

# Exergaming: Meaningful Play for Older Adults?

Eugène Loos 

University of Amsterdam, Nieuwe Achtergracht 166, 1018 Amsterdam, WV, The Netherlands  
e.f.loos@uva.nl

**Abstract.** Dutch historian Johan Huizinga [1] viewed games as a fundamental aspect of life. As long ago as 1938, he observed that, next to “homo faber” (man the maker), there is also the concept of “homo ludens” (man the player). The aim of this paper is to explore what we can learn from previously conducted empirical studies about the motivation and capability of older adults to use exergames. We were guided by the following questions. To which extent: (1) Are older adults *motivated to* play exergames and why is this the case?, (2) Are older adults *able to* play exergames and why is this the case? and (3) Can the *voices* of the older players be heard in the empirical studies on exergaming in later life? We conducted a narrative literature review to gain insight, not only into the factors relating to older adults’ engaging in exergames, but also into the ways older adults themselves experience playing such games. To avoid a mainly functionalist perspective on play, we will also include hedonic aspects of playing exergames.

**Keywords:** Exergaming · Older adults · Meaningful play · Narrative literature review

## 1 Introduction

To the left is a *virtual* Tai Chi instructor, while on the right is a representation of an older adult on a computer screen trying to follow the instructions given by the instructor; the number of calories burned (3) are shown in the lower right-hand corner. The miniature table flag next to the screen is from the Dutch senior citizens organisation, ANBO, the host of this research project. The project itself is aimed at understanding how older adults make sense of exergames (Fig. 1).

The next picture shows the *real life* setting (Fig. 2):

The older adult is playing an exergame, which is also known as “active video game, interactive video game, activity promoting video game” [3, p. 10], consisting of an electronic device that allows one or more persons to play a game “requiring physical exertion or movements” [3, p. 10], while receiving immediate digital performance feedback on a screen (see also Primack et al. [4, p. 3]). Kooiman and Sheehan [5, p. 1] state that: “Until recently exergaming was seldom a topic of research. The technology that makes exergaming possible was not available to consumers. In 2006, Nintendo released the Wii gaming system (see also Brown [6]). This new system allowed for interactive physical movement beyond simple hand held play. The Wii system contained hardware and software that responded to movements of the player’s body through the tracking of

hand held controllers and movements of the lower extremities using floor based hardware”.



**Fig. 1.** Screenshot [2]

Dutch historian Johan Huizinga [1] viewed games as a fundamental aspect of life. As long ago as 1938, he observed that, next to “homo faber” (man the maker), there is also the concept of “homo ludens” (man the player). Since then, as Bogost [7] pointed out, we have become as used to playing digital games in the living room as watching television (see also Juul [8] on “casual gaming”). Several studies have suggested that playing exergames can, to some extent (the evidence tends to be limited), benefit the wellbeing of *children and young adults*, and hence could form a potential valuable therapeutic instrument (e.g. [9–13]). Other studies have demonstrated that *older adults* are interested in traditional games (e.g. [14, 15]). Hoppes et al. [14] conclude that “Games are a purposeful activity that hold high interest for older adults and consequently have significant value as therapeutic tools for occupational therapists” (p. 71).



**Fig. 2.** Older adult playing a Tai Chi exergame [2]

The purpose of this study is to explore the role exergames could play in promoting the wellbeing of older adults. In doing so, we were guided by the following questions. To which extent:

- (1) Are older adults *motivated to* play exergames and why is this the case?
- (2) Are older adults *able to* play exergames and why is this the case?
- (3) Can the *voices* of the older players be heard in the empirical studies on exergaming in later life?

