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Adoption and Use of a Mobile Health Application in Older Adults for Cognitive Stimulation

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Abstract. Serious games could be used to improve cognitive functions in the elderly. We evaluated the adoption of a new tablet application dedicated to cognitive stimulation in the elderly. The Stim'Art application offers various serious games to work different cognitive functions (memory, attention, concentration, etc.). The usage of fifteen older adults was followed for six months. The type of the game, the number of launches for each game, the time spent on each game, the difficulty level, the success rate and perceived well-being of users have been studied and compared at the end of the first and the sixth months. The participants have played half an hour per day on average. The average time of playing per day in the sixth month was significantly higher than the average time of playing during the first month *(p value $<7 * 10^{-4}$)*. The same result was found for the average number of game launches per day *(p value $<7 * 10^{-4}$)*. However, older people seem not to launch more difficult levels in the last month. The success rate at sixth months was significantly higher than the success rate at the end of the first month (*p value $<6.4 * 10^{-4}$*). Generally, seniors have had an improvement in their wellbeing score judged by themselves. Our study showed that the mobile application receives a good admission from users. The results are promising and can pave the way for improving cognitive function in the elderly patients. The use of tablets and the constitution of serious games in close cooperation with health professionals and elderly patients (the end user), are likely to provide satisfactory results to improve healthcare provided for elderly patients suffering from cognitive disorders.

Keywords. mHealth, Adoption, Cognitive Therapy, Mobile Application

Introduction

The number of elderly dependents will quadruple by 2050. The economic impact of the long term care is likely to be very important [1]. No group of chronic diseases burdens the world more than mental illnesses [2]. Cognitive impairment is a major problem both for the elderly and for their family members and caregivers. The prevalence of cognitive impairment is increasing with the aging population and reaches up to 89% among older adults admitted in nursing homes [3–5]. Cognitive impairment has an adverse effect on psychosocial functioning of the elderly, affects the medical treatment and worsens the dementia. Therefore, it is important to pay more attention to the diagnosis and monitoring of cognitive status of residents in nursing homes. Apart from pharmacotherapy, that has a very limited effectiveness; various non-drug approaches

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have been considered in the literature to improve neuropsychological and cognitive impairment symptoms. Music therapy, art therapy, [6,7] and cognitive stimulation due to digital activities and video games are some of these approaches [8–10].

Cognitive stimulation is an intervention for people with dementia which offers a range of enjoyable activities providing general stimulation for thinking, concentration and memory usually in a social setting [11]. This intervention could be done via the use of mobile health applications. Participation in the iPad intervention resulted in enhanced performance on cognitive constructs compared with control groups [12]. The advantage of digital approaches, including the use of tablet computers and mobile applications is the ability to use multiple approaches (art therapy, group activity, etc.). A digital approach allows a dematerialized and distant follow up of each user.

The main aim of this study was to evaluate the adoption of a new application dedicated to cognitive stimulation in the older adults.

1. Methods

1.1. The application

Stim'Art (standing for stimulation through electronic arts) is a mobile application (iOS and Android platform) that offers serious games on memory and brain training. A tracking site service is linked to the application to provide usage tracking per user. The application allows through various exercises to work different functions of the memory, in a playful way: working memory, attention, concentration, visual-spatial memory, etc. These exercises include general knowledge tests, puzzles of famous paintings, chronology of events, serious games on the music recognition and reaction speed exercises. Data entry burden, loss of interest and cost are the causes that make users stop using apps [13]. In the development of this app these factors have been considered.

1.2. Settings

We set up a pilot study to evaluate the adoption of Stim'Art application. This was done by setting 15 tablets for 15 seniors. A face-to-face workshop was run for each user to explain the application and the different games integrated therein. We asked our seniors to take control of their tablets and run the games included in the application whenever they want. We also explained our study and its purposes, asking them not to let others play with their tablet. The use of the application was tracked throughout the study via a computer system supported by the application editor. This system ensures the traceability for the tablet used (and therefore the user's sex and age), the launched serious game, the number of launches for each game, the time spent on the game, the difficulty level, and the success or failure to the played game (quitting the app without completing the game is considered as failure).

To assess the wellbeing of each user and its evolution, we calculated the average wellbeing perceived by each senior. Whenever the user wants to quit the application, it responds to a simple survey of well-being. The scores range from 1 (totally displeased) to 6 (delighted). The options to be selected by the user are totally displeased, dissatisfied, bored, fine, very well and delighted. The average score was calculated at the end of the first and the sixth month of the study. We used the Wilcoxon test for our paired data to compare the distribution of the information found in the two groups at

the end of the first and the sixth month. We also used McNemar test to check changes between two states (M1 and M6), in contingency tables. We finally used the Mann-Whitney test to compare the difference in improving the well-being between male and female users.

