The Cognitive Mobile Games for Older Adults - A Chinese User Experience Study

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***Abstract*— Cognitive self-rehabilitation lacks updated means and tools. This paper provides a synopsis of novel cognitive recreation game tools, an analysis of their user feedback, as well as potential new ideas for game developers. The purpose of this study was to evaluate the attitudes and user experiences of Chinese elderly people on mobile memory rehabilitation games originally developed in Finland, Europe. Mobile games that require cognitive skills were tested with a test group in a Chinese elderly care home. User feedback was collected by interviews and observations in the game event. The most noteworthy finding was the positive user experience both of the elderly and the nursing staff and the experience of the games being cognitively stimulating. Games also seemed to provide potential for self-rehabilitation and to support social interaction. Also some special characteristics related to the Chinese culture were found in the game trial. The results are an encouragement for conducting further testing (on a larger test group, over a longer time) and continuing with the game development for cognitively impaired older adults. These results also encourage further development and testing of welfare technology applications in different cultural environments.**

Keywords—Cognitive impairment; cultural differences, mobile game; older adults; recreation; self-managed rehabilitation; serious games

I. INTRODUCTION

The Chinese population has joint the trend of ageing populations due to its decrease of mortality rate and one child family policy. An actual need to generate new innovative methods in care and rehabilitation services for older people has been noticed in several countries, and it is opening a growing market for healthcare products and services also in China [1-4].

Self-management is a way to empower a person to remain active and taking more responsibilities in one's own health condition. Self-management, however, requires knowledge, motivation, as well as easy-to-use and safe means to facilitate performance [5-6]. The most successful new tools seem to consist of two important factors: entertainment (self-motivation) and relevant therapeutic content (rehabilitation) [7-10].

The goal of this paper is to investigate three different mobile games, developed for older adults as potential self-managed rehabilitation tools. In a recent study, it was evidenced that despite of different user needs and expectations, if compared to regular mobile device users, the older adults were interested in and capable of handling their devices and associated applications [11]. This study focuses on collecting and analyzing the residents' and staff members' experiences about the games in a Chinese nursing home. It also evaluates touch-screen tablets as means of gaming interaction. Subjective user experiences were collected by semi-structured interviews of players and direct observations of the staff and researchers.

This paper is organized as follows: This Introduction Chapter is followed by Chapter II, which introduces the used gaming device and the three studied mobile games. The gaming trial is presented in Chapter III, and the results are presented and discussed in Chapter IV. Finally, the conclusions of this study are gathered together in Chapter V.

II. GAME PLATFORMS AND THE REHABILITATION GAMES

Commercial mobile games are typically fast-paced, rich in visualizations and other effects, and targeted for gaming-oriented user groups, familiar with various devices and used to performing complex commands.

When designing the games used in this study, the research group in Finland actively collected feedback from the Finnish target group regarding the overall design and other playability factors. The words simple and plain were repeatedly mentioned. Therefore, the graphics and controls were kept simple, avoiding demanding animations or background effects, which would blur vision or distract from the main

purpose of the games. The games used in this study were generated for touch screen mobile devices. As to the suitability of touch screen technology in serious games, the previous studies indicate that mobile touch screens are found generally easy for the older people to use, and even a small amount of experience generally improves their proficiency [12-14]. Two different tablet devices were used (Android Tablet and iPad) to evaluate the impact of the gaming device on the user experiences.

Game 1 (Cat vs Mouse) combines physical movement and cognitive stimuli. Playing the game requires coordination of hands and brain by means of light physical exercise. This approach is based on studies showing that both physical exercise and game play have positive effects on older adults [9,15,16]. Moderate, regular exercise may be just as helpful in combating serious depression in older people as antidepressant medication [17,18]. It is also known that acute cognitive benefits, such as temporary improvements in concentration, can result from as little as ten minutes of exercise [4,19].

