Older people's perceptions and experiences of a digital learning game

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The paper describes the evaluation studies of a learning game for older adults using a multicultural European sample. The goal of the evaluation was to explore the acquisition of knowledge as a result of game play, the acceptance of two different game interaction systems by the seniors, their experiences while playing the game, and the accessibility of the game's user interface. Several qualitative and quantitative research methods were combined among older adults in the Netherlands, Spain and Greece. The tests revealed that (i) the accessibility of the game menus and interaction devices was high, (ii) the player experience in digital game play with a TV remote control and 3D sensor were mostly positive, and (iii) the older adults reported that they experienced learning. Overall, it can be concluded that the goals were met, offering a similar accessibility and player experience between the three different countries, and to provide a learning experience for older Europeans.

Keywords: usability, acceptance, senior preferences, serious games, lifelong learning

Digital games are becoming popular among older adults. People who are 50+ years of age represent 29% of the gamer market in the United States (US); which is a 20% increase in comparison to their 1999 report[1]. Digital games have become a popular activity in the lives of many older adults in Western societies and scientific studies on older adults and games go hand in hand with the increasing popularity of digital game play among older adults.

Studies trying to capture and reflect the motivational aspects facilitating older people's engagement with digital games are progressively increasing[2]. De Schutter[3] found that the most popular playing motive among the older digital game audience was challenge, while social interaction proved to be the most important predictor for the time that respondents invested in playing digital games. Nap et al.[2] speculate that it is possible that there is an overlap between the motivations of older people to play digital games and those of young adults. However, senior specific lifetime experiences, world knowledge, age-related changes in perception, cognition, and motor control are likely to have an influence on specific gaming preferences, motivations and needs. Furthermore, various studies addressed game design requirements that are compatible with the older adults' cognitive, motor, and perceptual abilities[4-6]. As a consequence of both functional changes and a lack of technological experience, older adults are hurt more by usability problems than younger users.

Digital games – whenever compatible with older adults' needs and abilities – can provide a fun means to spend time and a way to meet others[2]. In addition, digital games can also have a positive influence on older adults' performance in a wide-range of executive control tasks, such as short-term memory, working memory, task switching, and inhibition. For example, Basak et al.[7] found significant benefits after 23.5 hours of strategy-based gaming on executive control functions following training. In the latest years, there is an increase of learning - or more specifically - of brain training games in the market and in our culture, like Nintendo's Brain Training by Dr. Kawashima, Big Brain Academy and the online Lumosity platform. Although brain training games are put to market, there is no evidence that these type of games make people smarter. In fact, the results from a recent study[8] supported by BBC Lab UK suggest that improved cognitive functioning by brain training games only hold for the cognitive tasks that are trained. They found no transfer to more general tests of cognition, even when those tasks were closely related to the trained task. Moreover, brain training games lack a number of qualities that most successful commercial games do offer like narration, a story line, appealing graphics, co- and multiplay, etc.

In terms of cognitive skills, a recent meta-analysis[9] concluded that the spatial skills improvements derived from playing commercially available shooter video games are comparable to the effects of formal (high school and university-level) courses aimed at enhancing these same skills. These improvements can be obtained in a relatively brief period and its effects may last over an extended period of time, being the most crucial outcome their transfer to other spatial tasks outside the video game context. In terms of socialization, players seem to acquire important prosocial skills when they play games that are specifically designed to reward effective cooperation, support, and helping behaviors[10]. One study that summarized international evidence from correlational, longitudinal, and experimental studies found that playing prosocial video games consistently related to, or predicted, prosocial behaviors[11].

When it comes to make games closer and attractive to senior novel gamers, the challenge is higher than with regular high-skilled, younger players. A relatively recent study[12] explored the key factors and motivations that would engage senior users for them to show interest in playing digital games. In the focus groups conducted, the main interests shared among the participants were to highlight the social aspect of the gaming experience, to experience challenge in games, to combine cognitive and physical activity, and to acquire specific abilities or skills. Two components were commonly agreed on in the participating countries: Challenge (as a basic foundation for the game development, with participants asking for challenging, fun-to-play games with increasing difficulty) and socialization (i.e., participants clearly pointed that they wanted to play with others - not necessarily against others). These results are in line with those reported by Whitcomb[13], who suggested that seniors playing computer games for an extended period may receive stimulation on their social interaction, and, additionally, outcome benefits in eye-hand coordination and fine motor ability, as well as in basic movements and reaction time, with transfer of these skills to their daily routine such as household chores and automobile driving ability.

