Brain trainer exercise game. Field tests in Finland and Japan

NIINA KATAJAPUU[1], PATRIC GRANHOLM[1], MIE HIRAMATSU[2], ERI ISHIHARA[3], JUNICHI HIRAYAMA[3], PAULA PITKÄKANGAS[1], PEKKA QVIST[1] MIKA LUIMULA[1]

Faculty of Health and Well-being and Faculty of Business, ICT and chemical engineering

[1]Turku University of Applied Sciences

[2] Sendai City Industrial Promotion Organization, Sendai-Finland Wellbeing Center

[3]Sendai Television Incorporated.

Joukahaisenkatu 3, 20520 Turku, FINLAND

niina.katajapuu@turkuamk.fi www.tuas.fi

mika.luimula@turkuamk.fi www.tuas.fi

Abstract: In this paper we are presenting the results of digital memory game use in field test setting in Japan and Finland. The game was developed by Sendai Television Incorporated., Japan. In this study setting a total 92 Japanese and Finnish elderly played digital memory game in individual and group settings. The brain activity during the game play was measured using near infrared spectroscopy (NIRS) for 6 Japanese and 6 Finnish study subjects. The post gaming questionnaire and straight observation was used in individual and group setting for 76 study subjects to examine the usability, enjoyment and difficulty in game play. Positive results was found in NIRS measurements in all study subjects. Correlation in game difficulty and game enjoyment was found in Finnish study subjects but not in Japanese population. The observation showed some cultural differences in digital game use and attitudes towards different digital brain exercise games.

Key words: - Brain, game, memory, elderly, digital, NIRS

1 Introduction

Working memory (WM) is an “umbrella” for cognitive activities varying from attention to complicated decision making. [1] It is challenging to differentiate normal ageing processes of memory from diagnose specific health conditions as mild cognitive impairment (MCI) or disease (MCD) early enough. One definition of normal ageing is successful ageing, which refers to several positive cognitive and functional outcomes of health, but also the psychological well-being [2] Alzheimer disease (AD) or other dementia causes one of the fifth of deaths among people 80 or older in Finland [3] WHO reported the estimation of 35, 6 million people having a dementia in the world. In the same report they stated that the frequency might be double in next 18 years [4] In review article of Kirova et al [5] they refer to fact that 10-20percent of people over 65 years have the diagnosis of mild cognitive disorder (MCD) which of 10 percent leads on AD. In normal ageing people tend to have decrease in working memory (WM) One possibility to regain cognitive functioning in MCD is to practicing demanding cognitive tasks [6]. Before the person is diagnosed for MCD the process has already started. It is possible to detect the symptoms of MCD with neuropsychological tests [7], but at that phase the process leading from normal ageing to MCD which is leading to dementia, has already started. The brain activity can be measured using different methods. Recently the near – infrared spectroscopy (NIRS) has been used in field circumstances as it is easy and portable

measurement tool. NIRS is a non-invasive monitoring method to measure the oxidation in brain tissue. NIRS device consists of one or more near infrared light source which brings the light on to cerebral cortex, and detector(s), which collects the light which hasn't been absorbed in brain tissue. Absorption of near infrared light differs from chromophores like hemoglobin and oxyhemoglobin (HbO_2). At the near infrared area absorption peak is 740nm in Hb and close to 900-950 nm in HbO_2. Based on this it is possible to measure the HbO_2 level in brain tissue using NIRS device. [8, 9] In this paper, we will report our memory game field experiments conducted in Finland and Japan. In these experiments, our objectives has been to study user acceptance and usability of developed memory games. From technical side user acceptance can be studied using so called technology acceptance model [10] This model focus on perceived usefulness, perceived ease of use, attitude toward using and behavioral intention to use. In our experiments we were more interested in human behavior. One of the most frequently used research methods in human computer interaction are Nielsen's heuristics and Nielsen usability criteria. Nielsen's heuristics are developed especially for user interface design [11] Nielsen usability criteria namely satisfaction, learnability, efficiency, and error rate are used in turn in empirical usability evaluations for example in field experiments [12] Gamified Solutions in Healthcare is an international project, funded by Finnish Innovation Fund (Tekes) that develops innovative gamified solutions for elderly. The project aims at researching, developing and testing new concepts to activate elderly people both physically and mentally, in order to enable them to stay healthy and live at home longer. The solutions created in the project are also for nursing home and professional use, to cost-effectively offer alternatives for activating groups. The international cooperation in the project includes 28 months of researcher exchanges, mutual game developing and several field tests in Finland, Japan and Singapore.

