DESIGN AND EVALUATION OF AN INTERGENERATIONAL GAMING PLATFORM FOR COGNITIVE STIMULATION

Sonia García [1], Víctor Peláez[2], Roberto González[3], Luis Ángel San Martín[4], Vanesa Lobato[5], Enrique Pérez Sáez[6], Mireia Tofiño García[7]

[1,2,3,4,5]R&D Department, CTIC Technology Centre, Spain

[6,7]National Reference Centre for Alzheimer and dementia care, Spanish Government

sonia.garcia@fundacionctic.org[1], victor.pelaez@fundacionctic.org[2], roberto.gonzalez@fundacionctic.org[3], luisangel.sanmartin@fundacionctic.org[4], vanesa.lobato@fundacionctic.org[5], neuropsicologocrea@imserso.es[6], mtofiñog@imserso.es[7]

Abstract: Cognitive stimulation therapies based on games are commonly used nowadays in care centers for people suffering from Alzheimer's or other cognitive diseases. Although users usually like the proposed games, they are not motivated enough to play willingly on a regular basis. This work presents a novel game platform for cognitive stimulation that introduces the factor of intergenerational interaction in order to increase user's motivation towards playing. This work tries to involve patient's relatives in the gaming experience by including the use of social networks. The presented gaming platform has been designed, implemented and evaluated with real patients, proving its technical feasibility and usability. Evaluation results and practitioners' experience show that the gaming platform will be more suitable for patients suffering from a mild level of cognitive disease.

Keywords: intergenerational games, cognitive disease, usability.

Introduction

During last years, the use of non-pharmacological therapies for the treatment of cognitive diseases, such as Alzheimer's, has increased as its therapeutic validity has been proven (Orrell, Spector, Thorgrimsen, &

Woods, 2005). These kinds of therapies are known as cognitive stimulation therapies and they are often based on games (Whitlock, McLaughlin, & Allaire, 2012). Practitioners often use these kinds of games in stimulation sessions with their patients, playing either with real cards or using new interaction systems that have recently emerged (interactive TV, multi-touch screens or tablets). Nevertheless, their main problem is that users are not motivated enough to play regularly.

Non-pharmacological therapies have also been evolved introducing concepts of social interaction. The main concept is that interacting with other people in their same situation will help patients with the development of their therapies. Moreover, intergenerational interaction (social interaction between people from different age groups) can be beneficial for them and also for their families, as the family environment usually takes part in it (A Guide to Intergenerational Practice, 2011).

This work presents a system that combines the benefits of game-based cognitive stimulation therapies with intergenerational therapies, using information and communication technologies. The proposed gaming platform allows people with cognitive diseases and their relatives to interact and play cognitive stimulation games by using social networks as a means of communication. As these two groups of users do not have the same characteristics, patients suffering from a cognitive disease will interact with a simple device (a tablet) while the other group of users will be able to integrate the gaming platform in their preferred social network. Results show that the use of a simple multiplayer game increases user's motivation to play and maximizes the benefits of the game as a cognitive stimulation therapy.

Cognitive stimulation systems using information technologies

Most care centers for people suffering from any type of cognitive disease offer some platforms for cognitive stimulation nowadays. Some of the most popular platforms for this kind of therapies are Gradior or Feskits. They are commercial platforms which offer different games for cognitive stimulation that will be run on a computer. During the last few years, research in Spain and Europe has been focused on the development of cognitive stimulation platforms for being run on simpler devices in order to improve usability: interactive TV (García et al., 2011) or interactive tables ("Elder Games" European project).

In addition to improving usability by defining special gaming platforms, another research topic is related to intergenerational games (Theng, Chua & Pham, 2012; "LEAGE" European project; Khoo et al., 2006). All these works obtained positive results regarding user's motivation for the games. Nevertheless, as targeted users of these platforms were people who did not suffer from any cognitive disease, the validity of these games as a cognitive stimulation therapy was not studied.

Besides intergenerational interaction, social interaction is important for older people and their use of social networks has been studied. Some works have proven that the reason why older people do not use social networks is not the lack of technical knowledge, but the lack of interest (Sundar, Oeldorf-Hirsch, Nussbaum & Behr, 2011). The last annual report of social networks in Spain (2013) shows that Facebook is the user's favorite social network: it is used by the 96% of the social network users during an average time of 5,18 hours a month. Taking these data into account, the existing social networks have to be considered in order to bring them closer to older people.

