Micogito: a Serious Gamebook Based on Daily Life Scenarios to Cognitively Stimulate Older Adults

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ABSTRACT

With the increase in the number of people aged 60 years and older, it becomes essential to promote active ageing. Adequate cognitive training activity can preserve older adults' health conditions, allowing them to live autonomously longer. However, older people often have difficulties with the use of digital technologies and risk being excluded from these. For this reason, this work proposes a solution that introduces older adults to new technologies while maintaining a familiar appearance to them. The solution proposed is Micogito, a web serious game that exploits the book metaphor for cognitive stimulation of older adults. It supports tasks which replicate daily living activities, and has been conceived, and designed to stimulate the most implicated cognitive functions in ageing and particularly in mild cognitive impairment. In its design and implementation, guidelines useful to make web applications accessible and usable for the target users were considered. We also report on a first user test with older adults, to assess the effectiveness of this approach, which provided useful and encouraging feedback, and discuss some lessons learnt.

CCS CONCEPTS

• Human-centered computing → Accessibility systems and tools

KEYWORDS

Serious games, Cognitive stimulation, Older adults, Gamebook

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1 Introduction

With the increasing number of older adults, it has become important to promote so-called "Active ageing" which, following the World Health Organization (WHO) definition is "the process of optimizing opportunities for health, participation and security to enhance the quality of life as people age"[1]. The WHO, with the term "health", defines a state of complete physical, mental, and social well-being. Regarding physical and social health, there has long been an important planning and active commitment of public institutions, and the voluntary sector. Regarding mental health, on the other hand, the lack of active commitments and targeted studies and projects are unfortunately well-known and widespread. Understanding the differences between normal and pathological brain ageing is often problematic since the ways and pace of decay in psychophysical functions differ substantially from individual to individual [1]. In general, the cognitive functions most implicated in cognitive aging are Divided Attention and Attention Switching, Working Memory, Executive Functions and Episodic Memory [2]
One of the forms of cognitive decline that has received continuous attention from studies and research in recent years is Mild Cognitive Impairment (MCI). Most recent criteria see MCI classified according to whether the memory is impaired and to the number of cognitive domains involved in the deficit. At the basis of this classification, however, the subject must not have a diagnosis of dementia, and have a cognitive decline in some domain with essentially normal functional activities [3].
In order to contribute to stable maintenance of cognitive conditions, allowing the older adults to live independently for as long as possible, it is important to examine and evaluate the main characteristics of cognitive ageing; what their major implications are, and how it is possible to intervene on them, with a forward-looking approach, and introduce increasingly effective supports.
Many of the proposed research and design solutions come from the ICT field which, in synergy with other disciplines, have long shown their potential to contribute to achieving this goal. Among the research conducted and projects launched, the use of serious games (games that do not have entertainment as their primary purpose) seems interesting for the pursuit of the purpose.

[1] https://www.who.int/ageing/

The solution proposed here is to adopt the gamebook structure, a narrative work that instead of being read linearly from beginning to end, requires the user to perform actions interactively. The choice is motivated by the promotion of a form of entertainment that combines the more traditional structure of the book to the use of the web, to better support user enjoyment while interacting with stimulating exercises. On these assumptions, Micogito was designed and created: a serious gamebook that allows users to practice with mini games, which replicate daily life scenarios aimed at stimulating the domains most involved in cognitive decay: memory, attention, executive functions.Its design of Micogito takes into consideration the characteristics and functionalities necessary to make the application usable and accessible for the target of older adults.

The aim of this work is to investigate whether the structure of a gamebook which replicates daily-life scenarios can be functional in terms of usability and appreciation by users. In addition, it will be investigated whether the games created have any correspondence to the main cognitive domains investigated through cognitive testing. In particular, we aim to understand whether the performance of users with the games in a given task targeting a certain cognitive resource is correlated to the user's ability in that cognitive domain because this would indicate that the task actually exercises the cognitive aspect that is less trained in the considered users (low performance with users with low ability).

