and cognitive declines[5]. This negative view of being old does not reflect the fact that a large number of older people still live an independent, active and healthy life[3]. Due to the increasing longevity, good health, and improved quality of life, a large number of older people, while identified as belonging to the 'aged' demographic, are still active, participative and healthy and do not consider themselves as being old[6]. Today, social historians highlight the social and historical contexts that shape the timing and sequencing of life cycle or stage[7,8]. Carroll et al.[9] even propose the concept of 'aging as resource' in the context of teams of workers who collaborate or learn in the workplace.

Social interaction is important to older people[10]. Research has shown that social interaction even outweighs physical and mental health condition in affecting older people's successful aging[11]. Although the mechanism for how social interaction affects successful aging is not clear[12], it is found that social interaction is associated with higher levels of quality of life[13], and lower levels of depression, anxiety disorder and hopelessness[14], neuroendocrine stress and distress of social separation[15]. However, research also suggested that the size of social networks decreases with advanced age[16]. Socio-emotional selectivity theory indicates that when time in life is limited, older people prefer emotionally gratifying social contacts over contacts with novel social partners, and increasingly emphasize familiar social partners and emotionally meaningful aspects of relationship[17]. So, a deceased network size should not "be cause for concern, as the nature of the contact is more important than the existence of contact per se"[6: p79].

INTERGENERATIONAL RELATIONSHIPS

Intergenerational gaps have increasingly become a norm in today's society[18]. A large number of people, including older people themselves, see social disengagement among older people with young people as a natural part of aging[10]. The term 'ageism' refers to both the negative attitudes towards older people, and the negative attitudes that older people hold towards young people[19]. Older people view young people as problematic, while young people find it difficult to imagine life of being old and perceive older people as frail and vulnerable[20], and view communication with them as less than satisfactory and problematic[21]. Factors such as extended families living apart, divorce and family disputes, and the rise of pension-supported retirements, have all led to age segregation and fewer opportunities for intergenerational interactions[19,22]. Differences in various aspects of physical and cognitive functioning as well as psychological changes associated with development and aging over the life-course and changes in the cultural, social and technological environment could also be expected to have an effect on interaction and value transmission between young and older people[10].

Communication and interaction between young and older people play an important role in an aging society[5,23]. Interaction with young people can provide opportunities for older people to develop intimacy and to nurture younger generation[5]. Intergenerational interaction is a crucial means of exchanging knowledge, skills, information, ideas and values[10]. Williams et al.[19] identify many benefits of intergenerational programs, such as reducing ageist attitudes and age segregation, allowing other generations to benefit from the wisdom and experience of older people, decreasing older people's isolation, providing opportunities for engagement with communities, and improving the quality of life of older people.

Within family contexts, the value and importance of intergenerational interactions has been widely acknowledged[22]. Healthy grandparent-grandchild relationships contribute to the wellbeing of both parties[22,24,25]. Grandparents can have significant impact on their grandchildren's lives by acting as "the family historian, mentor, playmate, nurturer, role model, confidante, advocate, advisor and surrogate parent"[26:p5]. There are four roles that the majority of parents believe grandparents could play in their children: being a friend, teacher, role model, and playmate[27]. For children, positive intergenerational relationships provide positive long-term psychological benefits as they move into adulthood[28]. Intergenerational contact also plays an important role in knowledge transfer and exchange within the family context[29].

TECHNOLOGY TO CONNECT GENERATIONS

Information and communication technologies (ICTs) including e-mail, mobile phones and social network sites have been used to keep in touch with distant family members, but they do not sufficiently bridge the communication gap for grandparents and grandchildren who are apart[29]. Information and communication technologies have typically involved information changes and purposeful message[24:p1476], and thus miss the opportunities to support reciprocal interactions and socially based communication[30]. New technologies have great potential for building and enhancing intergenerational connections and expanding educational pursuits, but "there is nothing that is automatic or guaranteed with regard to whether such benefits will be realized"[31:p11].