Based on these requisites, this paper describes the accessibility and player experience evaluations of a learning game for older adults with a multicultural European sample, following requirements previously reported[12]. The overall goal of the learning game is to activate and stimulate the aging body by mini-games that vary from brain training to physical exercise. The research was performed as part of the LEAGE (LEArning Games for older Europeans) project, partially funded by the Life-Long Learning European Program, with the goal developing a learning game for older adults.

Method

Participants

In total eighteen older adults participated in the experimental Beta study, who individually performed menu- and game play tasks. Six older adults participated in The Netherlands (M_{age}=78.4; SD_{age}=8.4; 5 female) six older adults in Spain (M_{age}=67.3; SD_{age}=4.4; 3 female) also six older adults in Greece (M_{age}=70.7; SD_{age}=7.5; 4 female). For the selection of the participants in The Netherlands, the KBO (senior organization in the province of Noord-Brabant) was approached, in Spain the Senior Citizens Day Centre of Lasarte and in Greece the Senior Care Centres (KAPI). Respondents were required to be 60+ years of age and of good cognitive health in order to participate in the study. The mean subjective memory ability score – measured by the Memory Assessment Clinics Self-Rating Scale (MAC-S[14]) questionnaire on a 5-item Likert scale – was 3.5 (SD_{MAC-S}=0.27).

The LEAGE game

The evaluation study of the digital learning game for older people aims to gather data in the following domains: (i) the knowledge acquisition due to game play; (ii) the perceptions and acceptance of the digital learning game and sys-

tem; (iii) the player experience when playing the game; and (iv) the accessibility of the game user interface (UI) and interaction devices. Prior to the study presented here, the potential success of the game was theorized to be determined by two key factors:
(a) The continuous involvement of older adults in the game design and implementation stages;
(b) The implementation on devices which have a low threshold of use for older adults (because they are already familiar with them (e.g., a TV remote control), or because the device is very intuitive (e.g., a Set-Top Box & 3D sensor-Microsoft Kinect).

Therefore, the LEAGE game is available in two versions, one played by means of a 3D-Microsoft Kinect sensor, and one played by means of a TV remote control on a Set-Top Box (from now on called the STB version of the game). The game aims to help older people improve their competences by practicing and expanding their knowledge on topics such as geography, history, health issues (first aid), nutrition and by motivating exercise and memory training.

The 'LEAGE of European Travellers' is a game about a road trip along several European countries. The goal of the game is to visit all countries and collect souvenirs (tokens). Each country is represented by three major cities, each with an important landmark or something distinctive (e.g. a famous recipe, person, dance, etc.) that makes the city worth visiting. Each city comprises of a narration (teaching) part and several challenges, each with a different educational goal. Countries and cities are presented on a map and are unlocked as the player proceeds. The rules imply that the player must complete a challenge to proceed to the next city, but can return to previous cities (challenges) in order to achieve a higher score. Each time the player completes a challenge s/he receives a souvenir (token) as feedback. Souvenirs are of three types (bronze, silver, or gold) according to the players score in the challenge. The player's score is based on the number of correct answers and the time (how fast a challenge is completed). Players also have the opportunity to voluntarily decide to play in pairs competing against each other in specific challenges.

Each country comprises of specific challenges. In all countries challenges are of the same type, to enable a seamless experience to players regardless of their own country. More specifically, each country comprises three locations, and each location has three challenges which all start from the village/city square (*Figure 1*), in total nine per country, i.e. three sight-seeing, two recipes, two emergencies (first aid), and two exercises/dances. In Table 1, the various challenges per country are listed. A sightseeing challenge consisted of first a narration part with a video (both 3D graphics and images) about the sightseeing place (*Figure 1*) about the history of the particular location. After this, the player receives a number of multiple choice questions about the narration part (e.g., When was the Mill Network built? 1. 1421; 2. 1740; 3. 1997). The recipe challenge consisted of an animated instruction about how a certain recipe should be prepared with the right ingredients (e.g., prepare Tzatziki at the Athens sight). The game could also be played by means of the 3D motion sensor Kinect, and then the actual movements of stirring, cutting, etc. had to be made. The emergency challenge is also a trivia game, yet, without a narration part. The exercise/

Figure 1. Screens from the LEAGE game: top-left the village square where players can select a challenge, top-right the narration part of the trivia game, center the Athens dancing game, bottom-left the recipe/cooking instructions, and on the bottom-right travel item selection game

Figure 2. Participant in the Netherlands playing the Set-Top Box (left) LEAGE game in the experimental session, and participant in Spain (center) and Greece (right) playing the Kinect version of the LEAGE game

dance consisted of an instruction video for the exercise and 3D animated person for the dance to train the player how to perform the actions. After that, players had to try it themselves and the Kinect monitored their behaviours and translated these into actual game behaviours.