To answer these three questions, a narrative literature review was used to gain insight not only into the factors relating to older adults' engaging (or not) in exergames, but also into the ways *older adults themselves experience* playing such games. To avoid a mainly functionalist perspective on play, we will also include hedonic aspects of playing exergames [16–20]. As Iversen [20] states in her paper 'Play and Productivity: The Constitution of Ageing Adults in Research on Digital Games' in which she reviews studies on the impact of digital games for older adults' daily life:

“While there are exceptions, the ageing adults in the examined studies are largely portrayed as ailing, hesitant, in need of encouragement to do what is good for them as well as requiring the care of others. This outlook is coupled with a mainly functionalistic approach to the use of digital games, where the beneficiality of playing in terms of health maintenance is central rather than, for instance, enjoyment, pleasure, or creativity. Importantly, it is not only the researchers who invoke the beneficiality of digital games above other reasons for playing. To the degree that the ageing adults themselves are given voice, they often, too, focus on learning and training elements of digital games.” (p. 14)

## 2 Method

The aim of this paper is to explore what we can learn from previously conducted empirical studies about the capability and motivation of older adults to use exergames for their wellbeing. As Kari et al. [21, p. 30] state: “Physical activity has been shown to have a positive impact on people's well-being. According to WHO [22], regular physical activity can, among others, reduce the risk of diabetes, cardiovascular diseases, depression, breast cancer, and colon [cancer]. It can also improve bone and functional health [23] and have other important health benefits.”

Our focus was on exploring how older adults make sense - or do not make sense - of such games. We therefore conducted a narrative literature review [24], the results of which we present in Sects. 3.2, 3.3 and 3.4. We started our search with a recent literature review on the motivation and benefits of digital games for the elderly conducted by Cota and Ishitani [25] and with the paper 'Older Adults' Digital Gameplay Patterns, Benefits, and Challenges. Simulation & Gaming', published in 2016 by Kaufman et al. [26]. We then used the snowball method [27] to search for additional studies more specifically focused on *exergames* that would be suitable for inclusion. The results of the narrative literature review will not only be used to present facts and figures, but also to give voice to the ways older adults themselves experience playing such games.

## 2.1 Results

According to the Entertainment Software Association ESA [28], the number of US older adults playing digital games is considerable: in 2016, 26% of all gamers are aged 50 or older. A similar picture emerges in the countries of Europe. According to Iversen [20], who refers to Bak et al. [29], Nordicom-Sverige [30, p. 2] and Vaage [31], “national surveys on the use of media in Norway, Sweden, and Denmark indicate that - varying between the countries - 5–12% of the population above 60 years of age play digital games at least once a day” (p. 2). Loos et al. [32] confirm this trend for the Netherlands: “New Zoo (the only source for reliable data on Dutch older adults’ use of digital games) clearly shows that (...) in 2013 39% of the 51–65 year-olds play digital games.” We agree with Pearce [33], who emphasizes that older gamers have “needs and interests that have gone ignored by both the mainstream game industry and the game press” (p. 142). In reviewing the literature in this area, we will therefore aim to gain insight not only into the factors relating to older adults’ engaging (or not) in exergames, but also into the extent to which the voices of the older players can be heard in the empirical studies on exergaming in later life.

## 2.2 Giving Voice to Older Adults’ Motivation to Play Exergames

Sherry et al. [34] conducted focus groups with four to eight participants (age 18 to 22, U.S. American undergraduate students, N = 96), adopting a Uses and Gratifications perspective [35]. They concluded that the dimensions arousal, challenge, competition, diversion, fantasy and social interaction were the motivations for the participants to play video games. In this section, we use their classification to gain insight into the motivations of older adults for playing – or not playing - exergames. We used the framework

**Table 1.** Why older adults play exergames

|                             | Dimensions: | Arousal | Challenge | Competition | Diversion | Fantasy | Social Interaction |
|-----------------------------|-------------|---------|-----------|-------------|-----------|---------|--------------------|
| 1. Graves et al. [36]       |             |         |           |             | +         |         |                    |
| 2. Aarhus et al. [37]       |             |         |           | +           | +         |         | +                  |
| 3. Brox et al. [38]         |             |         |           |             |           |         |                    |
| 4. Kari et al. [21]         |             |         |           |             | +         |         |                    |
| 5. Omholt and Waerstad [39] |             | +       |           | +           | +         |         | +                  |
| 6. Heuvelink [40]           |             | +       | +         | +           | +         | +       | +                  |
| 7. Heuvelink [41]           |             |         | +         |             | +         |         | +                  |
| 8. Skalsky Brown [42]       |             |         |           | +           | +         | +       | +                  |
| 9. Cota and Ishitani [25]   |             |         |           |             |           |         | +                  |
| 10. Loos and Zonneveld [43] |             |         | +         |             | +         |         | +                  |

developed by Sherry et al. (2006), adding column for dimensions (e.g. exercising) no included in their framework. The results are presented in Table 1. A dimension marked with a + means that the exergames were experienced as enabling wellbeing; a – denotes that this dimension was experienced as a barrier to playing.