How can we effectively transform media consumption into quality family time is at the center of intergenerational programs[32]? By reviewing 46 intergenerational programs and practices supported by new technologies, Kaplan et al.[31] emphasize that no matter what types of technology are used, the promotion of meaningful intergenerational relationships is the core of intergenerational programs and new ways of stimulating conversation and understanding and maintaining long-term interest and engagement should be created.

INTERGENERATIONAL GAMEPLAY

Play is a common activity between grandparents and grandchildren[24]. It involves "a range of voluntary and intrinsically motivating activities associated with pleasure and enjoyment"[32:p18] and can take a variety of forms such as card games, games of sports, playing catch or 'blind man's bluff'[22]. Play acts as a connecting force between the two age groups, providing opportunities for them to build relationships[33], and enjoy each other's company[19]. It provides opportunities for the two generations to learn together, resolve problems with the help of another perspective, and laugh over shared mistakes or difficulties[34]. For older people, building and maintaining intergenerational relationships via play can reduce stress, promote relaxation and facilitate positive changes in mood and higher level of engagement even among frail older people[35]. In addition, the informal interaction allows both parties to build a vehicle for developing positive attitudes towards each other, and breaks down the stereotypical feelings that they are very different[19,34].

Playing digital games has become a leisure activity for both young and old people[36]. In recent years, the potential of digital games as a leisure activity to facilitate intergenerational contact has been gaining researchers' attention[31]. Spending

high quality time with grandchildren is a strong drive for older people to play digital games as young children are less interested in 'pure conversation'[34,37]. Digital collaborative games combine fun and interaction and provide older people opportunities to "make creative, playful and social use of their leisure time"[38:p417]. Gaming elements such as complexity and challenge can sustain long-term motivation and interest between the two cohorts and engage them in satisfying play interactions[39]. Playing digital games together creates a leisure context for common goals, cooperation and equal status that are key factors for successful intergroup interactions and for developing positive intergenerational perceptions[23].

How digital games can be designed to facilitate IGL is another question of interest to researchers. IGL refers to the process of knowledge building, innovation and knowledge transfer that takes place between different generations[40,41]. It has been identified as an effective way for organizations to deal with problems related to an aging worker population and for people from different ages, learning styles, values and motivations to learn together[41]. The benefits of digital games as facilitators of IGL reside in its ability of transcending the dimensions of time, space and close personal relationships and allowing players to practice intergenerational skills in safe environments[42].

THE CURRENT STUDY

There is an emerging body of research highlighting the great potential of intergenerational play for enhancing intergenerational relationships and facilitating IGL. The question is to what extent digital games can be considered to be powerful tools for building and strengthening intergenerational relationships and IGL in diverse contexts, and what we can learn from current studies and practices. Ypsilanti et al.[42] reviewed IGL game-based training in educational, organizational and social settings and serious games for raising awareness on issues such as health and environment. Ypsilanti et al.'s study yielded some insights into the development of success indicators to evaluate the effectiveness of serious games designed to facilitate IGL, but this study focused on the theories on learning through serious games and the existence of serious games in European Union (EU) countries.

The purpose of this review is to better understand: (i) the nature and role of intergenerational play, (ii) the design-elements of digital games for facilitating intergenerational relationships and IGL, and (iii) the impacts of intergenerational digital gameplay on the lives of young and older people. To identify potential studies, web search and database search were employed. The search

keyword string was: (Computer OR video OR digital) AND gam* AND intergenerational AND play. To be included in this study, the potential study should address one of the three aspects mentioned above and mainly focus on intergenerational play between younger and older generations. Given the purpose of this review, papers that focused on intergenerational interactions between parents and children were excluded.

The database search and selection process identified a total of nineteen studies. Five of these are about the nature and features of intergenerational play, twelve about the design of digital games specifically for intergenerational play, and two are empirical studies associated with outcome measures. Information extracted from the four studies associated with the nature of intergenerational play includes: (i) relationship type (i.e., grandparents-grandchildren, older adults-young people), (ii) context (i.e., physical environment, online), (iii) game name, (iv) game type (i.e., traditional game, digital game), and (v) key findings.