System description

A game platform was designed and a prototype of a game was developed in order to have a functional system, which supported various user profiles and

devices. Every design aspect has taken into account the special needs of the users of the game platform. This design was addressed with the collaboration of practitioners from the National Reference Centre for Alzheimer and dementia care (CRE Alzheimer).

Components

Two types of clients have been developed for being used in two different types of devices. The tablet client is run in a Tablet PC and the social network client is run on a computer using a web browser. Both applications have the same functionalities, their main differences being the user interaction method: a touchscreen (for the tablet client) and a mouse and/or keyboard (for the social network client). Some social networks (Facebook, Tuenti and Google+) were evaluated for the implementation of the social network client. Finally, Facebook was chosen for the development of the prototype as it provided an Android SDK for mobile and web applications.

A server application was also developed for the communications management. This server application is used as a connection element between clients in order to synchronize the game state between players. The server is in charge of creating and transmitting the games to the clients as well as storing the data that the practitioners need in order to monitor the patients.

There are three types of user profiles considered in this work: patients with some kind of cognitive disease (the main group of users this work is aimed for), relatives (patients can use the platform to play with their relatives) and practitioners (they can use the game platform with their patients in the therapy sessions).

Main functionalities

The designed game platform can support any number of games, but only one kind of game was developed in this work as a proof of concept. Practitioners proposed the implementation of a memory game, which consists of finding

pairs of matching cards by turning them over. This game was suggested because the professionals used this game in therapies with paper cards and having it in an electronic format was interesting for them.

Both the tablet and the social network client allow a complete gaming experience. The main functionalities are briefly described below:

- Identification: the user has to log into the system with his Facebook user credentials. Once the login process is completed, an initial personalized screen will appear showing the user's profile image and a personalized welcome message with his name.
- Game mode selection: the user can choose to play in multiplayer or individual mode.
- Opponent selection: When a user selects the multiplayer mode, all Facebook contacts that are online at that moment will be shown. By selecting one of them, an invitation to play will be sent to that user.
- Invitation reception: When a user has been sent an invitation, he will receive a notification of this fact, showing the person that invited him and allowing its acceptance or rejection.
- Game: A game for finding matching pairs of cards is implemented.

Considerations on usability

This work tries to maximize the system's usability as the final users of the game platform have special needs. Two main aspects have been considered: personalization and user interface.

Personalization

The game platform has to adapt its content to the user profile, as the abilities of the potential users of the gaming platform could be very different. For this reason some parameters that affect the game difficulty can be personalized for each user:

- Game board size: the number of cards that appear on the game board is the main factor that determines the game difficulty. The game platform has been designed to use a variable game board size, supporting a range from 8 to 16 cards.

- Stimulus exposure time: in this context, the stimulus exposure time is defined as the time during which the non-paired cards are visible until they are hidden again. The longer the exposure time, the easier it will be to remember the location of each card.

- Game mode: the game platform will allow users to play against another user or on an individual mode. Nevertheless, for certain users, the multiplayer version of the game could be very difficult, so this game mode can be disabled for them.

The aforementioned parameters can be personalized individually for each user. As the practitioners know the abilities of each patient, they are responsible for editing these parameters before the patient uses the game platform for the first time. These parameters are also dynamic, so practitioners can change any parameter any time, for increasing or decreasing the game difficulty.

User interface

During the design of the game platform, the main objective was to achieve a user interface as usable as possible. Therefore, both usability guidelines and opinions from healthcare professionals were taken into account to select some design principles that have been applied to every screen the user has to interact with ("Buenas prácticas de accesibilidad en videojuegos", 2012; Ijsselsteijn, Nap, de Kort & Poels, 2007).

Distractions are very common in this kind of users so simplicity and consistency were very important restrictions to maintain users focused on the parts that contain the information or that he has to interact with. Moreover, the application has been designed to use big screen elements that provide a large area of interaction, as the main user input is tactile. The use

of big interaction elements also addresses some possible usage problems related to age (finger rigidity and deterioration of movement coordination).

Color combination had to be also considered in order to create enough contrast between the different elements and specially for improving text legibility. In addition, the application has to inform the user about its state so he knows at every moment if an action is required. To do this, both audio and textual feedback is used.

Figure 1 shows four different screens that are part of the application and follow the usability restrictions identified. Each of the screens implements one of the main functionalities of the platform: identification (top-left), opponent selection (top-right), invitation reception (bottom-left) and game (bottom-right).