Procedure

The participants were welcomed and an introduction was given by one of the experimenters to introduce the digital learning game under study (UI, controls etc.) and to provide information about the study procedure. After this, participants were asked to read and sign an informed consent form. The informed consent stated what was being studied, ensured anonymous analysis, announced that audio and image recordings were going to be made, and made clear to the participants that they could withdraw their consent and cooperation at any given point in time during or after the session. If necessary, the participants were supported by the experimenters in filling in the forms. Then, they filled a general questionnaire to gather the age, gender, etc. of the participants. The MAC-S was administered to ensure that all participants had sufficient abilities to (learn to) play the game. The game and controls were introduced the first time they started a game and they also received a manual. The participants had to perform game UI and game play tasks with the purpose of testing the usability of the interface, player experience, user acceptance, and learning. The participants filled in the IBM usability questions after they performed the UI tasks and after the game tasks. Then, an interview took place with each participant after he/she had finished the game. The interview provided users with means to 'step outside the box' of pre-constructed questionnaires. The focus of the interview was about the preferences and user acceptance of the digital learning (LEAGE) game. The interviews lasted approximately 15 minutes for the experimental session and the whole experiment took about 1.5 hours. At the end of all sessions there was a gift for participation. Figure 2 shows the various experimental sessions at the 3 pilot sites.

Game menu and play tasks

As it has been said, the digital learning game is composed by a series of activities and puzzles that the player has to solve. The activities and puzzles are grouped, and each group takes place virtually in a European city, immersing the player in its historical and geographical context. Moreover, during the starting of the game, it includes some screens to configure the avatar of the player, specify his/her language, etc.

The participants performed game menu tasks with the purpose of testing the usability of the interface and user acceptance. An example of a game menu task is: 'Create a new player'. In ad-

Table 1. The four game challenges in LEAGE, described per country and sightseeing place

Country & sightseeing place		Sightseeing / trivia	Recipe	Emergency	Dance / Exercise
Greece	Athens	Acropolis	Tzatziki	NI	Syrtaki dance
	Epidavros	Ancient theatre, history of theatre	Cheese pie	Skin burn	Not included
	Santorini	Akrotiri, wall paintings, Volcano	Not included	Earthquake	Swimming
Netherlands	Amsterdam	Ring of Canals, Anne Frank's house	Pepernoten	Fire in hotel	Not included
	Kinderdijk-Elshout	The Mill Network	Not included	Insect bite - tick	Turn cap of windmill
	Delta Works	Eastern Scheldt storm surge barrier	Zeeland mussels	Not included	Cycling
Spain	Bilbao	Guggenheim museum	Cod stuffed with peppers	Sun burn	Not included
	Santiago de Compostella	Saint James Cathedral	Saint James cake	Food poisoning	Not included
	Barcelona	Sagrada Familia Cathedral	Mongetes seques con botifarra	Not included	Sardana dance

dition, participants performed game-play tasks to gather an insight into older adults' player experience, user acceptance, and learning with the game. An example of a game play task is: "Go to Greece, then to Athens (Acropolis), go to the monument and play the game". Tasks were provided on separate sheets of paper.

Location & equipment

The experimental sessions took place in a specific room in the designated institution in the Netherlands (Ananz Geldrop), Spain (Ingema's lab), and Greece (KAPI Day Center in Ilioupoli). Due to technical difficulties with the Microsoft Kinect in The Netherlands, the Kinect version of the game could not be tested there. Due to technical difficulties with the LEAGE STB in Spain and Greece, the STB version of the game could not be tested in these countries. It should be noted that the LEAGE game was in a Beta stage during the evaluations, a stage in which technical problems are common.