The twelve studies were coded for information about: (i) relationship type, (ii) context, (iii) game name, (iv) game type, (v) design rationales or recommendations, (vi) intended impacts, (vii) game assessment, and (viii) key findings.

Information extracted from the empirical studies includes: (i) relationship type, (ii) participants, (iii) study design, (iv) outcome measures, and (v) key findings.

In the following sections, we summarize the results of this literature review, discuss the knowledge and understanding as well as issues generated from reviewed studies, and finally, provide a list of recommendations for future study.

INSIGHTS FROM THE REVIEW
Features of intergenerational play

Five of the included studies have discussed the interactions between young and older people during intergenerational play. Davis et al.[22] examined intergenerational play between grandparents and preschool grandchildren in community-based playgroups. Except for the traditional roles of carer, organizer, instructor or family historian, grandparents also played some roles that are equal to or subservient to their grandchild, such as entertainer, teaser or surrogate toy. For grandparents, the prominent activity of intergenerational play is maintaining a safe and caring environment for their grandchildren's play. They made efforts to participate in their grandchildren's play by physically placing themselves at the same height as their grandchildren, or playing with their grandchildren in a childlike manner.

Through a cultural probe, the Magic Box (a physical box for grandparents and grandchildren who live apart to exchange items such as gifts, photos and toys), Vetere et al.'s[24,25] study found that both parties initiated and responded to the items provided by their counterparts, but the intergenerational relationships were not symmetric. Grandparents were more likely to share family history with their grandchildren and place items that could evoke their grandchildren's thinking. It was also found that parents played an important role in facilitating the grandparent-grandchild relationship by encouraging their children to work on scrapbooks and select items for the Magic Box exchange.

For non-kin intergenerational play, Williams et al.[19] examined whether participation in a weekly playgroup for six months could promote intergenerational interaction and communication among eight residents from a residential aged care facility and ten families (consisting of parents/carers and children). The eight residents were observed to be quite reserved at the beginning, but week by week they became more comfortable talking to the younger generations and more confident within themselves. For them, the major benefit of this playgroup was the enjoyment of interacting with the children, watching them play seeing them happy and sharing knowledge with them. One gain for both parties was the decreased ageist attitudes in both directions (i.e., older adults towards children and children towards older adults).

In terms of intergenerational digital gameplay, Voida and Greenberg[43] examined the intergenerational gaming practices of four generations of console gamers at collocated environment. The opportunity for interacting with family members was a strong motivator for older generation to engage in the intergenerational play. It is found that older generations always gave gaming priority to gamers in younger generations. Similar to the Magic Box study, intermediary generations (i.e., the parents or adult children) were observed to play an important role in facilitating intergenerational play by being expert gamers to keep gameplay going and being mature models of pro-social behaviors to maintain people's interest. This intergenerational digital gameplay experience also inverted some of the roles taken on traditional intergenerational contact. Younger generations were more likely to take leadership roles in interaction and be the technology experts and teach the technical knowledge to older generations.

Design ideas
The included studies have examined the design ideas for intergenerational digital games be-

tween young and older people in community and family contexts. Rice et al.[39] conducted three separate design workshops with 50 participants aged between 15-21 and 55-74 years old to investigate common interests and design features between the two age groups. They recommended some design elements that could be considered when designing digital games for intergenerational play: (i) how the age differences could be used as an interaction component of the game; (ii) how the expertise of each group and any motivational factors (e.g., challenge and cooperation) could be used to engage the two groups and keep their interest; and (iii) how the game could be designed to accommodate some contextual factors such as limited space for play both at home and in community and special challenges/opportunities in local communities.