Figure 1. User interface

Evaluation

An evaluation process for determining the usability of the gaming platform, and especially the tablet client, was carried out using direct observation techniques and questionnaires. Users were provided with tablets of two different sizes (10 and 7 inches).

Participant description and evaluation set-up

Twelve participants took part in the evaluation process of the gaming platform. They were patients from the National Reference Centre for Alzheimer and dementia care who had been diagnosed with some type of dementia. They were in stages 3, 4 and 5 of the Global Deterioration Scale (GDS), being stage 4 the most common of them. Only two of them suffered from a mild level of a cognitive disease, whereas the cognitive disease level of the other ten people was medium. Participants' age ranged between 55 and 90, with a mean of 79 and a mode of 86.

User tests were conducted at the National Reference Centre for Alzheimer and dementia care at Salamanca making use of a Gesell dome (two contiguous rooms with a one-way mirror between them). The patients used one of the rooms to do the test while a group of researchers and practitioners observed the tests in the other room.

Evaluation procedure

Each patient who took part in the system evaluation had to use the system for 15 to 20 minutes. The number of games they played was variable as it depended on some factors such as user skills using the tablet or his ability for remembering the hidden cards. Practitioners had previously configured the parameters that affect the game difficulty for each user. They decided that only the mild level patients could play with the 16-card version of the game. The other patients used the 8-card version. Patients were always accompanied by a practitioner who helped them in everything they needed. The practitioner guided patients through the test following the procedure described in the following paragraphs.

The practitioner started the test by showing the user how to use the tablet. After that, the practitioner explained the objective of the game and how to play. Then, the user started playing in the individual mode with the 10-inch tablet. After a certain number of games, some users were given the 7-inch tablet to continue playing, being then questioned by the practitioners about their preferences.

Taking into account the game performance shown by users in the individual mode, the practitioners proposed certain users to play some games in the multiplayer mode. Their opponent could be another patient (who was in the same room) or another practitioner (who was in a different room).

*Figure 2. Evaluation procedure*

Test results

The mean playing time on each type of device was analyzed in order to determine the differences between the 10-inch and 7-inch tablets: 2:33 minutes for the 10-inch tablet and 1:52 minutes for the 7-inch tablet. The Student's t-test was applied (using the independent two-sample t-test for unequal sample sizes and unequal variances) and it proved that there were no significant differences between the tablets (t statistic = 2,001 – critical t value = 2,131 – P (T ≤ t) for a two-tailed test = 0,063).

Table 1.Game duration comparison.

User ID	Average playing time in individual mode (minutes)	Average playing time in multiplayer mode (minutes)
User 5	03:03	03:15
User 3	02:56	04:31
User 12	01:52	05:03

The gaming time for multiplayer games differs from the gaming time for individual games. Multiplayer games between a patient and a practitioner (Table 1) or between two patients (Figure 3) shows that the time spent in a multiplayer game is higher than the time spent in the individual mode. This is due to the fact that in the multiplayer version of the game the user needs to remember the cards for a longer time, which increases its difficulty.

Figure 3. Game duration comparison.
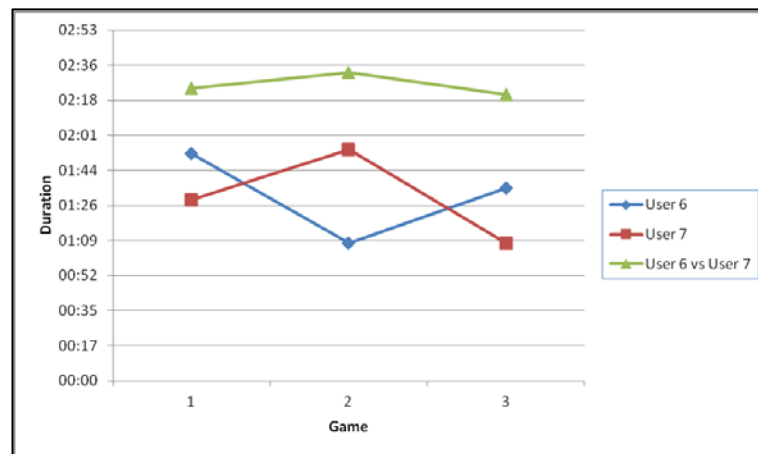
Practitioner's impressions

When the user sessions ended, evaluation questionnaires were sent to each practitioner that took part in the experiment. Some affirmations were written on the questionnaires and the practitioners had to answer if they agreed with the affirmations. Practitioners had to write their answers in a range from 1 to 5, where 1 meant that they "strongly disagree" and 5 meant that they "strongly agree". These affirmations were meant to get their opinions about the patients' use of the gaming platform.