In The Netherlands, the experimental sessions were conducted on an all-in-one PC (MSI Wind Top AE210) with an AMD Athlon dual core 3250e processor and with a 20.0" wide screen (1600x900-pixel resolution). To ensure the compatibility with the developed design of the game, the 20.0" screen was set to 1280x768-pixel resolution. The LEAGE STB was used as the platform on which the participants performed the UI and game tasks. For the STB version of LEAGE, a standard Microsoft Mediacenter Infra-Red remote and receiver was used. The tasks were written on paper. A stopwatch was used to measure task time. All instructions were read from pre-made printed cards. Audio and image recordings were made with a HTC Legend smartphone.

In Spain, the experimental and open sessions were conducted on a PC (Acer Aspire Revo) with an Intel Atom processor D525 and with a 20.0" wide screen (1600x900-pixel resolution). The Kinect version of the LEAGE game was presented on a 51" wide screen TV. To ensure the compatibility with the developed design of the game, the screen was set to 1280x768-pixel resolution and to 1280x800-pixel resolution for the Kinect version of the game. The LEAGE Kinect game was used as the platforms on which the participants performed the UI and game tasks. For the Kinect version of LEAGE, an XBOX 360 USB Kinect was used. The tasks were written on paper. A stopwatch was used to measure task time. All instructions were read from pre-made printed cards. Audio and image recordings were made with a Samsung Galaxy smartphone.

In Greece, the sessions were conducted with the use of a laptop computer (TURBO-X) with an Intel processor, a beamer as well as an XBOX 360 USB Kinect. The projection on the wall was about 70" wide with a 1280x768 pixel resolution on a crème-white wall. Instructions were written on paper and read to the participants by the researchers. Image recordings and videos were made with a Samsung Galaxy smartphone.

Measurements

Learning

Learning was assessed with qualitative data on perceived learning / knowledge acquisition from semi-structured interviews. In-game scores were also collected via log-files. Yet, a number of the log-files could not be identified and therefore the in-game scores were not used in the analyses.

Player experience

The player experience of the users was measured by the Game Experience Questionnaire (GEQ), which probes the players' feelings and thoughts while playing the game[15]. The questionnaires assess game experience as scores on seven components: immersion (e.g., "*I could use my fantasy in the game*"), flow (e.g., "*While playing, I forgot everything around me*"), competence (e.g., "*I was good at it*"), positive affect (e.g., "*Playing the game was fun*"), negative affect (e.g., "*I found it boring*"), annoyance (e.g., "*I felt irritable*") and challenge (e.g., "*I had to put a lot of effort in the game*"). The GEQ was administered during the experimental session where participants received it after a predefined play time (e.g., 5 minutes). Reliability is measured using Cronbach's alpha as a measure of internal consistency which is one possible dimension of scale reliability[16]. Cronbach's alpha scores for the seven components of the game experience are shown in Table 2.

A Cronbach's alpha is used to measure the internal consistency reliability of the used questionnaire. A reliability of 0.70 or higher is considered good, 0.60 or higher as acceptable[17]. As can be seen below, in our user studies at the various sites sometimes alpha scores were lower than this target value. This may be due to the relatively small

Table 2. Cronbach's alpha scores for seven components of game experience by country; NL=Netherlands; ES=Spain; GR=Greece; zero scores (with asterisk) were removed from the analyses

Component	Country		
	NL	ES	GR
Positive affect	0.97	0.79	0.86
Competence	0.92	0.92	0.94
Challenge	0.86	0.40	0.86
Annoyance	0.89	0.00*	0.00*
Negative affect	0.00*	0.36	0.00*
Immersion	0.64	0.79	0.78
Flow	0.75	0.55	1.00

sample sizes and/or the fact that some participants scored unreliably. Especially the latest was probably the case, as the GEQ was developed mainly for young adults and also used on children samples[18-20], however a special version for older adults was not available. It is possible that some senior participants did not understand the items as were supposed to be understood. However, since we employed the in-game version of the GEQ, which only has two items per scale, deleting items was not an option. Moreover, the scales employed here have been validated based on studies with large sample sizes (n>250). We therefore decided to stick with the original scales. Results on the scales with zero internal consistencies (negative affect and annoyance) were removed from the analysis.

