

Article

Benefits and Factors Influencing the Design of Intergenerational Digital Games: A Systematic Literature Review

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Abstract: The main purpose of this paper is to review the benefits and factors to be taken into consideration for the design of intergenerational digital games. We conducted a systematic in Scopus, Web of Science, PsycInfo, Pubmed and Science Direct, finally including 16 empirical studies written in English. The identified benefits were found to fall into four main categories, i.e., (1) reinforcing family bond, (2) enhancing reciprocal learning (3) increasing understanding of the other generation and (4) reducing social anxiety. According to the literature, two types of factors are important to take into consideration: player-centric and game-centric factors. We identified the nature of the interactions between older (55–81 year-olds) and younger players (4–22 year-olds), their motivations to play digital games and the difference in abilities as the main player-centric factors to take into account when designing intergenerational games. The most relevant game-centric factors were found to be goal-related and space-related forms of interaction. To gain more insight into how specific benefits of playing digital games are related to a type of game, gender or age of the participant, additional empirical studies (comparative analyses), that take these factors into account are needed.

Keywords: intergenerational games; systematic literature review; intergenerational play; game-centric factors; play-centric factors; playful interaction

1. Introduction

Our society is aging. The United Nations, Department of Economic and Social Affairs, Population Division [1] has estimated that the number of older people (aged 60 or over) will grow to more than 2 billion in 2050. Population aging brings many challenges for society, as well as a need for interventions that can improve the mental and physical health, and the social wellbeing of older people.

In recent decades digital devices have become a central part of everyday life [2,3], for information retrieval, health and fun. Digital games are a good example of how such devices can be used to enhance the mental and physical health, and the social well-being of all generations [4,5]. We know that nowadays older persons make use of the possibility to play digital games (e.g., 26% of all players in the USA is 50+) [6]. Studies have also shown that intergenerational contact can contribute significantly to realizing the above-mentioned improvements [7,8]. Such social interaction, however, must be stimulated, as not only do the generations hold negative age stereotypes about each other, age differences also contribute to a lack of mutual understanding, which may serve to inhibit interactions between the generations [9]. In line with this, digital games seem promising to foster intergenerational play [10].

In this paper, we present the results of a systematic literature review conducted with the aim of obtaining an overview of the knowledge already gained in relation to the benefits of intergenerational digital game-playing practices, i.e., playful digital interaction between participants of different

generations (e.g., grandparents and grandchildren), and the factors that need to be taken into consideration when designing games that target players of different generations. Although two literature reviews were recently published by other authors in this relatively young field, both of these addressed different aspects of this practice. Costa and Veloso [11] performed a review of empirical studies focusing on the potential of intergenerational digital game-playing to enhance intergenerational interactions, while a literature review conducted by Zhang and Kaufman [12] focused on the ways in which intergenerational digital play can facilitate interactions and learning.

We structured the results of the review into three different sections. In the first section, we provide an overview of the empirical studies included in this review to gain insight into the purposes, methodologies and focus of the most important observations. In the second section, we present a list of the benefits of intergenerational digital games, identified in these studies. Finally, in the third section, we provide a summary of the main factors that need to be taken into consideration when designing intergenerational digital games, according to the results of the empirical studies we reviewed in this paper.

2. Materials and Methods

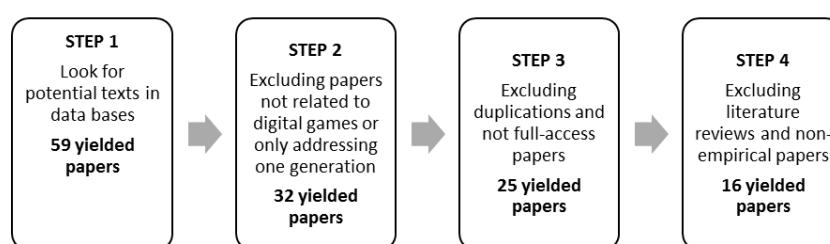
2.1. Purpose and Key Research Questions

To gain insight into the benefits of intergenerational digital game-playing practices and the implications these have for digital game design, we conducted a systematic literature review aimed at obtaining an overview of empirical studies in the field. As we explained in the introduction, the reviews of Costa and Veloso [11] and Zhang and Kaufman [12] focused on the potential of intergenerational digital game-playing as an instrument to enhance, respectively, intergenerational interactions, and interactions and learning. By contrast, the focus of our study was on the benefits of intergenerational digital games designed to be played by both older and younger generations together, and the factors that need to be taken into consideration when designing digital games to foster intergenerational interactions.