The Table above shows that older adults rarely mentioned the motive dimensions in the framework developed by Sherry et al. (2006) of arousal, competition and fantasy; challenge is somewhere in the middle, while diversion and social interaction are mentioned most often (Table 2).

**Table 2.** Studies on age-related functional limitations due to ...

|   |   |
|---|---|
| <b>Declining vision:</b> difficulties in seeing and processing cluttered online content and difficulties screen reading                     | Charness [50]; IJsselsteijn et al. [51]; Lunn and Harper [52]; Billis et al. [53]; Vasconcelos et al.; [54]; Omholt and Waerstad [39]; Skalsky Brown [42]   |
| <b>Useful field of view:</b> difficulties in detecting items in the periphery of screens  | Bergstrom et al. [55]   |
| <b>Decreased attention division skills:</b> difficulties in processing multiple forms of information (e.g., text and speech) simultaneously | Czaja and Lee [56]; IJsselsteijn et al. [51]; De Bruin et al. [57]; Aarhus et al. [37]  |
| <b>Hearing:</b> difficulties in detecting high-frequency alerting sounds (beeps)  | IJsselsteijn et al. [51], Czaja and Lee [58]; Billis et al. [53]; Omholt and Waerstad [39]  |
| <b>Visuomotor-coor-dination:</b> difficulties in using a computer mouse track   | Schueren [60]; Smith et al. [61]; Theng [62]; Diaz-Orueta et al. [63]; Vasconcelos, et al. [54]; Skalsky Brown [42]   |
| <b>Physical constitution:</b> health issues such as arthritis, bad backs, reduced balance   | Pearce [33]; Olmholt and Waerstad [39]  |
| <b>Cognition:</b> older adults are much slower than youngsters adults   | Salthouse [64, 65]; Vercruyssen [66]; Brown and Park [67]; IJsselsteijn et al. [51]; Czaja and Lee [56]; Billis et al. [53]; Aarhus et al. [37]; Vasconcelos et al. [54]; Olmholt and Waerstad [39]; Skalsky Brown [42] |

Lastly, we found that only four of the ten studies reviewed gave a voice to older adults, allowing them to explain why they do or do not play exergames. Let us listen to some of these older adults’ voices:

Aarhus et al. [37]: *It isn’t fun to do it alone. I’d rather have someone to talk to while doing it* (p. 113).

Omholt and Waerstad [39]: *If there is going to be any point in doing something together, it needs to be that you are enhancing each other. Like that you get a better result if you are cooperating* (p. 130).

Skalsky Brown [42]: *I enjoy it [digital games] and it’s fun and it’s okay to have fun... It’s okay for me to relax and have fun and enjoy myself, but that’s been a hard thing for me to let go of... that I can cut back on my work. I can slow down some and pick and choose and do what I want to do. So that has been the hard part for me, at this age* (p. 90).

Loos and Zonneveld [43]: *I experienced no pressure while playing, at the most a challenge because it's fun to play and because you're striving to achieve something and you see the scores rising, so that provides the challenge* (p. 335).

### 2.3 Giving Voice to Older Adults' Capability to Play Exergames

In Sect. 2.1 we saw that older adults in countries such as the USA, Norway, Sweden, Denmark and the Netherlands play digital games. Nevertheless, there are numerous older adults who refrain from doing so. Kari et al. [21, p. 11], in a study among Finnish (non)players of exergames in different age groups, found that: "In the two oldest age groups of 35–44 years and 45 years or over, the three most significant reasons [for not playing an exergames] were (1) no interest, (2) prefers other forms of exercise, and (3) ownership (...). In the youngest age group, the reason no money was the most significant one. The most significant differences between age groups were in the reasons no money and no interest. No money was more significant the younger the age group was."