In the FUGA project (EU FP6 project), player experience data was gathered per game genre, platform, etc. of about 400 younger to older players[20]. This data can be used to compare or benchmark the player experience of the user groups in the Beta tests of the LEAGE game. The LEAGE game on both end-devices should rather provide a similar player experience for a specific game genre to the player experience FUGA threshold. The game genres of which player experience data is available from the FUGA project are: First Person Shooters (FPS), Role Playing Games (RPG), Sports/Racing Games, Puzzle & Quiz Games, Action Adventures, and Strategy Games. The LEAGE game is closest to a puzzle and quiz game, and therefore the FUGA data of the Puzzle & Quiz games were used to benchmark the LEAGE Beta player experience.

User acceptance, perceived usability, preferences, and errors were gathered through interviews. An appropriate method to study user acceptance is by means of interviews to elicit in-depth information of the perceptions, opinions, beliefs, and attitudes. Key questions that were asked – among others: *"Please share your learning experiences with the LEAGE game"; "What were your feelings while playing the game?"; "What are your opinions about playing the games together?"*. Probing questions followed to gather additional insight information.

Accessibility of the UI

The accessibility of the UI was studied using the interviews and by means of the IBM usability questionnaire[21]. The IBM usability questionnaire was delivered in the language of participants (Greek, Spanish or Dutch) and usability experience assessed as scores on three components (system usefulness, information quality, and interface quality). The questionnaire contained nineteen usability items that had to be rated on a 7-item Likert scale. It measures system usefulness (e.g. "It is simple to use this system"), information quality (e.g. "The organization of information on the system screens is clear"), and interface quality (e.g., "This system has all the functions and capabilities I expect it to have"'). The interviewees could also comment on specific UI flaws, but also on their likes about certain aspects of the functionality of the system. Cronbach's alpha's were calculated (*Table 3*), and although one of the alpha's could not be calculated and one was negative, all components were used for the analyses since in general the internal consistency was high (Overall Usability had a Cronbach's alpha of 0.97).

Table 3. Cronbach's alpha scores for three components of usability by country; NL=Netherlands; ES=Spain; GR=Greece

Component	Country		
	NL	ES	GR
System usefulness	0.93	0.97	0.92
Information quality	-	0.95	0.62
Interface quality	0.82	-0.31	0.93

Results

Qualitative data

Results from the interviews are presented per discussion topic and interview question. The interviews were held in the mother language of the participant. The quotes have been translated into English for the purpose of this article. To prevent distortion of the original messages, the quotes have not been modified to create full sentences. Clarifications are presented above the quotes and between brackets within the quotes.

Learning

"Please share your learning experiences with the LEAGE game"

Overall, most participants reported that they learned new facts about different cultures and history, and that they experienced the game play as a learning experience:

"I really liked the fact that I learn about history and culture of other countries. It is a game for grown-ups!" (P1, Greece).

"I liked it. You learn something from it. Stuff is coming back to you" [experiences/knowledge] *(P6, The Netherlands).*

"Yes, [I learned about] *a couple of recipes. Certainly the information from Spain. The knowledge from The Netherlands was already in my head. It was certainly a learning experience"* (P2, The Netherlands).

However, some of the participants (especially from Spain) reported that although the game was informative, it was also fast paced with small fonts. Because of this, they perceived learning as difficult or limited:

"It is useful because it shows you things that you didn't know. The game is very fast and has a lot of text so it is difficult to remember the dates and places. At the end, you are not able to know the answers unless you are lucky. It's not possible to remember all the things" [facts presented in the game]. (P7, Spain).

"What were your feelings and thoughts while playing the game?"
Some of the participants reported that they did not experience a game or playfulness, but rather memory training:
"Simple game, [it is] *no game. It is more memory training that is how I see it. In a game you need to get to certain levels and it becomes more difficult. That is not the case here. Old-fashioned way"* (P1, The Netherlands).
"At the second or third time, you know how to use it. There is no motivation to lay alone with the remote control. There should be the option to practice more physical activity, it lacks something more playful" (P7, Spain).