2.2. Inclusion and Exclusion Criteria

In light of the fact that this is a relatively new field of research, we looked for empirical studies on the study of intergenerational interactions mediated by all types of digital games (ranging from console or computer games, to tabletop or mobile games, for example). We searched in Scopus, Web of Science, PsycInfo, Pubmed and Science Direct. Depending on the field of study and preferences of researchers, digital games are referred to in many different ways, and we included several forms of naming them to make sure we got access to all papers written about this topic. We used the same reasoning to find papers concerned with intergenerational forms of play, looking for terms that can be related to the same concept. Taking this into consideration, we used the following searching string: “intergenerational” OR “multigenerational” OR “co-play” AND “serious games” OR “digital games” OR “console games” OR “digital entertainment” OR “mobile games” OR “tabletop games” OR “intergenerational play” OR “videogames” OR “video games” OR “computer games”.

We did not use any timeframe limitations for this search. The search was conducted in November 2016. This search yielded 59 potentially eligible papers. After exclusion of those related to non-digital games and to games addressing one generation (young or old), 32 remained. We then eliminated all articles to which we did not have full access and all duplications, leaving a total of 25. At this stage, we also excluded literature reviews and selected empirical studies, which left a final sample of sixteen papers (see Scheme 1).



Scheme 1. Steps Systematic Review.

The inclusion criteria used to select candidate articles were: (a) written in English; (b) discussing the use of digital games to foster intergenerational interaction or discussing the design of digital games aimed at mixed-aged players; and (c) being an empirical study. Exclusion criteria were any of the following: (a) duplicate publication; (b) no reference to the concept of “intergenerational interactions”; (c) addressing a non-digital game; and (d) not meeting any of the inclusion criteria.

2.3. Data Extraction and Analysis

We coded the articles according to: (a) the benefits of intergenerational digital game-playing practices and; (b) the factors to take into consideration when designing intergenerational digital games. Three researchers were responsible for reviewing the different data bases and extracting papers for the analysis. The inclusion criteria mentioned above were used to select the sixteen papers that were finally part of the literature review. Two researchers analyzed the sixteen papers, and a team of four reviewed the results. Taking into consideration the objectives of the literature review, the researchers who analyzed the papers tried to identify in them any references to the benefits of intergenerational digital games, and any discussion related to the factors that needed to be taken into consideration. Paragraphs referring to these two questions were extracted to a document and grouped considering similarities. The four researchers involved in the project, reviewed this document and two of them proposed a possible categorization. The suggested categorizations were discussed by the four researchers until coming to a consensus. The first versions of the categorization included overlapping categories and not clear selection of category names, this was solved by discussing possible solutions suggested by the rest of the group.

3. Results

3.1. Overview of Empirical Studies of Intergenerational Digital Game-Playing Practices

In this section, we discuss the purposes, methodologies and focus of the most important observations of the sixteen empirical studies of intergenerational digital game-playing practices included in our literature review. We do this with the aim of providing an overview of the research practices that have been applied within this field of study. We critically reflect on these, to identify the possible limitations of the studies conducted to date and to be able to pinpoint any interesting gaps that still need to be covered.

Purposes: The purposes of the empirical studies of intergenerational digital game-playing practices in our overview could be classified into three different types (see Table 1): (1) Effects of intergenerational interactions in digital games specifically designed for scientific purposes (N = 9 studies); (2) effects of intergenerational game-playing in commercial games (N = 4 studies) and; (3) exploring intergenerational interactions between regular players of these commercial games (N = 3 studies).

1. A total of nine studies aimed to explore the specific effects of intergenerational interactions in digital games specifically designed for scientific purposes (see studies 4, 5, 6, 8, 9, 10, 12, 13 and 15 in Table 1). An example is the study conducted by Rice and colleagues [13], aimed at evaluating the

communicative and cooperative behavior of mixed-age players of *Xtreme Gardener*, a gestured-based game used to encourage collaboration, friendship and learning.

2. We identified a second group that consisted of three studies that explored the effects of intergenerational digital game-playing interactions in commercial games (see 2, 12, 14 and 16 in Table 1). Volda and Greenberg's research exploring the extent to which "existing game-playing technologies support interactions within collocated intergenerational groups" [7], in which mixed-age pairs were asked to play several console games in a controlled setting, is an example of one such study.

3. The three other studies (see 1, 3 and 8 in Table 1) were directed at exploring intergenerational interactions between regular players of intergenerational commercial games [8,9,14]. In a study conducted by Aarsand et al. [8], for example, qualitative video recording analysis was used to investigate the intergenerational video and computer game activities of families at their homes.

A comparative analysis of the different studies also showed that in those focused on games specifically designed for research purposes, the game mechanics were designed to foster collaborative interaction. In the studies in which commercial games were analysed, the games selected were of a competitive nature; a difference that is relevant to understanding the observations of the various studies.

Methodologies: Twelve out of the sixteen studies discussed in this paper are qualitative studies, 8 of which are case studies (see Table 1). The three remaining studies, conducted by Coyne et al. [9], Chua et al. [15], and Xu et al. [16], are quantitative in nature and involve a total of 287 families, 106 participants and 89 older adults (of which 26 played with adolescents), respectively. Interviews and focus groups (used in 6 studies), questionnaires (used in 11 studies) and game-play observations (used in 7 studies) are the most commonly used methods to study the benefits or effects of intergenerational game-playing practices. At least one of these methods is present in each of the studies discussed in this paper. The ages of the younger participants range from 4 to 22 years old, while those of the older participants vary from 55 to 81 years old.