Four practitioners filled out the questionnaire. They considered that the application interface is easy to use and they think that the best option for the patients would be the 10-inch tablet. Nevertheless, during the tests, the users showed no preferences between the devices. Practitioners were also asked about the validity of the gaming platform as a complement to other existing therapies. The 90-percentile shows that they strongly agree on this affirmation and also that playing against another person increases the

patient's interest on using the gaming platform. However, practitioners are not sure about users' understanding of the multiplayer concepts: 90-percentile shows a scoring of 4 out of 5.

The questionnaire had a set of affirmations regarding the patient's use of the platform describing four scenarios that took two factors into account: game mode and help needed. In addition, they had to distinguish between patients with a mild or a medium level of cognitive disease. Table 2 and Table 3 show the results for this set of questions.

For patients with a mild level of cognitive disease, practitioners strongly agree that they will be able to play both in the individual and multiplayer mode if they have the practitioner's help. If they do not have any help, practitioners think that they will be able to play in the individual mode (90-percentile is 4 out of 5) whereas the 90-percentile for multiplayer games is 3.7 out of 5.

Table 2. Practitioners' answers regarding patients with a mild degree of cognitive disease.

Question	Range	Mode	90 percentile
Patients are able to use the tablet to play in the individual mode, with a practitioner's help.	5	5	5
Patients are able to use the tablet to play against another person, with a practitioner's help.	4-5	4 and 5	5
Patients are able to use the tablet to play in the individual mode, without any help.	3-4	3 and 4	4
Patients are able to use the tablet to play against another person, without any help.	2-4	3	3.7

Table 3. Practitioners' answers regarding patients with a medium degree of cognitive disease.

Question	Range	Mode	90 percentile
Patients are able to use the tablet to play in the individual mode, with a practitioner's help.	3-4	3 and 4	4
Patients are able to use the tablet to play against another person, with a practitioner's help.	3-4	3 and 4	4
Patients are able to use the tablet to play in the individual mode, without any help.	1-2	1 and 2	2
Patients are able to use the tablet to play against another person, without any help.	1-2	1 and 2	2

If patients have a medium level of cognitive disease, practitioners' answers show some differences. While for the simplest scenario practitioners agreed unanimously that users with a mild level of cognitive disease will be able to use the system, the 90-percentile in this case lows to 4 out of 5. The same values are obtained for playing against another person if they can get help. On the other hand, practitioners do not think that patients will be able to play without help: values from 1 to 2 out of 5 were obtained, being 2 the 90-percentile, which clearly shows that they disagreed on these affirmations.

Discussion

Twelve potential users of the platform did the gaming platform evaluation. Although there were not enough users to get formal conclusions for its validity as a cognitive therapy, some valid results about the usability of the system were obtained.

Direct observation of the evaluation procedure revealed that users seemed comfortable using the tablet and they understood how to interact with it. They used 10-inch and 7-inch tablets, not showing any preferences for one or another. In addition, figures confirmed that tablet size did not affect the gaming time. Patient's attitude towards the game was positive and they seemed to be motivated in the multiplayer mode, as they liked to continue

playing to be the winner. Figures indicated that games in the multiplayer mode lasted longer than the individual ones: as they had to wait for the opponent's movement, they tended to forget the cards location more easily so they needed more movements to find the matching cards.

Patients suffering both a mild and a medium level of cognitive disease took part in the evaluation process. All of them were able to play with the tablet, but the practitioners had to give more indications to the group of patients that had a medium level of disease. Using these tests and their experience, the practitioners filled out a usability questionnaire. The main conclusion that can be obtained from this questionnaire is that users with a mild level of cognitive disease will be the more suitable user group for the gaming platform, as practitioners think that this kind of patients will be able to use both game modes without help. On the other hand, help will be a decisive factor for the other group of patients, as they only will be able to play if someone helps them.

Conclusions and future work

This work presents the definition of a new cognitive stimulation therapy, based on the concepts of serious games, multiuser interaction and intergenerational interaction. As a result, a gaming platform with these features has been designed, implemented and evaluated. This gaming platform allows users to play a memory game individually or against other people using a tablet (meant to be used by patients with cognitive disease) or a browser on a computer (meant to be used by relatives or practitioners who play against the patients). The design process focused on usability in order to adapt the application to the special needs of potential users. All of these features turn the gaming platform into a novel system.