2 Related Work

A recent systematic review [4] found that in recent years a wide variety of technologies have been exploited to create serious games to cognitively stimulate older adults. In terms of devices, the tablet is the technology that has most frequently been used in such studies. On the other hand, regarding the cognitive functions stimulated, regardless the characteristics of the various technologies, those most addressed are those most implicated in the cognitive decline of ageing: memory, attention, orientation, and executive functions. Among the solutions adopted by serious games to cognitively stimulate older adults, one type of approach, which seems to have some potential in terms of both utility and cognitive stimulation is the replication daily-life scenarios. Monaco et al [5] propose a game which replicates the daily-life scenarios in order to stimulate the major cognitive functions involved in cognitive aging such as memory, attention and orientation. The game uses a brain-computer interface to monitor the cognitive reaction of the patient, by means of EEG sensors. Haptic sensors embedded in gloves allow the user a more natural interaction with the game. This setting is very specific and excludes the users from the possibility of accessing the game at any time they wish. Mondellini et al. [6] propose a game that replicates the shopping activity in a virtual supermarket. The technology used to support this game is the HTC Vive virtual reality gaming system, consisting of a headset and two controllers useful for interacting with the virtual environment. Although the perception of usability of the system by users has been good, its adoption is limited by the need to use a specific technological device. Manera et al [7] propose a game solution that replicates the daily-life scenarios related to the kitchen activities. The game involves the tablet device and therefore does not require special technology to be used. However, the actions that the user has to perform involve complex touch interaction processes, which have shown to be problematic for older adult.

Thus, we decided to design a serious game in terms of a Web application in order to facilitate its access and use. In addition, since none of the serious games proposed in the articles resulting from the systematic review [3] uses the gamebook structure, we thought it would be interesting to investigate its use in the novel solution.

The gamebook structure combines the interactivity of the web app with the traditional elements of the book, which is usually familiar to older people. Familiarity and prior experience are factors often considered in the game design for older adults [8] as elements able to enhance older adults' ability and motivation in the game.

In such context, the guidelines proposed in the literature to make web platforms usable and accessible to the target of older users should also be addressed. In particular, we have considered a study conducted by Dias and collaborators [9] which examined the relationship between some devices used in web design and the performance of the elderly. In addition, Kurniawan and collaborators [10] propose a review of the guidelines for making websites usable for elderly users, which has been validated by experts and users. It concerns the clarity of the design target, the relevant and not merely decorative use of graphics, the clarity and simplification of navigation, the intuitive use of layout and language, visibility of the platform structure and connections, a reduction in load cognitive by promoting the recognition process rather than that of the recall (recovery direct memory), without facilitating stimuli, the use of colours and contrasts appropriate to the visual difficulties that the user category may encounter, and the inclusion of adequate help tools and error prediction. Arch and Abou-Zhara, who initiated the WAI- AGE (Web Accessibility Initiative: Aging Education and Harmonization) project, also drew some observations, additional to the WAI guidelines, for making content accessible to older adults [11].

3 Micogito Design

The design and implementation of the serious game was driven by aspects and requirements gathered in the analysis of the state of art. Therefore, the serious game Micogito takes its cue from the structure of gamebooks: narrative works that offer interactive scenarios in which the user, instead of reading the work linearly, actively participates by deciding between some possible alternatives. Since the results of the gamebook must be used to evaluate the cognitive domains and the user's progress, in the case of Micogito the users are not free to choose the "outcome" of the story they are reading: they will be the agent of a unitary story during which they will be asked to solve questions to move on to the next step of the narration.

We analysed the game typologies that have been used in the realization of serious games in literature, and decided to adopt as game scenarios the replication of daily activities, which, in addition to being generally appreciated by users who have

experience and familiarity with them, can combine the stimulation of multiple cognitive domains and be useful in everyday life.
The gamebook is structured into various tasks. In the identification of the tasks and how to support them, both the results of the state of the art and the characteristics of the deterioration of cognitive functions in the specific case of MCI were taken into consideration, because this also involves attempting to prevent more serious cognitive declines both for pathological and healthy subjects. Therefore, in the design of the Micogito tasks, it was decided to represent scenarios and actions that are widely common in the performance of the daily life of users, who act in the first person. The actions required from users in the tasks have been studied to constitute a test of the previously mentioned cognitive functions most involved in cognitive ageing.
In addition, guidelines for making the platform usable and accessible to the target audience of older users were taken into consideration. For example, it was verified that the contrasts respected the ratio of at least 4.5:1; the text is greater than 14 pixels (supported by two buttons that allow zoom-in and zoom-out of the text); exclusion of decorative elements not useful to the interpretation of the game; simple and essential navigation menu; prevention of errors by providing checks on registration and log in forms; a "contact us" section that can be used at any time during interaction.

4 The Game

The cognitive functions that have been considered for designing the tasks of the game are the executive functions, which are involved not only in the performance of tasks but also in the interaction with the entire game process, memory and attention. Below, the functionalities and structure of the seven identified tasks are explained.