Focus of Most Important Observations: The potential of intergenerational digital game-playing interaction to stimulate pro-social behaviour is the dominant focus of the studies discussed (see Table 1). All of the studies invoke this question, either in the theoretical framework or in the analysis. Motivation to play with other generations is also a recurrent point (discussed in nine studies). In relation to this, how the digital divide can be used as an approach to foster motivation to play is discussed in several cases [8,13].

3.2. The Benefits of Intergenerational Digital Game-Playing Practices

The sixteen studies analyzed in this paper discuss the potential of digital games to provide a common ground for players to relate to each other. This potential is related to the games' capacity to offer players the opportunity to act together around various topics, objects and identities in the presence of other players [17]. In connection with that, Mahmud et al. [18] claim that when designing intergenerational games, the game rules should be focus on maximizing social interactions.

According to Rice et al. [13], it is mainly due to their capacity to enhance positive interdependence that digital games facilitate social interaction, i.e., social interaction that is enhanced by having a common goal seems to be especially motivating for digital game players [7]. Furthermore, positive interdependence creates a form of continuous mutual awareness of other players [19]. For this reason, social interaction can be fostered through both co-locative and virtual games. An analysis of the literature included in this systematic review shows that empirical studies are focused and discuss different types of benefits of intergenerational gaming practices and different ways in which they can be used to foster social interaction. After analyzing the benefits discussed in the sixteen papers, we grouped these into four different categories based on the purpose of the social interactions (see Table 2 for an overview): (1) reinforcing family bond (N = 16 studies), (2) enhancing reciprocal learning (N = 7 studies), (3) increasing understanding of the other generation (N = 8 studies) and (4) reducing social anxiousness (N = 4 studies). Below, we describe the four categories of the purposes of the social interactions generated by digital game-playing practices.

Table 1. Overview of empirical studies of digital intergenerational gaming interaction.

Study n°	Authors	Game Type	N Old–Young Age	Methodology	Play Time	Country	Main Observations
1	Aarsand et al. (2007) [8]	Several commercial computer and console games, (several platforms)	8 families Children: 8–10 (range)	QUALITATIVE Questionnaires Interviews Qualitative video recording analysis	1 year	Sweden	For adults, displaying a lack of knowledge can work as a resource to enter into social intercourse with children. Creating and sustaining the digital divide in social interaction can be read as a type of strategic act where children’s competence is celebrated and where the child is cast at the centre of the attention.
2	Chua et al. (2013) [15]	3 Nintendo Wii Games: Wii Sports, Cooking Mama and Wii Party	53 elderly: 76 (mean) 53 young: 17 (mean)	QUANTITATIVE Interaction sessions Gaming Sessions Surveys	2 months	Singapore	“The result showed that all participants reported greater attraction towards their interaction partner over time, regardless of their interaction types. These findings imply that when members from different age groups are paired to play video games together, they tend to develop not only positive perceptions towards their particular play partners, but also positive general perceptions towards the members of the other age group as spill-over effects” [15] (p. 2308)
3	Coyne et al. (2010) [9]	Several commercial console games, (several platforms)	287 adolescents and their families Adolescents: 11–14 (range)	QUANTITATIVE Gaming Sessions Questionnaire	1 session	EEUU	For both younger and older players, positive emotions such as happiness and enjoyment coalesced with the bonding, the conversations, the feeling of being closer to loved ones and of maintaining relationships across distances.
4	D’Cruz et al. [20]	NA	20 parents: 31–51 19 children: 11–14	QUALITATIVE Focus groups	NA	Unites States	Participants agreed that a sex education game could improve communication. “They affirmed the demand for an immersive story-based educational adventure game using mobile platforms and flexible communication modalities. This study confirmed the potential of a game to be a viable medium to bring a shared dyadic sexual health educational experience to parents and youth that could engage them in a motivationally appealing way to meaningfully impact their sexual health communication an youth sexual risk behaviors.”
5	Derboven et al. (2012) [21]	<i>TranseCare</i> , a shopping game (computer game with video chat function)	15 couples (young–old) Older: 68 (mean) Younger: 22 (mean)	CASE STUDY Qualitative analysis of videotaped gaming sessions Questionnaires	2 sessions	Belgiu	“In intergenerational multiplayer games, use video chat to add value for older as well as younger players. As the communication channel can also be important for explanation and helping out the older players, moving through different game phases should be simultaneous. [...] Designing games in which players alternately can take control of game progression can allow the elderly to take the lead position, once they feel comfortable.” [21] (p. 64)
6	Khoo et al. (2007) [22]	<i>Age Invaders</i> : mixed reality platform game	10 Young: 11.7 (mean) 10 Adults: 58–80 (range)	CASE STUDY Questionnaires Qualitative data analysis Observations Focus Groups	1–2 sessions	Singapore	Social interaction has been identified as the key factor that attracts the elderly and young to play the game harmoniously. The elderly and young gave feedback that the game should be played with many spectators
7	Mahmud et al. (2010) [16]	<i>Save aMazed Princess Maze</i> (augmented tabletop games)	2 Young: 7–8 (range) 2 Adults: 65–70 (range)	CASE STUDY Questionnaire Interviews Observations	2 sessions	The Netherlands	Elderly and children prefer playing with their peers than with younger/older players. Elderly and children stated that they do not mind playing with younger/older if it is required and the game is tailored to their preferences

Table 1. Cont.