In a study among US older adults who did not play digital games, Skalsky Brown [6] found that lack of motivation was by far the most important factor: "Older adults who engage in digital games typically have at least a moderate degree of three domains that interplay with one another: motivation, experience with game-related technology, and functional ability [42]. To assess these domains among non-gamers, I interviewed persons over the age of 60 to explore whether or not any of these aspects surfaced as being deficient. Although most touched upon some concerns pertaining to their functional ability (declining) and limited tech experience, this paled in comparison to their level of motivation to play. Motivations varied widely among the older gamers, yet the strength of the individual motivation was strong enough to negate the other two domains if they were somewhat lacking. With the older non-gamers I interviewed, all but one stated that they simply had no interest in playing, as they believe they had better things to do with their time. Even when I posed the potential of playing as a means of inter-generational play (e.g., playing with grandchildren), this typically wasn't enough of a motivator, which surprised me." (personal communication, 10.10.2016)

Another point to take into consideration is the so-called "I"-methodology. Williams et al. [44] state that the majority of digital games designers (88,5%) are young (average age 31) male adults with highly developed ICT skills. Loos [45] and Loos et al. [46] argue that as typical young male adults, these game designers might have little understanding of the needs of older adults, causing them to fall into the I-methodology trap:

The I-methodology refers to a design practice in which designers consider themselves as representative of the users [47]. Akrich describes the I-methodology as the "reliance on personal experience, whereby the designer replaces his professional that by that of the layman" [47, p. x]. This is often an unconscious process: the designer is not aware of the fact that the user representation he or she is using resembles himself or herself. In contrast to the images created by designers and what people expect, implicit methods are often more powerful than explicit methods in shaping the design. [48, p. 41], Loos [45] and Loos and Romano Bergstrom [49] argue that young male game designers may specifically tend to overlook the aspect of age-related functional limitations due to the factors mentioned in the Table above.

We agree with De Schutter et al. [59] that “Designers must be aware of normative age-related changes and (1) how such aspects can affect technological interaction (e.g. reduced vision and hearing, slower pace, decreased attention division skills, etc., IJsselsteijn et al. [51, p. 1171]).”

Of the studies presented in the Table above, quotes from older adults were only found in Skalsky Brown [42]:

*I definitely use reading glasses when I game. I find I like to sort of recline when I game in my chair, sort of lean back like this and game. And I find I frequently have to sit up because I can't read the screen, so I have a lot more problems in some kinds of games. Some games are not very good at adjusting font sizes. So if you, say, run the game at high resolutions, the graphics look good. The graphics all scale so things are still the same size or just higher resolution, but all the text gets really small. And that can be very frustrating because I can't read it unless I lean up to the machine. So there are games out there where I actually can find it very hard sometimes to identify what's going on the screen because of the complexity that can now be shown with high-end... you know, high... modern processors and graphics quality (p. 104).*

As age-related functional limitations occur with a certain regularity from age 75 on, and are common from age 85 and up [68], these must be taken into account by designers of exergames, to avoid having older adults who are motivated to play exergames (see Sect. 3.2) being hindered by factors due to biological ageing. De la Hera et al. [69] give a specific example of how it would be possible to counter the problem of decreased speed by suggesting that “in-game adjustable speeds might be an option to support older players for whom time-restricted games are a challenge (Nap et al. 2009) [70].”

### 3 Conclusions and Implications for Future Research

Finally, we answer the research questions formulated in the introduction, and sketch some implications for future research:

- (1) To which extent are older adults *motivated to* play exergames and why is this the case?

Older adults are certainly motivated to play exergames. Not only do statistical data from countries such as USA, Norway, Sweden, Denmark and the Netherlands clearly show that a considerable number of older adults play digital games, our narrative literature review also shows which dimensions stimulate older adults to play exergames: diversion, social interaction and user friendliness.