Task 1 – Information recall

After receiving an introduction to the scenario, the user receives a call from a friend proposing dinner on a certain date; users are asked to check their availability and answer the friend's request.
Users should check their availability by checking the agenda provided. This is done by clicking a button that opens a pop-up window, which will then be closed to continue the interaction: in this way, the information will disappear from the view of the user, who will then have to perform an information recall exercise (Figure 1).

Figure 1: scenario introduction and the agenda

The cognitive functions stimulated in this first task are: Memory, once the agenda has been checked, the user will have to remember the day when is available and check it; Selective attention, the user reading the text must focus attention on the information "dinner date", ignoring the rest of the information provided in the text; Inhibition, a component of executive functions that ensures selective attention; Working memory, another component of executive functions, once the agenda has been checked and therefore the availability, the user will have to use this information to answer the question.

Task 2 – Selective attention

The second task requires the user to read a text about a friend's phone call and learn the information about his food allergies. Then the user has to choose a recipe to prepare for lunch. The task has a structure similar to the first one, and targets the same cognitive functions. The difference is in the form of information presentation: this time, the friend's food allergies information is visible to the user at the moment of the answer (there are no pop-up windows).

Task 3 – Text- image association

In the third task, the user checks in the cupboard if there are all the necessary ingredients for the preparation of the recipe. In addition to the cognitive functions implied in the first two tasks, in this third task also the visual memory is involved, due to the text-image association: if in task 2 in the recipe book the user sees, the ingredients in written form, in the cupboard of this task the ingredients are presented as images (Figure 2).

Figure 2: text-image association with with the cupboard example

Task 4 – Image recognition

In the fourth task, the user performs another association, this time an image - image one: the user will have to remember which was the ingredient of the recipe which was not present in the cupboard. An image that shows all the graphical representations of the necessary ingredients is provided, thus enabling the association.

Task 5 – Visuo-spatial skills

In this task, the user has to follow the presented directions to reach the supermarket (Figure 3). Here the cognitive functions addressed are both problem solving and visuo-spatial abilities, i.e. those processes that allow the individual to interact with the surrounding environment. Specifically, here the ability to mentally represent space according to both egocentric and allocentric coordinates is considered.

Figure 3: Visuo-spatial test with supermarket example

Task 6 – Delayed recall

In task 6, users, once at the supermarket, must remember, after a longer period, the missing ingredient they had to buy. Here, long-term memory (delayed recall) is stimulated.

Task 7 - Planning

In the seventh and last task of the serious game, the four steps to follow for the realization of the recipe are presented in the cookbook that the user must visualize through a pop-up window. The steps, presented in the cookbook in written form, are illustrated in the images on the left and after making the text-image association, the user is asked to reorder them, dragging them according to a drag-and-drop mechanism. Here, in addition to short-term memory and working memory, planning ability is stimulated (i.e., the set of cognitive activities necessary to create and follow a series of actions required to achieve a goal).

5 User Test

In order to validate the design of the serious gamebook a user test with older adults has been designed and carried out. The user test, due to the pandemic crisis, was administered remotely via Skype. It involved a cognitive assessment conducted through the Montreal Cognitive Assessment (MoCA) test [12], two questionnaires (the first one, administered before the game started, related to the user's digital competence assessment and the other one, administered after the game has been used, containing the System Usability Scale (SUS) [13] and two open-ended questions designed to investigate what the most appreciated and least appreciated elements of Micogito were. The test also involved the observation of the users throughout the interaction with the platform.

5.1 Participants

The participants to the user test were 17 (10 female and 7 male users), aged between 60 and 83 years (mean age 67). A questionnaire on digital competence was submitted to the users. In reviewing the questionnaire, the most evident finding was on the use of cognitive training applications: no participant had ever used cognitive training applications before. This indicates that often cognitive training is not considered an activity that is necessary, useful or crucial in the daily lives of people over 60.

Users were asked to self-assess their familiarity with smartphone, tablet, and PC devices using a scale that had "low", "sufficient", "good", and "excellent" as values. Regarding the PC, 6 users stated that they had good familiarity, 7 users stated that they had sufficient familiarity, 3 users stated that they had excellent familiarity, and 1 user stated that they had poor familiarity. These results connote a heterogeneous population in terms of familiarity with this device.

In the answers given about the smartphone device 10 users declared a good familiarity, 6 a sufficient familiarity. No user declared to have a poor familiarity with this device. Concerning the tablet, 6 people declared to have a poor familiarity with this device and in many cases, it has been declared not to own it at all.