2. Results

There were 15 senior users (9 females and 6 males) and they were between 79 and 88 years old. Overall, our 15 users have played the application 78800 minutes for the period of 6 months. On average, each user has played half an hour (29.16 minutes) per day. Table 1 compares the average time spent during the first month and during the sixth month of use according to the difficulty levels.

Table 1. Average time spent per day per person in the first and sixth month of study according to the difficulty levels

Average spent time (min/day/person)	Easy	Intermediate	Difficult	All levels
M1	12.37	7.99	4.7	25.06
M6	12.54	12.4	13.47	38.41

The average time of use (game playing) per day for the sixth month was significantly higher than the average time during the first month ($p < 7 * 10^{-4}$). During the sixth month, the users played and allocated more time to more difficult levels than the easy levels in comparison with the first month. However, this difference was not statistically significant ($p<0.999$). The various games of application were launched 4525 times by all users (1690 times during the first month and 2835 times during the sixth month). Table 2 compares the average number of game launches per day per person according to the difficulty levels.

Table 2. Average number of game launches per day per user in the first and sixth month of the study according to the difficulty levels

Number of game launches/day/person	Easy	Intermediate	Difficult	All levels
M1	2.03	1.1	0.62	3.76
M6	2.18	2.22	1.90	6.30

The average number of game launches per day during the sixth month was significantly higher than the average number of launches during the first month ($p < 7 * 10^{-4}$). This result confirms the previous result on the duration of use and shows that the more time passes, the more users adopt the app's games. We could not conclude that older adults launch more difficult levels in the last month ($p<0.73$). Therefore, launching more difficult levels during the sixth month is due to the overall increase in launching the games. Success rates were calculated for the games launched in the first month and for games launched during the last month of the study. The results are displayed in table 3.

Table 3. The success rate (in percentage) at the end of the first and sixth months of the study according to the difficulty levels

Success rate (%)	Easy	Intermediate	Difficult	All levels
M1	63.36	62.73	56.76	60.95
M6	70.82	71.33	68.88	70.34

The success rate during the sixth months was significantly higher than the rate at the end of the first month ($p < 6.4 * 10^{-4}$). The result is distinctly the same for each level. In our observation, the difference in success rates between M1 and M6 increases based on the difficulty level. This means that older people may learn and would be able to successfully pass the challenges that improve their cognitive functions.

The average perceived well-being scores among the studied older adults are displayed in table 4.

Table 4. The average well-being scores for the first and last month of the study

Senior ID	Sex	Wellbeing score M1	Wellbeing score M6
1	M	4.9	5.3
2	M	4.8	5.4
3	F	4.2	4.1
4	F	5.1	5.4
5	M	3.6	4.2
6	F	4.1	4.3
7	M	4.5	5.1
8	F	3.2	3.9
9	M	4.9	5.3
10	M	5.1	5.1
11	F	5.1	5.4
12	F	4.2	4.6
13	F	4.4	4.7
14	F	3.8	4.6
15	F	4.1	4.7

Apart from one user (number 3), all seniors had improvement in their perceived well-being score (p *value* < 0.001). The average overall improvement was 0.41 (0.43 in men and 0.39 in women). However, there were no significant difference in improving the well-being between male and female users.

3. Discussion

In this study, we have set up a mobile health application that provides memory games adapted for seniors to improve their cognitive functions. When a senior runs the application, the selected game, difficulty level, time spent, success or failure, etc. are recorded by the system. We used these data during six months of using the application in order to assess the adoption of the application in the elderly as well as its effectiveness on the perceived well-being of users. The results were satisfactory and we found that users are never tired of playing with their tablet over time and that the average daily time spent on games increases with time. The number of launched games also drastically increases with time. These results show a good acceptability of the app's games that continues and improves with time. The success rate also improved over time. An improved success rate over time may imply a better game adoption by the elderly as well as an improved memory and cognitive abilities. The specific features of the application that explained the adoption could be the face-to-face workshop for the first use of the app, considering the ease of use and avoiding the adoption barriers in the development.

Our study is in line with other researches that have shown computer-assisted cognitive remediation is a therapeutic approach to enhance cognitive abilities [14,15]. The results of this study and the applications are promising and open new perspectives

for improving cognitive function in the elderly. Further studies with a larger number of users and considering various clinical factors co-related with cognitive stimulation, like clinical diagnosis and medication of each user are suggested to confirm these results. Using a neuropsychological scale to evaluate the effectiveness of these games to improve each cognitive function would be another perspective for future research. Studying the mood of the elderly and their participation in life would be of considerable interest. The participation of health professionals in the conception or development of health related apps is one of the criteria of creating reliable apps [16]. The use of tablets and the constitution of serious games in close cooperation with health professionals and the seniors (the end user), would lead to create tools that are more likely to succeed with good results once they are subject to a rigorous evaluation.

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