- (2) To which extent are older adults *able to* play exergames and why is this the case?

While older adults are definitely able to play exergames, game designers, who are often relatively younger, should take into account age-related functional limitations due to declining vision, useful field of view, hearing, visual motor-coordination and cognition. De la Hera et al. [68] offer a specific example of how the problem of decreased speed could be countered by suggesting that “in-game adjustable speeds might be an

option to support older players for whom time-restricted games are a challenge (Nap et al. 2009) [70].”

- (3) To which extent can the *voices* of the older players be heard in the empirical studies on exergaming in later life?

Only a very limited number of studies reviewed gave a voice to older adults, allowing them to explain why they do or do not play exergames.

Future research should give voice to the experiences of older adults playing exergames in natural settings, pay attention to differences in the group of older adults (e.g., age, gender, education) and compare the ways older adults make sense of exergames versus traditional approaches. We agree with Kari et al. [21, p. 12] who argue that: “Overall, finding the equilibrium between the hedonic and utilitarian aspects of playing exergames and delivering this message to potential customers seem to be the main challenges facing the exergame designers and the exergaming industry today and most probably also in the future.”

**Acknowledgement.** This paper is based on the research report ‘The impact of exergames: A panacea for older adults’ wellbeing? Using narrative literature reviews to make sense of exergaming in later life’ for the multi-methodological Ageing+Communication+Technologies (ACT) network (<http://actproject.ca/>). The author would like to thank ACT for financially supporting this research project (grant 895-2013-1018), the chair “Old and New Media in an Ageing Society” at the University of Amsterdam for the research time and Utrecht University Master’s student Nynke Meijer for her help with the narrative literature review.

## References

1. Huizinga, J.: *Homo Ludens: A Study of the Play Element in Culture*. Bacon Press, Boston (1938). (1950)
2. Zonneveld, A.: *Wat beweegt ouderen? Kwalitatief onderzoek naar het gebruik van exergames onder ouderen (What moves Older People? Qualitative Research on the Use of Exergames among Older People)*. Unpublished Master thesis. Utrecht University School of Governance, Utrecht, The Netherlands (2013)
3. Oh, Y., Yang, S.: Defining exergames and exergaming. In: *Proceedings of Meaningful Play*, pp. 1–17 (2010)
4. Primack, B.A., Carroll, M.V., McNamara, M., Klem, M.L., King, B., Rich, M., Nayak, S.: Role of video games in improving health-related outcomes: a systematic review. *Am. J. Prev. Med.* **42**(6), 630–638 (2012)
5. Kooiman, B., Sheehan, D.D.: Exergaming theories: a literature review. *Int. J. Game Based Learn. (IJGBL)* **5**(4), 1–14 (2015)
6. Brown, J.A.: Digital gaming perceptions among older adults non-gamers. In: Zhou, J., Salvendy, G. (eds.) *ITAP 2017, Part II. LNCS*, vol. 10298, pp. 217–227. Springer International Publishing, Switzerland (2017)
7. Bogost, I.: *Persuasive Games: The Expressive Power of Video Games*. MIT Press, Cambridge (2007)
8. Juul, J.: *A Casual Revolution: Reinventing Video Games and Their Players*. MIT Press, Cambridge (2012)