Users were then asked to self-report how frequently in a week they use the devices on a scale: "never," "a few times a week," "every day," and "several hours a day". Even in these results, the most heterogeneous data is given by the use of PC: in fact, 3 users declared they never use it, 6 users declared they use it "a few times a week", 4 users "every day", and 4 users "several hours a day". Concerning the tablet, many users (i.e., 8) stated that they do "never" use it and concerning the smartphone, no user stated that "never" use it or "few times a week": 8 users answered that they use it "every day" and 9 users "more hours a day". The results of this questionnaire connote a population of users therefore averagely familiar and competent with the PC, but certainly more accustomed to the use of smartphones. Most users also claimed to spend an average of 3 hours a day surfing the web. This result indicates that the participants were averagely familiar in web activities.

5.2 Cognitive assessment

Participants in the user test were subjected to a cognitive assessment carried out using the remotely executable version of the MoCA, which was chosen because it is a relatively short test (it takes about 15 minutes) and provides a general cognitive assessment of several cognitive domains (memory, attention, executive functions, orientation, language). Before testing the participants, the non-diagnostic purpose of the test was explained as well as the absolute confidentiality of the data collected.

For the users' cognitive assessment, not only the total test score obtained was considered, but also the partial scores related to the various functional areas into which the MoCa test is divided. In the Delayed Recall test (whose maximum score is 5, one point for each word recalled) a Memory Index Score (MIS) is calculated, in the case of recollections not performed spontaneously. The MIS provides suggestions to facilitate re-enactments at two levels: a semantic cue and a multiple-choice cue.

The average of the total raw MoCa scores obtained in the tests was 26.1; the average of the total corrected score, after assignment of the point for less than 12 years of schooling, was 26.4; the minimum total score obtained was 20 and the maximum was 29. According to the applied calibration, all MoCa results, obtained from the users, can be considered.

Utilizing the environment for statistical analysis R, the correlation between total correct MoCa score and age of the subjects and its significance level were calculated. The value of the correlation between the two values (-0.58) shows that these are negatively correlated. Partial scores of the seven cognitive domains assessed in the MoCa were then examined and mean values, standard

deviations, minimum, and maximum were calculated (Table 1). In the table, the Tot column indicates the maximum score that can be reached for the considered domain and the Mean % column indicates the mean results as percentage over the maximum possible scores.

Domain	Tot.	Mean	Mean %	St. Dev.	Min.	Max.
Visuospatial/Executive	5	3.71	74.2%	1.21	1	5
Naming	3	2.88	96%	0.332	2	3
Attention	6	5.53	92.2%	0.624	4	6
Language	3	2.53	84.3%	0.717	1	3
Abstraction	2	1.76	88%	0.562	1	2
Delayed recall	5	3.88	77.6%	0.857	2	4
Orientation	6	5.82	97%	0.393	5	6

Table 1 – Users' partial scores of MoCA

5.3 Game Evaluation

Users were observed throughout the entire process of their interactions with the gamebook, from the moment of registration until the end of the game. The complete reading of the interactive story took each user between 10 and 15 minutes. The task that took the user the longest to perform was task 5 (visuo-spatial skills), which in most cases implied a need to re-read the written text in order to follow the directions on the map. In the last task, the one that requires ordering the figures by drag and drop according to a provided scheme, almost all users encountered similar problems: their first attempt was to drag the figures into the scheme (Figure 4).

On the other hand, regarding the scores with the game tasks, they were generally positive: in 4 tasks out of 7 no errors were reported by any of the users. All of the errors made by users are clustered in task 1 (information recall), task 3 (text-image association), and task 5 (visual-spatial skills). An assumption is that the errors

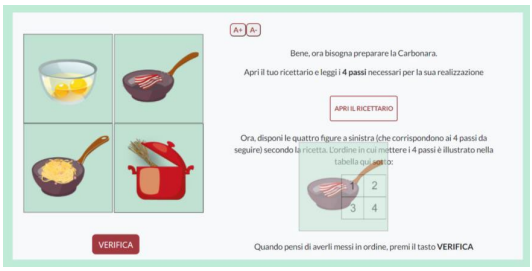

Figure 4: common error in task

reported in Task 1 are due to the fact that, in order to answer the question correctly, users had to remember the commitments in the agenda in the previous scenario. Since it was not necessary to open the agenda in the pop-up window to proceed with the game, many users (8 users) did not even open it. This was also due to a poor predisposition to reading the texts of the gamebook.