Study n°	Authors	Game Type	N Old–Young Age	Methodology	Play Time	Country	Main Observations
8	Osmanovic et al. (2016) [14]	Several Commercial Casual online social games	27 Young: 17–22 (range) 22 Old: 59–71 (range)	QUALITATIVE Interviews Face-to-face and online focus groups	Not specified	USA	For both younger and older players, positive emotions such as happiness and enjoyment coalesced with the bonding, the conversations, the feeling of being closer to loved ones and of maintaining relationships across distances.
9	Pappa & Pannese, 2010 [23]	e-VITA, SGs that allow younger generations to “live” stories told by older people	Not specified	CASE STUDY Questionnaires Interviews	Not specified	Spain, Portugal, Poland, Italy, Greece, UK	“Serious games used in the context of intergenerational learning, need not only to appeal to younger generations of players, or convey practical or historical information about past decades, but rather to immerse players in the life of older generations” [23] (p. 236)
10	Rice et al. (2013) [13]	Xtreme Gardener: Interactive augmented reality game	30 Young: 15–20 (range) 30 Adults: 55–74 (range)	CASE STUDY Observation and Questionnaires	1 session	Singapore	Participants of Young–Old couples reported better understanding of the game thanks to the support of the younger partner. Younger players accommodate to older players’ preferences. Younger players exhibited more dominant behavior.
11	Siyahhan et al. (2010) [24]	Family Quest: an educational computer game	8 Adults 7 Children: 9–13 (mean)	CASE STUDY Questionnaires Observations	5 weeks	EEUU	“We need to find productive ways to bring parents and children together around video games and create opportunities for exchange of expertise to facilitate family relations and learning” [24] (p. 431)
12	Vanden Abeele & De Schutter (2014) [25]	4 Commercial physical mini-console games (Wii Platform)	5 pairs (old-young)	QUALITATIVE Observation game play Questionnaires	1 session	The Netherlands	“It is not physical action but rather enactive interaction that ensures ease-of-use for seniors and youngsters. The use of enactive knowledge avoids relying on digital competences and/or mental models of how to operate digital appliances which would favor youngsters.” [25] (p. 432)
13	Vetere et al. (2008) [18]	A Collage: a technology for mediating intergenerational play	1 family	CASE STUDY Methods not specified	8 weeks	Australia	Collage “allows families to express some of their traditional forms of collocated social engagement over a distance. These forms of engagement include playful activities, but also extend story-telling, gift-giving, and confirmation of social roles” [18] (p. 176)
14	Voida & Greenberg (2011) [7]	Several commercial console games	36 participants Children: 9 (mean) Adults: 55 (mean)	QUALITATIVE Questionnaire Group Game Play Gaming Environment Sketch, Focus Groups	1 session	Canada	Observations suggest that intergenerational interactions can provide some of the developmental benefits crucial to individual well-being; young gamers were exposed to older gamers who served as models of behaviours and older gamers had the opportunities to share their knowledge and experience with younger gamers.
15	Vutborg et al. (2011) [26]	Collage and Storytelling, technologies for mediating intergenerational play	3 Families Children: 4–14 (range)	CASE STUDY Interviews Observations	3 weeks	Australia, Denmark	“Our findings highlight the importance of: the need to consider the parents’ role in facilitating contact and making the technology easy to use by children independently; the advantage of concurrent synchronous and asynchronous interaction forms; and the need to respect people’s private time. These findings can inform the design of technology for supporting young children’s communications with adult relatives across time zones.” [26] (p. 291)
16	Xu et al. [27]	3 Kinect games	41 young-old aged adults: ≤74 48 old-old aged adults: >75 26 adolescents	QUANTITATIVE Game sessions Pre and post questionnaires	3 session 10–15 of minutes	Singapore	“There was a significant decline in social anxiousness and an increase in sociability for young-old (≤74 years old) participants playing with adolescents.”

Table 2. The Benefits of Intergenerational Gaming Practices (QUAL: qualitative, QUAN: quantitative, CS: case study).