9. Daley, A.J.: Can exergaming contribute to improving physical activity levels and health outcomes in children? *Pediatrics* **124**(2), 763–771 (2009)
10. Papastergiou, M.: Exploring the potential of computer and video games for health and physical education: a literature review. *Comput. Educ.* **53**(3), 603–622 (2009)
11. Biddiss, E., Irwin, J.: Active video games to promote physical activity in children and youth: a systematic review. *Arch. Pediatr. Adolesc. Med.* **164**(7), 664–672 (2010)
12. Peng, W., Crouse, J.C., Lin, J.H.: Using active video games for physical activity promotion. a systematic review of the current state of research. *Health Educ. Behav.* **40**(2), 171–192 (2012)
13. Baranowski, T., et al.: Games for health for children—current status and needed research. *Games Health J.* **5**(1), 1–12 (2016)
14. Hoppes, S., Hally, C., Sewell, L.: An interest inventory of games for older adults. *Phys. Occup. Ther. Geriatr.* **18**(2), 71–83 (2000)
15. Hoppes, S., Wilcox, T., Graham, G.: Meanings of play for older adults. *Phys. Occup. Ther. Geriatr.* **18**(3), 57–68 (2001)
16. Lieberman, D.A.: Dance games and other exergames: What the research says. (Internal publication) Santa Barbara University of California (2006). [http://www.comm.ucsb.edu/lieberman\\_flash.htm](http://www.comm.ucsb.edu/lieberman_flash.htm)
17. McLaughlin, A., Gandy, M., Allaire, J., Whitlock, L.: Putting fun into video games for older adults. *Ergon. Des. Q. Hum. Factors Appl.* **20**(2), 13–22 (2012)
18. De Schutter, B., Brown, J.A.: Digital games as a source of enjoyment in later life. *Games Cult.* **11**(1–2), 28–52 (2016)
19. Gerling, K., De Schutter, B., Brown, J., Allaire, J.: Ageing playfully: advancing research on games for older adults beyond accessibility and health benefits. In: *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*, pp. 817–820. ACM (2015)
20. Iversen, S.M.: Play and productivity: the constitution of ageing adults in research on digital games. *Games Cult.* **11**(1–2), 7–21 (2014)
21. Kari, T., Makkonen, M., Moilanen, P., Frank, L.: The habits of playing and the reasons for not playing exergames: Gender differences in Finland. In: Lechner, U., Wigand, D., Pucihar, A. (eds.) *The 25th Bled eConference “eDependability: Reliable and Trustworthy eStructures, eProcesses, eOperations and eServices for the Future” Research volume*, 17–20 June 2012, Bled, Slovenia, pp. 512–526 (2012)
22. WHO: Health topics: Physical activity (2012). [http://www.who.int/topics/physical\\_activity/en/](http://www.who.int/topics/physical_activity/en/)
23. WHO: Global Strategy on Diet, Physical Activity and Health: Physical Activity (2012). <http://www.who.int/dietphysicalactivity/pa/en/index.html>
24. Lewis-Beck, M., Bryman, A.E., Liao, T.F.: *The Sage Encyclopedia of Social Science Research Methods*. Sage, London (2003)
25. Cota, T.T., Ishitani, L.: Motivation and benefits of digital games for the elderly: a systematic literature review. *Revista Brasileira de Computação Aplicada* **7**(1), 2–16 (2015)
26. Kaufman, D., Sauv e, L., Renaud, L., Sixsmith, A., Mortenson, B.: Older adults’ digital gameplay patterns, benefits, and challenges. *Simul. Gaming* **47**, 465–489 (2016)
27. Ridley, D.: *The Literature Review: A Step-By-Step Guide for Students*. Sage, Los Angeles (2012)
28. ESA 2016: *Essential Facts About The Computer And Video Game Industry* (2016)
29. Bak, L., Madsen, A., Henriksen, B., Trolldborg, S.: *Danskernes Kulturvaner*. Danish Ministry of Culture, Copenhagen (2012)
30. Nordicom-Sverige: *De f rsta resultaten fra Nordicom-Sveriges mediebarometer 2012*. Nordicom-Sverige, G teborg (2012)