Through observing the intergenerational gaming practices of four generations of console games, Voida and Greenberg[43] discussed a number of design recommendations that could make digital games more appropriate for intergenerational play: (i) design more roles so that there are characters left over for grandparent(s) to play; (ii) support intermediary generations to engage in the play; and (iii) support transitions between roles. Based on the understanding of the features of intergenerational play between grandparents and preschool grandchildren, Davis et al.[22] discussed some problems for creating new technological artefacts to mediate intergenerational play, such as supporting the various roles that grandparents could play, allowing the two age groups to support each other and recognize the contribution of each group, making the game easy to get in and out, and considering any physical, cognitive and social differences between the two parties.

Räisänen et al.[40] investigated how digital games could be used to support IGL in EU countries. By interviewing members of the EU-funded SILVER-project they proposed a three-component (i.e., context, interventions and mechanisms) requirement for designing games that could facilitate IGL. Sports and nature were the most often mentioned contexts in which the game should take place. Regarding interventions (e.g., game components and elements), it is crucial that the game could have fictional scenarios that mimic real-world situations and did not have clear right or wrong answers. Learning and knowledge sharing were the most often-proposed mechanisms that should be triggered by the interventions.

In terms of the design process, Loos[44] recommended a human-centered procedure to design intergenerational games for and with the younger and older generations. A human-centered (HC,

also called as 'user-centered') design uses "an iterative process in which designers create and evaluate increasingly complex prototypes, possibly involving end users"[45:p86]. It seeks to collect data around users' behaviors, needs and practices in order to provide more intuitive systems and interfaces[46]. A HC design procedure can avoid the pitfall that designers conduct their practice by representing the end users[44].

INTERGENERATIONAL-PLAY GAMES

The search performed for this review identified one game concept and seven digital games that have been designed specifically for intergenerational play. This subsection describes the core gameplay of each game, their intended impacts and assessment.

Introducing the games

Table 1 presents the core gameplay of each game. It is difficult to categorize the games into different groups based on game type, as some games have the elements of more than one type of game. Age Invaders, Curball and Distributed-Hide-and-Seek are physical games or require mini-exercise. TranseCare could be defined as a brain-training game. The target population of this game are older adults who suffer from a chronic or degenerative illness. The playful interactions of Collage reside in playful 'dance' between grandparents and grandchildren by selecting photographs and messages for display on the screen and by sending photographs and messages that evoking each others' thinking. From this point of view, Collage takes the shape of a digital display tool. e-Treasure is a combination of learning game and mini-exercise game. Toy Generations is a learning game used in organizational settings. E-VITA is a game concept designed to promote knowledge sharing and transfer between young and older people in the workplace.

To balance the different needs and technological skills between the two generations, Vanden Abeele and De Schutter[3] constructed three design rationales on physical games: (i) design for enactive interaction (i.e., exploit existing mental models, offer digital affordances), (ii) design for competition, and (iii) design for acceleration (i.e., demand fierce movements, avoid complex, multistep actions). They empirically tested the three design rationales, and integrated them into the design of e-Treasure.

Khoo et al.[26] followed a eight-step methodology for designing Age Invaders: (i) understanding older people's level of computer skills, (ii) awareness of popular commercial digital games suitable for older adults; (iii) medium of gameplay (e.g., how and where the game will be played,

and what medium or interface is best for older adults); (iv) preference of team work/collaborative/multi-player/competitive or individual game, (v) level of opponents; (vi) usability (i.e., ease-of-use for the elderly); (vii) a three-phase user study (i.e., observation, Q&A, and interview); and (viii) an iterative design process.

Intended impacts

Table 1 also describes the intended impacts of the included games. In general, these games were designed to: (i) promote intergenerational connections between grandparents and grandchildren over distributed distances; (ii) connect older people with young people; (iii) build meaningful intergenerational relationships; (iv) facilitate knowledge sharing and transfer between young and older people; and (v) improve the quality of life of older people. The main intended impacts of the games (based on how many times they were mentioned among the games) are to promote communication and understanding and facilitate knowledge sharing and transfer between young and older people.