Some of the participants experienced fun and had a positive player experience, yet, they did report that the text that was shown in the Trivia game was too fast and the font sizes too small:
"Good, it is easy. You do need to read the text very well. Sometimes a fact is double. Need to look carefully at the text" (P3, The Netherlands).
"Cooking was fun. Text too fast. New screen, new sentence. Sometimes I missed something. Not synchronous. A lot of information in a short time. The Netherlands and Spain, general knowledge" (P4, The Netherlands).
"[The game] *is fun. Next time the results will be higher. It was very fast" (P5, The Netherlands).*
"At the beginning you feel a little bit clumsy, but at the second or third time it [the game] *is more easy to use. When you hit the answer you feel a little joy. When you play with another person it is more fun because you can compete with him. It is easier to play with the remote control because you know where the buttons are" (P15, Spain).*

User acceptance - replayability
"Did you keep playing LEAGE until the end of the pilot? If yes/no, why? Would you keep playing LEAGE after the pilot if possible?"
Overall, most participants reported that they would play it again if additional content would be provided:
"I would want to extend my knowledge. Every time a new version. Would play it at least one more time. New cities, extend it" (P4, The Netherlands).
"Would like to continue playing with it if it would have more countries, cities more dynamic games (famous painters, agriculture, people, cities, sports, literature, etc.). I would like to have the same game with more contents" (P7, Spain).
"Yes I would. Because I think it is interesting. Three cities, etc. more countries" (P6, The Netherlands).
"I would play with it if I would have it and if it would include more contents and activities" (P15, Spain).

One participant reported that she would not play it again, since she experienced little challenge. However, increasing the difficulty level and adding more countries could enhance replayability:
"One time and another time [playing it twice] *and that is it. There is no challenge. Having read the text three times and that is it.* [The game should be] *more difficult, more countries, more time"* (P1, The Netherlands).

Social play
"What are your opinions about playing the games together (turn based, social play)?"
A considerable group of participants reported that they would play the LEAGE game together with other people and reported positively about this possibility:
"Playing together would be fun/ [a] *laugh.* [Would like] *One time to try. Interesting, but no"* (P1, The Netherlands).
"Playing turns is always more fun" (P4, The Netherlands).
"With my wife, taking turns. We always play together. IQ, dictation, etc." (P5, The Netherlands).
"The game is thought to play with other people. One of the strengths is that is good to compete with other people" (P7, Spain).
"I guess playing it together with others would be more fun, as we will laugh with at each other's mistakes or movements" (P2, Greece).

Quantitative data
Usability
The results from the IBM usability questionnaires of the older adults in experimental sessions in respect to usability and player experience for the devices and countries are shown as means and standard deviations per country and usability component (*Table 4*). Ideally, usability should be above the scale mid-point of 4, should not differ between the countries, and should be similar on both end-devices. Multiple comparisons were run with a Bonferroni correction to account for chance capitalization. No significant differences were found between the devices and countries on the usability components.

Player experience
Positive player experience should rather be above the GEQ scale mid-point of 2. The end-devices should not significantly differ in their

Table 4. Usability Means (M) and Standard Deviations (SD) by country with end-device; NL=Netherlands; ES=Spain; GR=Greece; STB=Set-Top Box

Player experience		Country		
		NL (STB)	ES (Kinect)	GR (Kinect)
Overall usability	M	6.19	5.11	6.21
	SD	0.93	1.62	0.73
Information quality	M	5.96	5.14	6.24
	SD	1.22	1.67	0.67
Interface quality	M	6.29	4.96	6.08
	SD	0.75	1.27	0.96
System usefulness	M	6.33	5.12	6.26
	SD	0.81	1.86	0.77

player experience scores, as for the scores between the participating countries. From the data it seems that both the player experience for both devices and countries do not differ, except possibly 'challenge' and 'flow' which both seem to differ between the countries (*Table 5*). Again, multiple comparisons were run with a Bonferroni correction to account for chance capitalization. No significant differences were found between the devices and countries on the player experience components.

Benchmark

In respect to the benchmark scores, it is interesting to note that 'immersion' was rated higher on the LEAGE game than the benchmark. Both negative player experiences 'annoyance' and 'negative affect' scored lower than the benchmark, which implies that the LEAGE game was less boring and frustrating than the benchmark. Yet, competence scores were lower for LEAGE than the benchmark (*Table 5*).

Discussion & conclusion

The evaluations of a digital learning game for older people provided rich in-depth data about older people's perception and experiences from a multi-cultural sample from The Netherlands, Spain, and Greece. From the evaluations, both qualitative and quantitative data was gathered and the qualitative results showed that the majority of older adults learned new facts about different cultures and history and experienced the game play as a learning experience. Nevertheless, an important aspect of the player experience is positive affect or fun and some of the older adults reported a lack of fun and described LEAGE as training and did not experience game play. Therefore, the game mechanics, dynamics and aesthetics (MDA) should be enhanced. The MDA could - in potential - be enhanced by an additional game design iteration, possibly supported by game developers from the entertainment game industry. The findings do indicate that learning games in potential be a valuable tool for memory training purposes among older people.