A group of patients suffering from several types of cognitive disease, such as Alzheimer's, and a group of practitioners have evaluated the gaming platform. Technical feasibility of the system has been proven and positive results regarding user's acceptance have been obtained after these tests.

Taking into consideration the evaluation results, patients with a mild level of cognitive disease will be able to use the gaming platform on their own, whereas patients with a medium level of cognitive disease will need some kind of assistance. Results also showed that the multiplayer game option increased user's motivation: they wanted to continue playing and they were also more concentrated on the game.

A more detailed evaluation of the system from the therapeutic point of view is needed in order to guarantee its validity as a cognitive stimulation therapy. This evaluation will have to be carried out for a longer time and focusing on the patients with a mild level of cognitive disease. Patient's relatives should also take part in this evaluation process, so the intergenerational and multiplayer benefits regarding user's motivation could be studied.

Acknowledgements

References

[1] A Guide to Intergenerational Practice. (2011). Retrieved from http://www.centreforip.org.uk/res/documents/page/BJFGuidetoIPV2%20%2028%20Mar%202011.pdf

[2]   Buenas prácticas de accesibilidad en videojuegos. (2012). Retrieved from http://www.ceapat.es/InterPresent2/groups/imserso/documents/binario/accesvideojuegos.pdf

[3]   Elder   Games   European   Project.   Retrieved from http://www.eldergames.org

[4]   Feskits. Retrieved from http://www.feskits.com/demo/index_esp.html

[5]   García, S., Lobato, V., Peláez, V., González-Ingelmo, E., Barrientos, F. & Carretero, S. (2011). Evaluación de la usabilidad de una plataforma de estimulación cognitiva basada en televisión interactiva. *IV Congreso Internacional de Diseño, Redes de Investigación y Tecnología para todos (DR4ALL)*, 220-235.

[6]   Gradior.   Retrieved from http://www.intras.es/index.php/productos/software-gradior

[7]   Ijsselsteijn, W., Nap, H. H., de Kort, Y. & Poels, K. (2007). Digital game design for elderly users. *Proceedings of the 2007 conference on Future Play*, 17-22. DOI: 10.1145/1328202.1328206.

[8]   IV   Estudio   anual   Redes   Sociales.   (2013).   Retrieved from   http://www.iabspain.net/wp-content/uploads/downloads/2013/01/IV-estudio-anual-RRSS_reducida.pdf

[9]   Khoo, E. T., Lee, S. P., Cheok, A. D., Kodagoda, S., Zhou, Y. & Toh, G.S. (2006). Age invaders: social and physical inter-generational family entertainment. *CHI'06 extended abstracts on Human factors in computing systems*, 243–246. DOI: 10.1145/1125451.1125503.

[10]   LEAGE European project. Retrieved from http://leage.exodussa.com/

[11]   Orrell, M., Spector, A., Thorgrimsen, L. & Woods, B. (2005). A pilot study examining the effectiveness of maintenance Cognitive Stimulation Therapy (MCST) for people with dementia. *International journal of geriatric psychiatry, Wiley Online Library, 20, 5*, 446-451. DOI: 10.1002/gps.1304.

[12]   Sundar, S. S., Oeldorf-Hirsch, A., Nussbaum, J. & Behr, R. (2011). Retirees on Facebook: can online social networking enhance their health and wellness? *CHI'11 Extended Abstracts on Human Factors in Computing Systems*, 2287-2292. DOI: 10.1145/1979742.1979931.

[13]   Theng, Y., Chua, P. H. & Pham, T. P. (2012). Wii as entertainment and socialisation aids for mental and social health of the elderly. *CHI'12*

Extended Abstracts on Human Factors in Computing Systems, 691-702. DOI:10.1145/2212776.2212840.

[14]   Whitlock, L. A., McLaughlin, A. C. & Allaire, J. C. (2012). Individual differences in response to cognitive training: Using a multi-modal, attentionally demanding game-based intervention for older adults. *Computers in Human Behavior*, *28*, *4*, 1091-1096. DOI: 10.1016/j.chb.2012.01.012.

.

www.jacces.org

Twitter: @Journal_JACCES   LinkedIn: JACCES page