Game assessment

Collage, TranseCare, Age Invaders, e-Treasure and Curball have been tested with target populations. By observing the intergenerational play of Age Invaders, Khoo et al.[26] mentioned that greater teamwork was more obvious as the game progressed and the two parties knew each other better although the majority of older people were slow in understanding the game at the beginning. The young players had helped their older partners by warning them about the approaching laser beam. However, other studies didn't discuss whether older people encountered any technological problems when playing games and how the two parties overcame their physical, cognitive and social differences. In addition, possible generational differences with regard to assumptions about young and older people's technological competence and the roles that each party plays (e.g., technological experts and novices, teachers and students) were not fully discussed as well. The direction of technology-related teaching and learning was not clear. It seems older people generally played the role of playmates.

One reason, as mentioned above, may be that the seven games were designed specifically for young and older people. So, the differences between the two generations might have been taken into account during the design process. Vanden Abeele and De Schutter[3] indicated that they adopted a player-centered design process, including both parties from the beginning to the end. The three design rationales, mentioned above, were refined to make the game ease-of-

Table 1. Overview of digital games designed for intergenerational play, their intended impact and evalua-

Game	Core-game play	Intended impact
Collage	Shared displays; mobile camera-phones as input device; touch-screen for synchronous communication between children and their grandparents. Both touch-screens receive and display the same content at the same time. Manipulation of an item on one display is seen on the other in real time.	Support engagement between grandparents and grandchildren
TranseCare	A shopping game; players see a shopping list with groceries to memorize; they enter the store, and buy items from the shopping list; discuss the progress of the game using video chat; players move on to pay for the items they have bought; the initial grocery list is compared to the items bought	Offer a fun way to connect the elderly (suffering from a chronic or degenerative illness) and their family and friends
Age Invaders	Uses a floor display; players follow a predefined pattern (dance like performance) which will light up on the electronic game floor in a given time, or else the health level of the player will drop quickly	Improve welfare of the elderly using interactive media; enhance family interaction; bridge the physical distance between family members through real time remote Internet interaction with the physical real world
e-Treasure	The shape of a Nintendo Wii game; called 'Blast from the Past!'; played in the living room by 4 players; addressing popular culture of the past 60 years; 6 quiz rounds; 2 physical mini-games (Atomium and one other); playing with the WiiMote acceleration sensors; players have to screw, rub off some dirty spots and put one of the balls in the right place by swinging a crank; first finisher is winner.	Foster intergenerational play; facilitate knowledge transfers between youngsters (7-10 years old) and seniors (65 years or older)
Curball	Senior player has a physical ball; junior player has a game field with a starting area, a finish area and physical obstacles, which he distributes over the field; parties collaborate to enable the virtual ball to successfully roll from the starting to the finish area without touching any of the obstacles	Support playful aspects of life as an older person
Distributed Hide-and-Seek	Grandparent is 'hider'; grandchild is 'seeker'; both have pre-installed maps of each other's homes on PC with touch-screen; grandparent selects and drags icons (gifts) onto various positions on the map of grandchild's house; grandchild has to find the gifts	Strengthening social relationships for people who are not co-located
Toy Generations	Toy factory; in 1960s player character's first day at work; progresses to 1980s; finally ends in 2000s; player character grows older, e.g.inexperience and prejudices (as a young employee), intergenerational teams and mentoring (as middle-aged worker), and management issues (as an elderly worker).	-Facilitate(s) intergenerational learning and raise(s) stakeholder awareness
E-VITA	Younger generations experience and understand life that older people have experienced before the EU was established	-Promote and study problem-based learning; experiment and explore knowledge sharing and transfer

use for older people. Another reason, as can be seen from *Table 1*, is that the core gameplay of the reviewed games is so simple that older people do not need to be 'technology savvy' to play.