Benefit	Number of Studies that Discuss This Benefit	Example in the Literature
Reinforcing Family Bond	Total: 14 3 (QUAL) 2 (QUAN) 8 (CS)	“When parents play video games with their daughters, they may be sending a myriad of messages. First, parents may show that they are willing to engage in an activity that is important to daughters. Second, playing video games can represent quality time between a daughter and a parent, especially when such play involves conversation between parent–child.” [9]
Enhancing Reciprocal Learning	Total: 7 3 (QUAL) 4 (CS)	“For children, the activity of intergenerational play helped them learn “how to help people.” For parents, on the other hand, the activity meant that they learned about “how their children react” and “how their minds worked” while spending time together as a family.” [28]
Increasing Understanding of the Other Generation	Total: 8 2 (QUAL) 2 (QUAN) 4 (CS)	“Our results support the potential of video-game play in developing positive intergenerational perceptions as a means of shared leisure activities when individuals from different age groups are paired to interact together.” [15]
Reducing Social Anxiousness	Total: 4 4 (CS)	“Results showed a significant three-way interaction effect among exergaming, play type, and age group on older adults' psychosocial well-being. There was a significant decline in social anxiousness and an increase in sociability for young-old participants playing with youths.” [16]

3.2.1. Reinforcing Family Bond

The sixteen studies discuss the capacity of intergenerational digital games to serve as a mediating tool to help to strengthen family relationships, both in situations where family members live close to one other, and in situations in which family members live far apart. The mediated interaction that a game fosters between adults and children in local families who play the same game can cause their relationship to improve, for example, by generating new conversational topics [20,29]. The game can also promote positive interaction, say, by dispelling the underlying tension that may exist between the two generations [20]. Simply engaging in the game is enough to help draw the focus away from the friction between family members in family interactions. Moreover, a game is perceived as a promising tool to improve positive intergenerational communication on sensitive topics such as sexual health [24].

For family members living far apart, online social games have been shown to be able to become a shared virtual space that can help to overcome the lack of interaction. The game can, for example, provide opportunities for interaction by becoming an initial conversational topic [14,23].

3.2.2. Enhancing Reciprocal Learning

The exchange of knowledge and skills across generations is an interesting benefit of intergenerational digital game-playing practices discussed in seven of the studies analyzed in this paper. The study conducted by Siyahhan et al. shows that the exchange of expertise between two generations around an interactive narrative-based game context is a productive form of intergenerational play [28]. Besides this, promoting joint actions in which younger players are placed and ratified as those in the know, and the older players as the less knowledgeable, appears to offer potential for keeping both generations interested in the experience [8,30].

3.2.3. Increasing Understanding of the Other Generation

Mixed-age interactions are often asymmetrical interactions in which older individuals make the greater effort to stimulate younger individuals to interact [8,31]. Usually, the lack of interaction comes from the negative stereotypes both generations hold of one another and/or the lack of mutual understanding [27]. Eight of the sixteen studies analysed in this paper show that intergenerational digital games can contribute to a greater mutual understanding between the generations. The quantitative study conducted by Chua et al. [15], for example, shows that digital games as a shared activity among two generations can result in positive changes in their intergenerational perceptions.

3.2.4. Reducing social anxiousness

The capacity of intergenerational gaming practices to reduce social anxiousness and increase sociability is also discussed in four of the papers analysed in this review. The study of Xu et al. [16], for example, showed that social anxiousness decreased and sociability increased in the young-old adults (aged ≤ 74 years old) after playing exergames with adolescents, while playing with peers or alone did not have any effects on social anxiousness and sociability.

3.3. Factors to Consider for Intergenerational Digital Game Design

In this section, we focus our attention on the factors to be considered when designing intergenerational digital games discussed in the papers included in the literature review. Our analysis helped us to distinguish two different types of factors, namely, (1) player-centric factors and (2) game-centric factors. The most relevant player-centric factors discussed in the literature are: (1.a) the nature of the interactions between older (55–81 year-olds) and younger players (4–22 year-olds) (N = 7 studies), (1.b) their motivations to play digital games (N = 10 studies) and (1.c) the difference in abilities (N = 10 studies) as the main player-centric factors to take into account when designing intergenerational games. The most relevant game-centric factors were found to be (2.a) goal-related

(N = 4 studies) and (2.b) space-related forms of interaction (N = 6 studies). The list of factors proposed below (see Table 3 for an overview) can be used as a theoretical framework that can help to design intergenerational digital games.

3.3.1. Player-Centric Factors

(1.a) Old-Young Interactions

Seven of the studies included in the literature review stress that one of the factors to be taken into account when designing intergenerational games is the type of interaction between the different generations. Each generation has a different connection to the other generation, which influences the behavior and the roles played by the members of the generations towards one another. In the case of grandparents and grandchildren, for example, the interaction tends to be an asymmetrical one, with the grandparents assuming the role of caretaker and/or instructor while trying to induce the children to interact with them [20,31]. To facilitate a natural intergenerational interaction, games can be designed that encourage this kind of asymmetrical interaction to evolve between the players. Intergenerational digital games can enhance these roles, for example, by enabling grandparents to enact the role of teachers, admirers or caretakers, while grandchildren adopt the role of students wishing to demonstrate their abilities [7,21]. For instance, Vetere et al. [20] designed the 'Collage', a form of intergenerational play that relies on these roles. In the game, grandchildren can use a digital system to ask their grandparents (living abroad) to tell them a story [26]. They can also use the system to send them pictures or messages. The goal of this form of free play is not the exchange of information between the generations, but the shared activity, which enables them to keep in touch with each other, strengthening their bond.