Overall, most participants would play the game again and found the game content interesting. One of the major achievements of the developed learning game is the ease-of-use of the game menu and input devices, although the narration text could be enlarged and the narration part is somewhat fast paced, which should be enhanced in a future version of the game. In The Netherlands, the STB (with remote control) to operate the game was perceived as easy, as the Kinect in Greece. The older adults further reported that they would play the game together with other people, indicating a positive social play possibility for digital learning games as LEAGE. Finally, older adults from The Netherlands, Spain, and Greece were positive about the design, usability and player experience of the game and suggestions for improvements were reported (e.g., slower game speed, enhanced Kinect responsiveness, larger fonts).

The quantitative usability results showed – per country and device – that the satisfaction, information quality, interface quality, and system usefulness of the game menus and interaction devices were scored positively – above the scale mid-point of 4. No significant differences were found on usability and player experience between the devices and countries. In respect to the player experience compared to the benchmark, the developed learning game seems to be competitive compared to existing puzzle and quiz games. Future evaluations will provide more insight in the player experience of the LEAGE game compared to exemplar games.

Table 5. Player experience Means (M) and Standard Deviations (SD) by country with end-device, and benchmark; NL=Netherlands; ES=Spain; GR=Greece; STB=Set-Top Box

Player experience		Country			Benchmark
		NL (STB)	ES (Kinect)	GR (Kinect)	
Competence	M	1.58	1.83	2.42	3.00
	SD	0.97	0.93	0.80	0.85
Positive affect	M	2.42	2.50	3.17	3.14
	SD	1.11	0.89	0.68	0.76
Immersion	M	2.58	2.67	2.92	1.69
	SD	0.97	0.98	0.58	0.72
Flow	M	1.75	2.83	2.83	2.22
	SD	0.99	0.82	0.75	1.12
Challenge	M	2.00	1.33	0.83	2.33
	SD	1.10	0.83	0.41	0.82

Possible limitations of the study were the small sample size, unbalanced study design, and most importantly, the current stage of the game design. The game still needs to be polished in respect to usability issues (e.g., small fonts, narration speed, etc.) and an additional game design cycle is needed to enhance the game MDA. In addition, the Kinect and STB technology needs to be further improved to ensure stability of the software, and social and cooperative play should be made possible. Although all participants had no cognitive impairments and reported to be healthy, future studies should include auditory- and visual acuity measurements that could serve as inclusion criteria, or as moderator variables to gain more insight in the results. Furthermore, research in the field of senior gamers should put effort in the development and validation of a GEQ that is attuned to capture the player experience of seniors. Longitudinal research is needed to gather an insight in the re-playability of the LEAGE game. Continuous player experience data could be represented by and extracted from in-game achievements, and the frequency and duration of game play sessions. Future research is needed to which extent these measurements relate to the various player experience components. Overall, the results from the study represent data at one moment in time of a game at a Beta stage.

In conclusion, the experimental evaluations provided us with a number of valuable and in-depth results. The usability of the game menus and interaction devices and the player experience in digital game play with the STB and Kinect were high. Older adults reported that they experienced learning and overall we can conclude that the game provided accessible and attractive game play for older Europeans. Research results also indicate that the learning game holds the potential to improve older people's quality of life by enhancing social interactions and enriching their leisure time. As stated in a recent review[22], caution is warranted for any gamified intervention in the health and education sciences, as very few of the games developed to improve health and learning outcomes are scientifically evaluated. Also in the case of LEAGE, we lack a control group to assure that the benefits can be implemented in the long term and, most important, transfer them to the daily life routine of senior gamers. As a result, for many games and also for LEAGE, further work is needed to examine how much more effective it can be to change behavioural and health outcomes than are conventional approaches. In addition, whenever a game as LEAGE will be deployed in real-life applications, several challenges will have to be addressed. For example re-playability, the availability and/or costs of ICT equipment to run the game, the accessibility of peripheral equipment and operating system, and the availability of specific selling channels that reach the intended stakeholders. As any game, the developed learning game is still open for improvements and deployment challenges will have to be addressed, yet, the LEAGE game shows potential for entertaining and accessible means to learning by digital game play for an older audience.

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