Table 1 (right side) presents a summary of the evaluation process of each game. It is clear that the evaluations predominantly focused on usability testing, including participants' experiences, perceptions and acceptance of the game and whether they would continue to play the game. Collage

was played by one family for a period of eight weeks. TranseCare, Age Invaders and e-Treasure were played by more participants than Collage was, but the duration of the testing was short. Curball was played by two older adults and one child for six or seven rounds. Distributed Hide-and-Seek and Toy Generations have not yet undergone usability evaluation. In addition, the testing methods were mainly qualitative observation, questionnaires or Question-and-Answer surveys and interviews. These methods were useful to understand

tion process; IP=intergenerational play

Game	Evaluation process		References
	Test design	Measurements	
Collage	-Used by one family over 8 weeks -Analysis of exchanged items and interactions	-Degree of understanding of distributed IP -Degree to which families have expressed traditional forms of collocated social engagement	25
TranseCare	-15 couples of one elder and one of his/her (grand)child -Analysis of videos of the game sessions with video chat -Post-test questionnaire	-User experience of the game with or without video chat functionality -Whether participants liked the game and which version they preferred	47
Age Invaders	-Observational and qualitative user study -Question-and-Answer survey -Interview	-Participants' enjoyment -Usability -Whether the game is good and whether they want to play the game again	26, 48
e-Treasure	-7 seniors and 8 youngsters played for 4 trials of 60 min each -Observation and interview	-Verify design rationales -Explore user reactions	3
Curball	-2 older people(56-65 yrs); 1 child 8 yrs -6 or 7 rounds of gameplay -Observation and group discussion	-Acceptance and handing the game	38
Distributed Hide-and-Seek	-No usability evaluation	-Not applicable	49
Toy Generations	-No test whether intergenerational learning is facilitated	-Not applicable	40
E-VITA	-Still a game concept	-Not applicable	2

players' experience and identify any technological problems. However, as also shown in *Table 1*, the intended impacts of these games were to bring young and older people together, promote intergenerational contact and facilitate IGL. None of these games was tested to examine whether they were effective in achieving the intended impacts.

Impacts
Studies empirically testing the impacts and benefits of intergenerational digital gameplay have

been conducted less frequently. Chua et al.[23] examined the effects of videogame play on intergenerational perceptions amongst youths and the elderly. Each pair of participants, consisting of one youth and one elderly, was randomly assigned to either the video game condition (n=25 pairs) or the non-video game condition (n=28 pairs). For the video game condition, participants played Nintendo Wii once a week over two months. Each session lasted about 30 minutes. The participants in the non-video game condition

were required to interact with each other through the daily routine of intergenerational activities at the senior centres for the same amount of time. Attraction, intergroup anxiety, attitudes, and game enjoyment were measured through pre-test and post-test. The participants in the video game condition reported more positive changes in intergroup anxiety and general attitudes towards the other age group than the participants in the non-video game condition did. Chua et al. interpreted that the stronger effects of intergenerational play on positive perceptions towards the other age group may be due to its novelty.

Older people's digital gameplay may break down the stereotype that they are reluctant to accept new digital technology, a negative stereotype that the youth usually hold for the elderly. On the other hand, older people may develop attraction towards young people as they gradually enjoy gameplay with the help of their younger partners. Chua et al. also indicated that the leisure context of video games introduces a natural status within the games – that of young people as experts and older people as novices, and the two groups accept this role change without much resistance. However, this quantitative study didn't investigate the direction of teaching and learning of gaming skills between the two age groups (although it is a presupposition that young people will help older people play digital games as they are commonly viewed as having more technology competency) and how they view this role change. So, there has been no evidence to support that enjoyment of digital games creates a natural context for the two generations to accept the role reversal.

Rice et al.[50] measured the social interaction and general perceptions of engagement of Xtreme Gardener across three user groups (i.e., Young-Young, Old-Old, and Young-Old). Each group consisted of 10 pairs of participants and completed five levels of the game in 30 minutes. The self-designed post-test questionnaire measured three aspects of social engagement: cooperation, communication and partner preference. It is found that the social interaction with partner was improved among all pairs as they played the game longer. For the young-old group, the younger player would often help their older partners by physically playing the game for the older and selected on-screen features, both for themselves and their partner. However, their older partner occasionally followed their body actions. These findings indicate that older people were not comfortable with learning from the younger generation.