Game 2 (Modified Trail Making Test) is based on part A of the traditional Trail Making Test, which is used for assessing/detecting several types of cognitive impairments [20,21].

Game 3 (Brain Farmer) is a working memory game. To acquire more knowledge about working memory is of central importance since it is involved in a variety of complex cognitive tasks. Therefore, the use of working memory training games can lead to a wide range of significant impacts in a person's life. This is why Brain Farmer game was selected as a part of this game trial. Another reason for selecting Brain Farmer game was the graphically richer appearance compared with the other tested games, which from usability and cultural point of view was interesting [22].

These three games have been originally developed in Finland as means to motivate rehabilitation in different user groups, like people with learning disabilities and older adults [23], and they are now described in more detail as well as tested in a new cultural environment.

A. Game 1: Cat vs Mouse (Android tablet)

The idea of Game 1 is to control a mouse's direction and speed by tilting the device, and to collect as many cheese chunks as possible in a one minute's time. The controlling does not require any push-button actions. The player gets 10 points for each cheese chunk collected. The game ends when the time is up or when the opponent (a cat) catches the mouse. See Fig. 1 for a Game 1 screen.

The game starts with no opponents. The bar in the middle of the screen is an impenetrable obstacle that has to be bypassed. The first opponent, a cat, joins the game after the mouse has collected 50 points (5 chunks of cheese). From that point on the cat keeps on chasing the mouse, which puts a little more difficulty into the game. The next cat joins the game after the player has collected 100 points. At the same time the first cat gets faster and harder to evade. The last opponent joins the game after 150 points, while the two existing opponents again get somewhat faster.

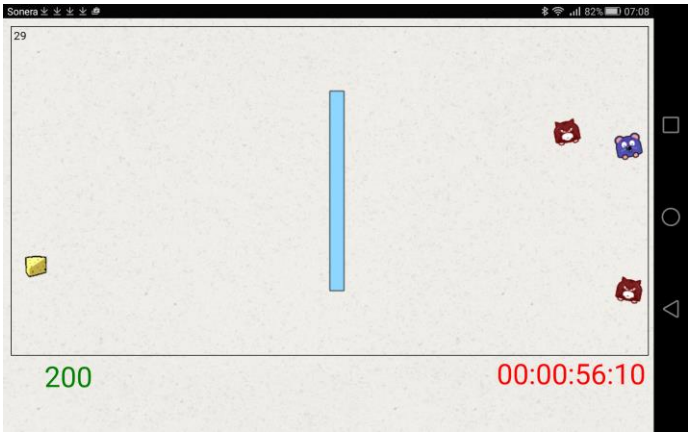

Fig. 1. A screenshot of Game 1: The purple mouse is controlled by titling the tablet and the idea is to collect the cheese chunks and avoid the cats.

The game elements (mouse, chunk of cheese, and cat) were selected to facilitate the perception of the simple game logic. The facts that mice love cheese and that cats love chasing mice has not changed over the years, which makes the game logic easy to grasp for people in any age group.

B. Game 2: Modified Trail Making Test (Android tablet)

Game 2 is an interactive, slightly modified version of the traditional Trail Making Test. A traditional Trail Making Test contains part A and part B. Both parts consist of 25 circles distributed over a sheet of paper. In Part A, the circles are numbered 1 – 25, and the testee should draw lines to connect the numbers in ascending order, or in this interactive version, tap the numbers in ascending order. In Part B of the traditional test, the circles include both numbers (1 – 13) and letters (A – L) but due a different alphabetic system in China, only part A was used in this gaming trial.

In the traditional test, the testee is instructed to connect the circles as quickly as possible, without lifting the pen or pencil from the paper. The time taken by the testee to draw the "trail" is measured. Possible errors are pointed out immediately and the testee is allowed to correct these and continue the test. Errors affect the patient's score only in terms of increased completion time of the task. In traditional use, it is unnecessary to continue the test if the testee has not completed both parts within five minutes. The results are reported as seconds required to complete the task; the higher score (i.e., time required) the greater the impairment [20, 24-27].