31. Vaage, O.: Norsk Mediebarometer 2012. Statistics Norway, Oslo (2012)
32. Loos, E.F., Kubinsky, P., Romero, M.: The misrepresentation of older players in the world of digital games: grandparents trying to play a digital game
33. Pearce, C.: The truth about baby boomer gamers a study of over-forty computer game players. *Games Cult.* **3**(2), 142–174 (2008)
34. Sherry, J.L., Lucas, K., Greenberg, B.S., Lachlan, K.: Video game uses and gratifications as predictors of use and game preference. *Play. Video Games Motives Responses Conseq.* **24**, 213–224 (2006)
35. Ruggiero, T.E.: Uses and gratifications theory in the 21st century. *Mass Commun. Soc.* **3**(1), 3–37 (2000)
36. Graves, L.E., Ridgers, N.D., Williams, K., Stratton, G., Atkinson, G.T.: The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. *J. Phys. Act. Health* **7**(3), 393–401 (2010)
37. Aarhus, R., Grönvall, E., Larsen, S.B., Wollsen, S.: Turning training into play: embodied gaming, seniors, physical training and motivation. *Gerontechnology* **10**(2), 110–120 (2011)
38. Brox, E., Luque, L.F., Evertsen, G. J., Hernández, J.E.G.: Exergames for elderly: social exergames to persuade seniors to increase physical activity. In: 2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth), pp. 546–549. IEEE (2011)
39. Omholt, K.A., Waerstad, M.: Exercise games for elderly people. identifying important aspects, specifying system requirements and designing a concept. Unpublished Master thesis. Norwegian University of Science and Technology, Department of telematics (2013)
40. Heuvelink, A., De Groot, J., Hofstede, C.: Let's Play. Ouderen stimuleren tot bewegen met applied games. TNO & Vita Valley (2014)
41. Heuvelink, A., Tak, Y.R., Van Meeteren, N.: The opinions of people in the Netherlands over 65 on active video games: a survey study. In: Schouten, B., Fedtke, S., Schijven, M., Vosmeer, M., Gekker, A. (eds.) *Games for Health 2014*, pp. 62–66. Springer, Wiesbaden (2014). doi: [10.1007/978-3-658-07141-7\\_9](https://doi.org/10.1007/978-3-658-07141-7_9)
42. Skalsky Brown, J.A.: Let's play: understanding the role and significance of digital gaming in old age. Theses and Dissertations–Gerontology. Paper 6 (2014). [http://uknowledge.uky.edu/gerontol\\_etds/6](http://uknowledge.uky.edu/gerontol_etds/6)
43. Loos, E., Zonneveld, A.: Silver gaming: serious fun for seniors? In: Zhou, J., Salvendy, G. (eds.) *ITAP 2016. LNCS*, vol. 9755, pp. 330–341. Springer, Cham (2016). doi: [10.1007/978-3-319-39949-2\\_32](https://doi.org/10.1007/978-3-319-39949-2_32)
44. Williams, D., Martins, N., Consalvo, M., Ivory, J.D.: The virtual census: representations of gender, race and age in video games. *New Media Soc.* **11**(5), 815–834 (2009)
45. Loos, E.F.: Designing meaningful intergenerational digital games. In: Proceedings of the International Conference on Communication, Media, Technology and Design, Istanbul, pp. 46–51, 24–26 April 2014
46. Loos, E.F., Simons, M., De la Hera, T., Gevers, D.: Setting up and conducting the co-design of an intergenerational digital game
47. Akrich, M.: User representations: practices, methods and sociology. In: *Managing Technology in Society. The Approach of Constructive Technology Assessment*, pp. 167–184. Pinter, London (1995)
48. Oudshoorn, N., Rommes, E., Stienstra, M.: Configuring the user as everybody: gender and design cultures in information and communication technologies. *Sci. Technol. Hum. Values* **29**(1), 30–63 (2004)
49. Loos, E.F., Romano Bergstrom, J.: Older adults. In: Romano Bergstrom, J., Schall, A.J. (eds.) *Eye Tracking in User Experience Design*, pp. 313–329. Elsevier, Amsterdam (2014)