One problem of this study is that Xtreme Gardener might be too difficult for the elderly. As observed in the Old-Old group, the Old-Old exhibited the lowest understanding of the gameplay and often turned to the facilitator for help before consulting each other. Another problem is due to the short duration of the game intervention. Rice et al. recognized that training or longer game intervention might improve the social interactions and comprehension of the game, in particular for the older participants. The contradictory findings of these two studies with regard to the role change highlight the need for future research to investigate the impacts of intergenerational play using different types of digital games and a variety of research methods.

Discussion
Understanding intergenerational play
Collectively, the reviewed studies provided significant insights into the features of intergenerational play.

First of all, it is the enjoyment of interaction and communication with family members that motivates older adults to engage in intergenerational play rather than the play itself.

Second, the interaction and communication facilitated by intergenerational play among family members is not symmetric and reciprocated. Grandparents often engage in activities such as maintaining a safe environment for their grandchildren' play, giving play priority to the younger generations, and exhibiting greater consideration and commitment to the dynamics of play.

Third, older adults usually adopt the roles of organizer, instructor, caregiver, playmate or teaser in traditional playgrounds. When intergenerational play is mediated by new technologies such as digital games, the traditional roles of older adults are often reversed with their younger partner controlling the play and functioning as technology tutors or teachers.

Fourth, the modes of communication may change as the two generations spend more time together and know more about each other although they are quite reserved at the beginning.

Fifth, intermediary generations (e.g., parents and older children) could play an important role in facilitating intergenerational play. However, we only identified one study that was interested in the experience of intergenerational digital gameplay and this study examined the role of different generations using console games[43].

There is a lack of studies that examine how different types of digital games (e.g., MMORPGs) affect intergenerational contact and communication between young and older people and how it affects the social roles of them.

Challenges of designing

Intergenerational play, in particular facilitated by digital games, engenders the dynamics of interaction different from traditional contexts and changes the traditional roles of both young and older people. Designing digital games for intergenerational play is, therefore, a challenge for game researchers and designers. Although there is no such thing as 'one size fits all'[39], a number of common characteristics of intergenerational digital games were shared among the reviewed studies such as short session, easy to get in and out, educational component or practical learning embedded, supporting the various roles of both age groups and taking into account various motivational factors (e.g., cooperation, competition and single/multi-player mode) and contextual factors (e.g., how the game will be used in different contexts). Participatory design and HC design methodology has been applied to the design process in order to provide the two generations playful experiences.

There are some common presuppositions when designing intergenerational games. For example, digital games are new technologies or novelty to older people but a core activity for young people; young people are better than older people at gameplay due to older people's physical and cognitive declines; and young people have more computer literacy than older people. Despite the potential cognitive and physical declines, older people have the eagerness to accept technological advancements and exhibit as equally positive attitudes towards the use of computers as young people[51].

Kaplan et al.[31] indicated that "some assumptions about how young people and older adults will embrace the technological aspects of the program experience should be put aside"[31:p11] if we want to develop technology-assisted intergenerational programs. The importance must be placed on how the games will be designed and used to achieve the established goals (e.g., relationship formation, mutual understanding, and knowledge sharing and transfer) although balancing the different needs and skills between the two age groups is necessary.

Instead of highlighting the differences, game designers should understand how the age differences could be utilized as an interaction component of the game and consider how the expertise of each group (e.g., the role of older people as passing on cultural inheritance and positive life and work experience) could be used to sustain mutual engagement in the game[39], allowing the two age groups to support each other and recognizing what each group can contribute to their

play[22]. Age Invaders is a good example of leveraging on differences in ability between the two age groups. The game offers adaptable game parameters to suit the simultaneous gaming of young and older people[26]. Another approach to empower older people is designing digital games to facilitate IGL in different learning environments. IGL is an effective way to value older people's knowledge and experience and support life-long learning[41]. Digital games that facilitate IGL may be powerful tools to "decrease skills obsolesce, and loss of critical knowledge within an organization"[42:p526]. This is an area that deserves further research in order to value older people's knowledge and experience that they have developed through their entire life.