In Game 2, the circled digits are randomly spread over the tablet screen and the testee is instructed to tap the circles in the right order as quickly as possible (See Fig. 2). When the correct digit is tapped, it turns more transparent. If the testee makes an error, the incorrect digit circle tapped on turns red (original digits are drawn in blue). To better accommodate the older users, the digits were made relatively large and colored visibly. The indication of incorrect tap was also made as noticeable as possible. The game ends when all circles are tapped in the correct order or after four errors. The difficulty level can be raised in the game menu by increasing the amount of digits on the screen.

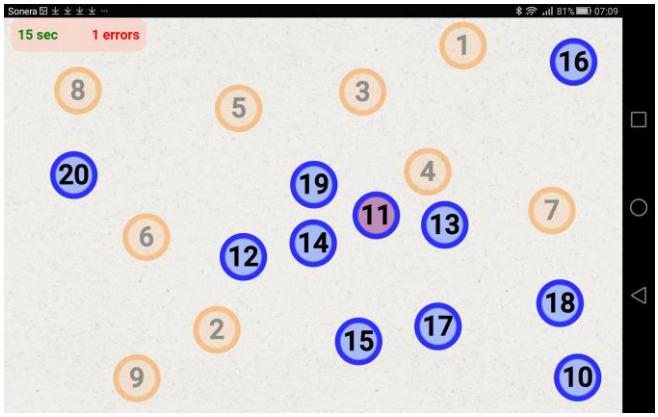

Fig. 2. A screenshot of Game 2: A modified electronic version of Trail Making Test -A.

In transferring this test to a mobile device based application, the designers also omitted the line drawing component of the original test. Although this means the mobile game is not directly comparable to the traditional test, the idea of the interactive game is still quite similar to the original test, in which the person is required to find and also connect the numbers in the right order, which is closely related in terms of the cognitive skills used as well [21,28].

C. Game 3: Brain Farmer (iPad)

Game 3 was designed according to n-back training protocol. The player has to recall the location of a sheep and answer by pressing one of two buttons indicating either "yes", if the place of the animal was the same, or "no", if the place was different than condition determined by n-back. Screenshots of Game 3 are presented in Fig. 3.

Fig. 3. The Brain Farmer mobile game starting screen (left) and game screenshots (right).

In this trial, the player had a one-minute gaming time, due to the limited amount of devices in the trial (it is possible to select also 5-minutes and 7-minutes gaming times). At level one, the player has to remember if the previous (n-1) sheep appeared from the same window as the current sheep. Player earns points by answering correctly and suffers damage on wrong answer. After 30 correct answers, the player proceeds to the second level, in which the current position of the animal is compared with the position that appeared two steps ago (n-2). Due to the predefined time limit, the second level was the most difficult level used in this trial. A farm animal theme was selected to Game 3 as it became evident that most of the target group have had some contact to farm and farm animals, in Finland, where the game was originally designed.

III. CONDUCTING THE STUDY

During the study, the games were played in a semi-controlled environment, in which care staff was present assisting on request and researchers were observing the players.

Participants (N=6) were male (2) and female (4) with an average age of 82 years. All the participants were residents in an elderly home in Changzhou, China. The amount of participants was intentionally kept rather small, since this study was supposed to be a preliminary trial with the selected target group and with the focus on qualitative findings (understanding personal characteristics and Chinese cultural aspects, such as previous experiences, likes and dislikes, lifestyle, manners and norms, history, environment). Participants were volunteers willing to join the trial.

After playing, each participant was interviewed privately in order to obtain as much authentic and subjective information as possible. The interviews consisted of questions related to participants' previous experiences on and use of mobile games and devices, subjective experiences about the trial, and participants' comments on the usability of the devices and games in general. In addition, the researcher's and care staff's observation notes and comments were collected and analyzed to ascertain reflections base on participants' subjective experiences.