50. Charness, N.: Aging and communication: Human factors issues. In: Charness, N., Parks, D.C., Sabel, B.A. (eds.) *Communication, Technology and Aging: Opportunities and Challenges for The Future*, pp. 1–29. Springer, New York (2001)
51. IJsselsteijn, W., Nap, H.H., de Kort, Y., Poels, K.: Digital game design for elderly users. In: *Proceedings of the 2007 Conference on Future Play*, pp. 17–22. ACM (2007)
52. Lunn, D., Harper, S.: *Senior Citizens and the Web*. School of Computer Science, Manchester (2009)
53. Billis, A.S., Konstantinidis, E.I., Mouzakidis, C., Tsolaki, M.N., Pappas, C., Bamidis, P.D.: A game-like interface for training seniors' dynamic balance and coordination. In: Bamidis, P.D., Pallikarakis, N. (eds.) *XII Mediterranean Conference on Medical and Biological Engineering and Computing*, pp. 691–694. Springer, Heidelberg (2010)
54. Vasconcelos, A., Silva, P.A., Caseiro, J., Nunes, F., Teixeira, L.F.: Designing tablet-based games for seniors: the example of *cogniplay*, a cognitive gaming platform. In: *Proceedings of the 4th International Conference on Fun and Games (FnG 2012)*, pp. 1–10. ACM, New York (2012)
55. Bergstrom, J.C.R., Olmsted-Hawala, E.L., Bergstrom, H.C.: Older adults fail to see the periphery in a web site task. *Univ. Access Inf. Soc.* **15**(2), 261–270 (2016)
56. Czaja, S.J., Lee, C.C.: The impact of aging on access to technology. *Univ. Access Inf. Soc.* **5**(4), 341–349 (2007)
57. De Bruin, P.D.E., Schoene, D., Pichierri, G., Smith, S.T.: Use of virtual reality technique for the training of motor control in the elderly. *Zeitschrift für Gerontologie und Geriatrie* **43**(4), 229–234 (2010)
58. Czaja, S.J., Lee, C.C.: Information technology and older adults. In: Sears, A., Jacko, J.E. (eds.) *Human-Computer Interaction: Designing for Diverse Users and Domains*, pp. 17–32. CRC Press, Boca Raton (2009)
59. De Schutter, B., Brown, J.A., Abeele, V.V.: The domestication of digital games in the lives of older adults. *New Media Soc.* **17**(7), 1170–1186 (2015)
60. Schueren, B.: Can decline in intellectual functioning be reversed? *Dev. Psychol.* **22**, 223–232 (1986)
61. Smith, M.W., Sharit, J., Czaja, S.J.: Aging, motor control and the performance of computer mouse track. *Hum. Factors* **41**(3), 389–397 (1999)
62. Theng, Y.L., Dahlan, A.B., Akmal, M.L., Myint, T.Z.: An exploratory study on senior citizens' perceptions of the Nintendo Wii: the case of Singapore. In: *Proceedings of the 3rd International Convention on Rehabilitation Engineering & Assistive Technology*, p. 10. ACM (2009)
63. Diaz-Orueta, U., Facal, D., Nap, H.H., Ranga, M.M.: What is the key for older people to show interest in playing digital learning games? initial qualitative findings from the LEAGE project on a multicultural european sample. *Games Health Res. Dev. Clin. Appl.* **1**(2), 115–123 (2012)
64. Salthouse, T.A.: The processing-speed theory of adult age differences in cognition. *Psychol. Rev.* **103**(3), 403 (1996)
65. Salthouse, T.A.: What and when of cognitive aging. *Curr. Dir. Psychol. Sci.* **13**(4), 140–144 (2004)
66. Verduyssen, M.: Movement control and speed of behavior. In: Fisk, A.D., Rogers, W.A. (eds.) *Handbook of Human Factors and the Older Adult*, pp. 55–86. Academic Press, San Diego (1997)
67. Brown, S.C., Park, D.C.: Theoretical models of cognitive aging and implications for translational research in medicine. *Gerontologist* **43**(1), 57–67 (2003)

68. Bouma, H.: Document and interface design for older citizens. In: Westendorp, P., Jansen, C., Punselie, R. (eds.) *Interface Design & Document Design*, pp. 67–80. Rodopi, Amsterdam (2000)
69. De la Hera, T., Loos, E.F., Simons, M, Blom, J.: Exploring the possibilities of intergenerational digital gaming. a narrative literature review
70. Nap, H., Kort, Y., IJsselsteijn, W.: Senior gamers: preferences, motivations and needs. *Gerontechnology* **8**(4), 247–262 (2009)