In looking at the games specifically designed for intergenerational play, it is revealed that some games stimulate relatively simple interaction between the two age groups. For example, the usability test of TranseCare revealed that it was a boring game for young participants and most of the conversation time was spent discussing the game interface rather than the game content itself[47]. The game Distributed Hide-and-Seek, was a virtual version of real-life hide-and-seek[49].

Therefore, some questions that must be considered are: how do these games facilitate conversation, communication and understanding between the two generations? How do these games sustain both generations' long-term interest? How will these games be used in different contexts? These questions are important if the primary goal is to build intergenerational bonds and understanding or facilitate knowledge transfer mediated by social interaction rather than just have them play together. When designing digital games for intergenerational play, making the games easy to use and understand for older people is crucial, as technology anxiety is one reason for older people to avoid the use of new technology[51]. Ease-of-use is not equal to simple interaction, but means that games should not burden older people with hard-to-use interfaces[26].

Problems with usability testing

Researchers in the area of intergenerational play have criticized the usability and enjoyment evaluation of available digital games designed for intergenerational play[3,38,39]. This issue is reflected by the results of this study as well. Examining the test methods reveals that participants' perceptions of game efficacy, verbal communication, engagement during the gameplay, and laugher have been used as the indicators of good usability. Some intergenerational games that facilitate IGL have not undergone testing. So, there is often a lack of convincing evidences supporting

the assertion that the game is effective to engender the intended impacts.

More important questions need to be addressed. Does playing together stimulate meaningful communication between the two age groups beyond technology mentoring? What kind of intergenerational dynamics and communication modes are formed during intergenerational play? Does the game have short-term or long-term impacts on the players, communities and organizations? How can the expected learning outcomes be measured? How can the knowledge and skills learned through intergenerational play be effectively used at work[42]?

Another problem emerging from the usability tests is the short duration, which may lead to the intergenerational conversation focusing on the game interface. It is naturally difficult to evaluate the benefits of intergenerational games due to the numerous interrelated variables[42]. Providing a number of indicators that can prove the effectiveness of intergenerational games is beyond the scope of this review, but there is definitely a need to develop measurable outcomes or usability metrics in game design and implementation if we want to generate useful findings.

Limitation and future research
The limitation of this study is the small number of available published studies. It seems that this review has raised more questions than what has been addressed by current field studies. Based on knowledge and problems generated from previous studies, we have provided a list of recommendations that could be taken into account when investigating how to use digital games to promote intergenerational relationships and learning in different contexts (i.e., family, community and organizations):
(i) Employ a variety of design elements and game mechanics to stimulate and deepen intergenerational communication and understanding and maintain long-term interest.
(ii) Create digital games that offer both entertainment and educational components for knowledge transfer between young and older people in different contexts.
(iii) Explore the nature and role of intergenerational play using different types of digital games and in different contexts.
(iv) Develop indicators or outcome measures, and compare game programs with other intergenerational programs, to evaluate the effectiveness and success of the game programs.
(v) Conduct empirical studies to examine the impacts of intergenerational games in terms of relationship building and learning using different types of games and research methods in different contexts.

CONCLUSION
Intergenerational play changes the modes of communication and the traditional roles of young and older people, and thus provides new ways and opportunities for connecting the two age groups. Understanding the dynamics of intergenerational play, facilitated by traditional artefacts and digital games, is beneficial to design digital games to stimulate intergenerational interactions and promote meaningful intergenerational relationships and learning. What we have learnt from previous studies has implications for the way we approach the design and evaluation of digital games to support intergenerational play in diverse contexts. However, we need to conduct more research before we can fully understand how digital games can be designed and used to facilitate intergenerational interactions and how both generations can be empowered to participate in mutual engagement. The knowledge and understanding generated from previous and future intergenerational programs supported by digital games would provide new viewpoints to engage the two generations together and address the problems of an aging society.

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