IV. RESULTS AND DISCUSSION

A. General findings, Observations

In general, the games received a warm welcome by the participants and the staff involved in this trial, and the overall feedback from the trial was extremely positive. The games concerned were seen interesting, exciting, entertaining, and evidently catching the participants' interest. Some general findings of the researchers from the session are presented next.

The nursing staff was very sceptic first, explaining the elderly in China not being familiar with the devices, and only being interested in traditional board games, such as mahjong. Especially Game 3, Brain Farmer, was experienced difficult by the care personnel. However, immediately after the first resident tried the first game, the personnel turned from sceptic to very excited, interested, and supportive. After the gaming trial, the care personnel even offered to continue data gathering afterwards on their own, if necessary.

The close relationship between the care personnel and the elderly was evident in terms of holding hands, hugging, helping with the games by holding the tablet together, applauding, cheering, and genuinely supporting the residents. The staff was genuinely happy for the residents' success in the games, as were the other players too. The gaming situation was very social with a lot of laughing and loud screams during the session. Some players had to wait to play but they were waiting and not going away from the session, which indicates interest in gaming. As mentioned earlier, the Chinese elderly people play traditional games a lot, and even simultaneously with the mobile game session, there were other gameplays going on.

People with more severe memory impairment were not interested in anything, including the games, but people with moderate or mild impairment were interested and easily learned how to play the games. Most players tried the games several times in a row. One of the nurses commented one of the participants typically giving up on everything easily. When trying the mobile games, the person gave up but started over several times and kept playing by starting and quitting. Also people passing by came to see what's going on and volunteered to try the games. Some of the residents needed a somewhat longer time to observe the situation before gaining the courage to try the games. Generally speaking, the Chinese elderly were easily encouraged to try the games. At the end, the players commented the researchers being good people preparing these kinds of technologies for them.

B. General findings, Interviews

When interviewed, all of the residents informed being familiar with mobile devices; each one had a mobile phone (typically mentioned not being a smart phone) and 4 out of 6 participants also had a tablet or a computer. One of the participants was an active player of online games. However, another underlined never having tried any mobile, computer, or online games. This indicate the test group being somewhat heterogeneous related to technology use, but clearly having experience on mobile devices.

In general, there were few comments on usability issues. The only major challenge was about the touch screen. Two of the participants mentioned touching the screen being new to them and they did not know how hard to tap. Also, it was noticed that the residents pushed the screen too hard (See section C in this chapter, where this challenge is discussed with details). A touch screen pencil will be used in the following trials to ease the use of the tablets.

All except one participant thought the games were fun and they would like to continue playing on their own, if the tablet with the games were available. The participant not enjoying mobile gaming described not being able to concentrate on the games. The person also mentioned Poker with regular playing cards as something the person does often, enjoys more, and feels the memory to benefit more from. The player with most declined physical condition (capability to use only one hand) was very happy with the gaming experience. Also a resident who described being very active with many recreational activities enjoyed the gaming and saw a clear place for this kind of rehabilitating recreational tools. On one hand, it is obvious that the games are not everybody's cup of tea. On the other hand, these mobile games seem to be playable despite some physical limitations and also appear to be welcomed despite other recreational activities available.

All participants saw the games useful for rehabilitation and recreation, although the one disliking the mobile gaming did not feel they would help in this person's case. In general, these game trial findings indicate the participants' high motivation level and sense of usefulness are crucial factors in using mobile games as means in self-initiated rehabilitation.

C. Findings related to the games and devices

Game 1, Cat vs Mouse, was the first game tried by the testees. It was seen also appropriate by the researchers to lower the threshold to try, since the game controlling method by tilting was not typical tablet use. The game logic of Game 1 was immediately understood by the testees. In Game 1, both the players and the audience were expecting the cat to appear, which increased excitement. Some physical limitations restricted the game play, one person with advanced state of Parkinson's disease was not able to play. Another testee was in a wheelchair, and was only able to use one hand, but could play Game 1 several times.