(1.b) Motivation to Play and Game Preferences

Another factor to be taken into account is the difference between the generations in motivations for playing digital games, discussed in ten out of the sixteen studies. This difference must be considered when designing an intergenerational digital game, if both the older and the younger generation are to remain interested in playing the game together in the longer term [25].

Older players, for example, were found to largely reject reflex-oriented games, such as fighting or racing games. Not only do they find such games more difficult, less interesting and hence less enjoyable to play, due to age-related physical conditions or disabilities [5]; likewise, as older players tend to be less competitive and inclined to assume more passive and supportive roles, they also avoid action and violent games [14]. Also, older adults seem to be more adaptable than younger players, which is why Mahmud et al. suggest that when designing intergenerational games, priority should be given to the preferences of children [18].

(1.c) Differences in Abilities

The third aspect, discussed in ten studies, is the influence of age on the difference in abilities, which creates disparities in digital game-playing skills between younger and older players, specifically between grandchildren and grandparents. Unlike the present generation of children, today's older adults did not grow up with computer technologies. Accordingly, they might not be as familiar with computer technology as children are, which can cause a breach between the generations [8]. Hence, a digital game that an older player might not be able to understand may be far too simple for a child, who might well already be a technology expert. In addition, older adults also struggle with age-related cognitive and physical limitations. The differences in abilities manifest themselves depending on the technology and form or interaction that is used in the game. The studies discussing intergenerational interactions mediated by computer and console games, reflect on these differences in abilities to control the game and understand how to interact with it [7–9,14].

There are several types of age-related limitations that should be taken into consideration when designing intergenerational digital games. For this reason, digital games that pay special attention to usability for older players, for example, by using physical or simple controls are recommended [22]. Furthermore, senior gamers also struggle with high game speeds due to slowed reflexes. For this reason, in-game adjustable speeds might be an option to support older players for whom time-restricted games are a challenge [32]. Vanden Abeele and De Schutter argue that enactive forms of interaction with these games may serve to overcome these difficulties [25]. Intergenerational games that enable enactive forms of interaction, are capable of identifying and responding to motor responses or gestures of players that were learned during their everyday life [25]. According to the authors, these forms of interactions may serve to overcome the differences in abilities related to the interactions with complex game controllers or computer devices. It should be noted, however, that children are also subject to age-related limitations. As technology experts, they usually do not struggle with different mechanics and complex controls, and therefore need to be challenged more than older players, to sustain their interest in the game [13,33]. Nevertheless, because of their young age, the game technology should be tailored to their age and abilities [20].

Chance-based games that include easy to master physical or tactile controls elicit high degrees of engagement in individuals of both generations, because of the diverse opportunities for playful interaction these offer. In addition, these games tend to be shorter (especially appealing to older players) and to feature lighthearted themes and characters (especially appealing to younger players) [33]. Moreover, enactive interaction, which avoids relying on specific digital competences and/or mental models of how to operate digital games, provides an interesting solution to deal with the difference in abilities of members of both generations [25,33].

In intergenerational digital games, the differences in abilities between older and younger individuals can be accommodated by enabling different players to play according to their own abilities. The research-based game *Age Invaders* [22] is a physical puzzle-solving game that addresses this gap in abilities between older and younger players by incorporating modifiable adjustments for both generations. The game is divided into short play sessions resulting in a challenging and fast-paced gameplay suited for children, while also providing a simple form of interaction that is understandable for the older adults [22].

3.3.2. Game-Centric Factors

(2.a) Goal-Related Forms of Interaction

The different goal-related forms of interaction and their influence on the effects of intergenerational digital games are also a focus of discussion in four of the studies analyzed in this paper. As previously discussed, positive interdependence plays a major role in facilitating social interaction between different generations. Collaborative digital games have been found to have a strong potential to foster positive interdependence [22,34]; accordingly, a collaborative game in which both generations share the same objective would seem to be a suitable goal-related form of interaction for intergenerational digital games [13,14,22]. As older players are generally less competitive than younger adults and children, collaborative games provide a better fit with the preferences of both generations [25,33]. The technical prototype of a digital game based on the traditional hide-and seek, as developed by Vetere et al. [20] is an example to use fun instead of competition to foster interaction.

Notably, though digital games that implement cooperative competition can offer a middle-ground option, as these are considered to be more exciting than pure collaborative games, yet still facilitate social interaction [22]. Khoo's *Age Invaders* [22], for example, was designed in such a way that although a grandparent and grandchild are competing against each other, they have to cooperate to stay in the game to win. Accordingly, on one hand, cooperative competitive games are challenging for children, as they satisfy children's competitive streak and enable them to show off their skills. On the other hand, the cooperative nature of these games ensures that mutual interdependency prevents the competitive

element from becoming dominant, enabling older generations to enjoy the gameplay by cooperating with the younger generations.