On the other hand, user performances in Tasks 3 and 5 was not subject to any obstacles or skipped steps in the performance. Therefore, errors are considered to be due to the difficulty of the required task depending on the user's abilities.

Lastly, an analysis was carried out on the relationships existing between the users' number of errors made in the three tasks of the serious gamebook and their scores in the individual domains of the MoCa cognitive test, in order to understand whether the performance of users in a given gamebook task is correlated to the user's ability in the cognitive domain addressed by such task (i.e. those with lowest cognitive domain abilities were those who performed worst).

Performing the T-test on the cognitive domain related to attention and a categorical variable (i.e., task_error), which divides users into those who have made errors (9 users) and those who have not (8 users), we found a p-value of 0.002175, indicating that the data are significant. This fact indicates a correspondence between users' performance on gamebook tasks and their attention cognitive resource.

We then addressed the question of whether it was the score obtained in task 1, task 3 or task 5 that determined this statistical significance (as these are the only tasks where errors have been reported). By means of the T-test we compared the errors reported in the single tasks of the serious game with the scores obtained in the MoCa index of Attention. The p-value provided by T-test for task 5, the one related to the navigation in the map, is 0.001537, considerably lower than the 0.05 limit. This test was therefore statistically the most significant regarding the relationship between the MoCa index of Attention decay and the level of errors committed in the single tasks of the serious game. The same analysis was replicated by correlating the scores of the tasks of the serious game with the domain of the MoCa test related to visual-spatial and executive functions. From this further investigation the resulting significance of the T-test for the relationship between users' results in task 3 (the check of the food in the cupboard) and the scores obtained in the above mentioned MoCa domain, is 0.04147. Also the p-value provided by this T-test indicates significance, thus it seems that there is also a correspondence between the users' cognitive resource of visual-spatial and executive skills and their performance in task 3.

We also asked the users, after using the game, to self-assess their perception of usability of the Micogito system. To this end, we submitted a questionnaire containing the SUS and two open questions: "what are the Micogito features you liked the most?" and "what are the Micogito features you would improve?".

The average score obtained from the SUS applied to the evaluation of Micogito is 80.2941 (standard deviation of 14.5). The perception of usability of the system was therefore good and close to the ideal values (i.e., 80.3). The elements most appreciated by users were the graphics (5 responses), the simplicity of the structure (4 responses), and the fact that the gamebook had helped them focus (2 responses). Regarding the things that would improve Micogito, many users answered"don't know"/"nothing" (7 responses). The other answers

are about increasing the duration of the game, providing more help and support function for people with cognitive problems and giving more space to tasks that address the memory cognitive domain.

6 Discussion

The questions we aimed to address in creating the web serious game Micogito were whether the gamebook structure was suitable in terms of usability and enjoyment to the target users considered, and whether the created tasks have any correspondence to the cognitive functions most involved in ageing and MCI.

The observation of the users during the process of accessing the platform and the game itself suggests that the proposed structure is sufficiently explicit in terms of its elements' functionality and navigation structure. No correlation was found between the results of the digital competence questionnaire and users' performance in the game: this is an indicative finding suggesting that the structure and level of the game is adequately flexible to the different characteristics of the users. Even the SUS questionnaire provided interesting results: the high value obtained (i.e., 80.29) suggests the ease and pleasantness of the interaction with the platform. Therefore, adherence to the guidelines related to making the platform accessible and usable to the target users was appropriate.

The analysis performed to correlate the scores obtained by users in the various domains of the MoCA and those obtained in the tasks of the game has provided values that indicate the existence of relationships between the levels of cognitive functions measured by the MoCa and game performance for two tasks of the serious game. Task 5, despite being one of the most closely designed for visuo-spatial skills, appears significantly related to the MoCA domain regarding attention. This result can probably be explained by the fact that in this task, the user must activate the attentional system, and especially divided attention, to move from the reading of the street directions in written form to the interpretation of the graphic map provided.

The existing relationship between the scores obtained in the MoCa domain related to visual-spatial and executive skills and task 3 was also explainable. This task (in which the user was asked to check that all the ingredients were in the cupboard) requires the user to estimate the graphic representations of the text that was presented initially, with ingredients. This addresses the skills which allow human beings to act, perceive and operate on mental representations as a function of spatial coordinates and the visual memory of the objects, which are part of what visual-spatial abilities are.