As to the Game 2, modified TMT, some usability issues appeared: if the players were holding the tablet in their hands, the holding thumb was constantly touching the screen, avoiding tapping to be registered by the game. In addition, dry skin in finger tips prevented the tapping to be recognized. This is one down side to the otherwise effective working of capacitive touch screens, based on the change in capacitance caused by an electrically conductive object, such as human touch. A touch pen or touch gloves could be used to increase the touch sensitivity in the future trials targeted to older adults. Another option is to employ resistive touch screens, which do not require the touching object to be electrically conductive. The tapping was first performed too hard (a pen would probably again help, since the elderly are familiar with holding a pen) but quite soon during the gaming the correct way to tap was attained.

Game 3, Brain Farmer, was seen most interesting among the testees having only light memory impairment. Some players tried to tap the sheep in the game instead of "yes" or "no" button, indicating a usability issue for further investigations. Game 3 was sometimes felt to be too long, although the gaming time was limited to one minute. The players advised the game developers to add a "game over" button or to make the game consisting of shorter steps (for example a 30-seconds game, after which the player can choose whether to continue or stop).

The iPad tablet was commented being easy-to-use and light to handle. The Android tablet, on the other hand, was not found as practical. All players seemed to prefer iPad instead of Android tablet due to usability issues, but also due to the fact that the testees' grandchildren had an iPad most commonly).

The most significant difference, when comparing the user experiences of the Finnish and Chinese elderly people, is the game visualization. The Chinese love colorful, even "childish" graphics, voices, and animations. They even suggested visualizing the game progress differently, like showing game scores by collecting flowers instead of numbers. Some modification is definitely needed in the games originally designed for the Finnish older people, in order to better meet the interests of the Chinese elderly. In addition to richer graphics, one concrete example mentioned was a hope of using a goat in Brain Farmer game, instead of a sheep, which is not an animal you see often in China.

D. Limitations

The main limitation in this trial was the relatively small test group, with a limited amount of data, which is why no far-reaching conclusions can be made. However, the results in this study encourage further testing and game development targeted for cognitively challenged older persons. In the original game development process in Finland, Mini Mental State Examination (MMSE) and Clinical Dementia Rating (CDR) scale [29,30] were used to select people with mild and moderate memory impairment in the game development and testing. In this study, the participants' memory condition was only roughly commented by the nursing staff. The participants were not tested with any memory rating scale, since the main goal was rather to study the general attitude of the Chinese test group than analyze the attitude of people with a certain impairment status. However, it is a topic of a future study to analyze the effects of early-started (people with mild or no memory impairment) regular gaming on memory functions. These results can then be compared with the results of people with more advanced state of the memory disease. Despite its limitations, this study provided parallel results to previous studies endorsing gaming as suitable means for self-managed activity combining physical, cognitive, and social elements to enhance people's well-being.

V. CONCLUSIONS

In this study, cognitively stimulating mobile games were investigated as potential means for self-rehabilitation. Both motivation and rehabilitation elements are required for a self-rehabilitation tool. This study concentrated on the acceptance and experienced values of the three different types of mobile games particularly generated for improvement of older people's attention and reaction skills. The test group was a group of 74-87 years of age residents in a Chinese elderly care home in Changzhou. The test group's user experience and usability assessment data was collected by interviewing testees and nursing staff, and by researchers' and nursing staff's observations. In general, the games were well accepted by the participants, as well as the nursing staff, and the participants supported the games as potential rehabilitation and recreation means. However, some modifications for the games designed for the Finnish elderly are needed, in order for them to be more suitable for the Chinese elderly. Therefore, cultural differences require deeper investigation with a larger amount of Chinese participants. Finally, long term trials will also be conducted to analyze the effects of regular game plays on cognitive skills and quality of life.

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