(2.b) Space-Related Forms of Interaction

In intergenerational digital games, social interaction between individuals of different generations is one of the main objectives. For this reason, six of the studies analyzed explore the effects of different space-related forms of interaction in intergenerational games. These studies show that the degree of playing in the presence of others is relevant to determine the success of mechanisms that aim to foster social interaction among players. Accordingly, higher levels of playing in the presence of others were observed between players continuously engaged in virtual collaborative games, than between players involved in a co-located game in which solitary goals without any great need to interact were pursued [21]. In relation to this, a study conducted by Derboven et al. [21] showed that the addition of extra communicative functionalities in virtual intergenerational games, are often welcomed by members of both generations. According to this study, these can be a useful channel for young players to share their knowledge and experience with digital media with older adult players.

Table 3. Factors to Consider for Intergenerational Digital Game Design (QUAL: qualitative, QUAN: quantitative, CS: case study).

Type of Factor	N° Os Studies Discussing This Factor	Factor	Implications Discussed in the Literature
Player-centric Factors	Total: 7 1 (QUAN) 2 (QUAL) 4 (CS)	Old-Young Relationships	Mix-aged relationships are asymmetrical Negative stereotypes and/or lack of mutual understanding
	Total: 10 1 (QUAN) 6 (CS) 3 (QUAL)	Motivation to Play and Game Preferences	Older Players Motivation to Play: Fun and relaxation, escaping reality and social interaction and connectedness Game Preferences: Strategy games, short gameplay sessions, simple game rules, intellectual challenges over reflex-oriented games Younger Players Motivation to Play: Social presence, diversity and enjoyment, fun and relaxation Game Preferences: Fantasy and imaginative immersion
	Total: 10 4 (QUAL) 1 (QUAN) 5 (CS)	Differences in Abilities	Differences in digital technology skills Physical Differences (vision, hearing, reflexes) Cognitive Differences
	Total: 4 2 (QUAL) 2 (CS)	Goal-Related Forms of Interaction	Competitive Collaborative Cooperative Competition
Game-centric Factors	Total: 6 3 (QUAL) 1 (QUAN) 2 (CS)	Space-Related Forms of Interaction	Virtual Co-locative

4. Discussion and Conclusions

The main goal of this paper was to identify the benefits of intergenerational digital game-playing practices and the factors that need to be taken into consideration when designing games that target mixed-aged players. To that end, we conducted a systematic literature review that helped us to structure and gain insight into the results of previous studies in relation to this topic, resulting in a theoretical framework that can be useful for the analysis and design of intergenerational digital games.

The results of this systematic literature review were presented in this paper in three different sections. First, we provided an overview of previously conducted empirical studies in the field of intergenerational digital games. The analysis showed that most of the studies conducted in this area were qualitative exploratory studies, involving a limited number of participants. These studies tended to be focused on exploring a specific benefit or effect of intergenerational digital game-playing practices, usually related to their capacity to foster positive intergenerational interaction. The most

common methodologies used to achieve this purpose were questionnaires, gameplay observations and interviews. The analysis yielded the interesting insight that studies in which the selected game was specifically designed for scientific purposes focused on a single collaborative game, whereas studies comparing the effects of the use commercial games were generally focused on multiple competitive games. Future empirical studies should consider the possibility of exploring the differences between collaborative and competitive forms of play and their effects on intergenerational interactions.

The included studies showed that the benefits of intergenerational digital games are linked to their capacity to serve as a backdrop for social interaction and to enhance positive interdependence that facilitates social interaction [13]. According to the results of the analysis, we have identified that playing these games is associated to four benefits associated to this capacity of digital games to facilitate social interaction: (1) reinforcing the family bond and communication, (2) creating opportunities for reciprocal learning, (3) facilitating an understanding of the other generation and (3) reducing social anxiety.

Regarding their capacity to reinforcing family bond, the included studies showed that intergenerational games can generate new conversational topics, promote positive interaction and communication among family member from different generations [24]. Games can create a shared virtual space, where family members can be updated about the daily life of their relatives through in-game actions that are associated with their real-life activities, which can help to strengthen the family ties [19].

Besides this, by creating opportunities for reciprocal learning, is not only a good way to engage players in intergenerational playing sessions by increasing their interest [28], but it is also an opportunity for players to discover the skills and knowledge of their family members and to learn to value them in a different way [8,30].

Furthermore, by mutual understanding between generations, intergenerational digital games can help to overcome the interference of negative stereotypes when members of two generations try to interact, which usually result in asymmetrical interactions in which older individuals need to put extra effort to ensure interactions [8,31]. Mutual understanding can result in positive changes in intergenerational perceptions [15]. Finally, intergenerational gaming practices can also serve to reduce social anxiousness, especially among older generations, increasing sociability of players that live in situations of social isolation, and experience difficulties when need to initiate social interactions [16].