The digital competence questionnaire reveals that the smartphone is the device with which users spend most of their time and with which they are most familiar. This result is not what we expected from the literature reports, where the device most considered was the tablet. In the specific case of the users who participated in this test, many of them did not even own a tablet.

7 Conclusions and Future Work

This study stemmed from consideration and awareness that studies and research on the use of solutions based on innovative interactive applications to address the cognitive decay of the older adult population are necessary and important. In this context, through the design and use of appropriate techniques and procedures, such as cognitive stimulation and training, it is now considered possible to perform tests on the older population to detect the early onset of cognitive decline processes.

To this end, we propose Micogito, a serious game characterized by a structure of storytelling and play typical of gamebooks and implemented as a web application. The implemented application has been subjected to a user test carried out on a sample of older adults. The user test results were encouraging in the acceptance of Micogito by such users: the structure of the gamebook seems to be suitable for their needs of enjoyment and ease of interaction, and their cognitive stimulation.

For the future, we plan to gather further empirical feedback from subjects with different cognitive capabilities. Besides, we plan to further enrich Micogito with new interactive stories that aim to stimulate other cognitive domains.

A possible further technical development of the interactive stories is the introduction of some type of adaptivity in terms of difficulty level of each story to the experience and the level of ability of the user, concerning specific cognitive domains.

REFERENCES

[1] Lawrence J. Whalley, Ian J. Deary, Charlotte L. Appleton, John M. Starr, "Cognitive reserve and the neurobiology of cognitive aging", Ageing Research Reviews, Volume 3, Issue 4, Pages 369-382, 2004

[2] Glisky EL. Changes in Cognitive Function in Human Aging. In: Riddle DR, editor. Brain Aging: Models, Methods, and Mechanisms. Boca Raton (FL): CRC Press/Taylor & Francis; 2007. Chapter 1

[3] Petersen, Ronald C., and Selamawit Negash. "Mild cognitive impairment: an overview." CNS spectrums 13.1 (2008): 45. Author, F., Author, S., Author, T.: Book title. 2nd edn. Publisher, Location (1999).

[4] Vanessa Palumbo, Fabio Paternò, "Serious games to cognitively stimulate older adults: a systematic literature review". s.l. : In Proceedings of the 13th ACM International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '20), 2020.

[5] Monaco, A., Sforza, G., Amoroso, N., Antonacci, M., Bellotti, R., de Tommaso, M., Di Bitonto, P., Di Sciascio, E., Diacono, D., Gentile, E., Montemurno, A., Ruta, M., Ulloa, A., Tangaro, S.The PERSON project: a serious brain-computer interface game for treatment in cognitive impairment. Health and Technology, 9 (2), pp. 123-133, 2019

[6] Mondellini, M., Arlati, S., Pizzagalli, S., Greci, L., Sacco, M., Ferrigno, G. Assessment of the usability of an immersive virtual supermarket for the cognitive rehabilitation of elderly patients: A pilot study on young adults (2018) 2018 IEEE 6th International Conference on Serious Games and Applications for Health, SeGAH 2018, pp. 1-8.

[7] Manera, V., et al., Kitchen and cooking', a serious game for mild cognitive impairment and alzheimer's disease: A pilot studys, Frontiers in Aging Neuroscience, 2015.

[8] Blocker, K. A., Wright, T. J., & Boot, W. R. (2014). Gaming Preferences of Aging Generations. Gerontechnology : international journal on the fundamental aspects of technology to serve the ageing society, 12(3), 174–184.

[9] Ann Chadwick-Dias, Michelle McNulty & Tom Tullis, Web Usability and Age:How Design Changes Can Improve Performance, Proceedings of the 2003 conference on Universal usa-bility (CUU '03), 2002.

[10] Sri Kurniawan and Panayiotis Zaphiris, Research-derived web design guidelines for older people. In Proceedings of the 7th international ACM SIGACCESS conference on Comput-ers and accessibility (Assets '05). Association for Computing Machinery, New York, NY, USA, 129–135, 2005

[11] Andrew Arch, Shadi Abou-Zhara, How Web Accessibility Guidelines Apply to Design for the Ageing Population, World Wide Web Consortium, 2002

[12] Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, Cummings JL, Chertkow H, The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment., J Am Geriatr Soc, 2005.

[13] Brooke, J. "SUS: a "quick and dirty" usability scale". In P. W. Jordan; B. Thomas; B. A. Weerdmeester; A. L. McClelland (eds.). Usability Evaluation in Industry. London: Taylor and Francis, 1986