In the last section of this paper we presented the factors that, according to the studies analyzed in the systematic literature review, need to be taken into consideration when designing intergenerational digital games. We saw that these factors could be divided into two different categories: player-centric factors and game-centric factors.

The nature of the interactions between older and younger players, their motivations to play digital games and the differences in abilities were identified as the main player-centric factors to be taken into consideration. The included studies showed that digital games can facilitate a natural intergenerational interaction. This is in line with what previous studies focused on seniors and in children have shown. A study in seniors, for example, showed that enact in a teaching role is a motivational factor for seniors to play digital games, as they can lead to an increase in social connectedness and interaction [32]. A study in children also showed that collaborative digital games are an interesting tool to foster social interaction [34].

Another point to consider is the fact that the type of interaction between individuals of different generations might become an obstacle in achieving the purposes of the game. Negative stereotypes and/or lack of mutual understanding because of the age difference are common problems associated with young-old interactions [27]. As previously stated, intergenerational digital games can contribute to overcoming these issues by facilitating positive interaction between mixed-age players. However, in this sense, it is important to introduce mechanisms into the game that encourage a mutual exchange of information and/or ideas [3].

As far as game-centric factors were concerned, goal-related and space-related forms of interaction seemed to be the most relevant to take into consideration when designing intergenerational digital games. The decision to engage players in collaborative, competitive or cooperative competitive games

has relevant implications on the effects of these practices. In addition, virtual or co-locative forms of interaction both seem to be able to foster the benefits of mixed-age individuals playing together. To this end, the study of Loos [35] is of interest as it identified three possible patterns of motivation shared by younger and older adults and leading them to play digital games: fun and relaxation, escaping reality, and social interaction and connectedness. Older adults who play games for fun, enjoyment and relaxation tend to enjoy strategy games with simple game rules that can be played in short sessions [32]. This is closely related to the young players' motivation for playing games, namely diversity and enjoyment [36]. Furthermore, older adults seem to play games to escape from the reality of, for example, daily life chores or sorrow about the loss of a loved one [32,37]. Games that seem to accommodate this kind of motivation best are those with a story and strong imaginative visuals. This escapist gameplay is related to the fantasy and imaginative immersion that motivates younger players to play games [35,37].

Besides this, older players tend to be less competitive and inclined to assume more passive and supportive roles than younger players and they also avoid action and violent games [13]. Instead, studies among older adults showed that older players especially seem to like communication [36] and intellectual challenges [32,37]. In addition, older individuals usually play games because of the social aspects. In particular, when playing with family members, the social aspect is more important than the game itself, prompting older adults to play a game, only because, for example, their children or grandchildren play it, instead of being interested in the game itself [23]. This, in turn, is associated with the younger players' interest in playing in the presence of other people [35].

Next, the literature review also showed that differences in ability should be taken into account. In line with this, from the perspective of older adults, Loos [35] identified a series of interface-related limitations for older players, such as difficulties in reading texts in screens and detecting items in the periphery of the screen; problems with using mouse and keyboard controls, selecting and scrolling pages on the screen; and difficulties with speed-related behavior in-game and with hearing. These are important factors to take into account when developing intergenerational games.

Limitations and Suggestions for Further Research

In the current review we focused on digital games because of the increasing interest in the use of these types of games to engage and motivate both generations in intergenerational interactions. We decided to leave outside of this review other game types such as alternate reality games, as they differ from digital games in many aspects. Although alternate reality games also seem promising game types for intergenerational interactions [38,39], this was out of the scope of the current review.

A main limitation of the current review is the broad approach of the literature review and the few amount of studies included in it. As intergenerational interactions through digital games is a new field of research, there only a few studies yet on this topic. We therefore decided to keep our focus wide and include all digital game platforms, behaviors and age ranges. This strategy allowed us to get a broad view on the state of the art in the research field of intergenerational digital games. For more specific results on platforms or age ranges, however, more research on this topic needs to be conducted.

We also looked at a different type of studies, including quantitative and qualitative studies with different samples of players. This afforded us a broad overview of the types of benefits associated with intergenerational interactions through digital games and the design factors that need to be taken into consideration. However, to gain more insight into how specific benefits of playing digital games are related to type of game, gender or age of the participant (very young, young, old, very old), additional empirical studies (comparative analyses) that take these factors into account are needed.

The studies in the literature review discussed mainly grandparents-grandchildren interactions. Other intergenerational relationships could also be relevant, but the results of the review show that there seems to be a gap on this topic in current literature. We recommend future research should look further than only grandparents-grandchildren interactions.

In addition, future quantitative studies in which not only more participants, but also a larger variety of games are studied, could contribute to a better understanding of intergenerational digital game practices. Furthermore, the factors that we found were relevant for the design of such games serve as a framework for game designers, to ensure younger and older players can fully enjoy the benefits of playing together.

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