2 Problem Formulation

The aim of this study was to verify the level (+ or -) of brain activity during the "Brain Trainer Exercise game playing, and evaluate the acceptability, usability of "Brain Trainer Exercise Game" developed by Sendai Television and to observe the human behavior during the game play. The verification was conducted in Finnish and Japanese elderly population. The Brain Trainer Exercise game is a game, which has developed to enhance the cognitive skills in elderly population. It consists of 13 different mini games on game platform and one calculation task with pen and paper.

Fig.1

The player can choose the game based on his own interest in random order. Each game has several difficulty levels. Difficulty is based on for example decreasing time to complete the game or increasing amount of upcoming objects or issues to remember. The game demands more perception cognitive skills or demands more speed to give accurate answers. Different mini games demanded different cognitive skills and memory. Some of the games were based on the simple calculations, some of them were based on remembering different colors and shapes and in some of them the player has to follow the moving objects and afterwards remember different tasks. Game is played with touch panel screen.

3 Problem solution

The field tests were conducted in Turku University of Applied sciences (Finland) in December 2015 and Sendai City Industrial Promotion Organization (Sendai-Finland Wellbeing Center, Business Innovation International Unit) (Japan) in February 2016

There was three different settings in this study. First one used near infra-red spectroscopy (NIRS) to test brain activity of the study subjects during the game playing. In second test setting study subjects were playing the game in 3 groups of 4-5 people and in third setting the game was played individually. In setting two and three the usability and acceptability

of the game was measured using questionnaires developed by Sendai Television Broadcasting Company and the questionnaires were localized for Finland for Finnish study subjects. The straight observation was used in all three study settings.

The volunteered study subjects were recruited from Turku city elderly service center Ruusukortteli by public announcements and Sendai City Health Welfare Organization (Sendai City Health Promotion Center) (Japan) in Japan. There was 12 people in NIRS test (6 in Finland, 6 in Japan), 32 study subjects in group test (16 in Finland, 16 in Japan) and 48 subjects in individual test (24 in Finland and 24 in Japan) Total amount of study subjects in this study was 92. (Table 1) In all settings the subjects were asked to sign the written consent to adhere to study and to give approval for photo shooting during the test. The gender and age was also confirmed.

In NIRS test the subjects were given explanation about test procedure and instructions for game playing. The neuroscientist set the head gear on subject's forehead (Fig. 2 and Fig. 3)

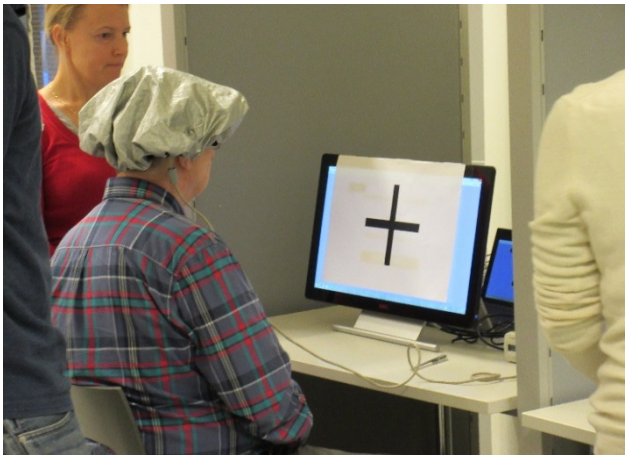

Fig. 2

Fig. 3

The study assistant explained to the subjects how games were working. After the explanation, the screen was covered with blank paper with + icon on it. The subject was looking at the icon for 20 seconds to flatten the brain activity after the previous question. After that the subject was playing the given game for 30 seconds. After 30 seconds game was interrupted by study assistant and white cover with + icon was set on the screen and subject was asked to look at it next 20 seconds. This was repeated for 13 different games in different order for each study subjects. Along the games, each participant did one calculation task with pen and paper.

In the group game setting, each group of 4-5 study subjects were invited to the research room at the same time. Before playing the game subjects answered a pre-game questionnaire. Each question was read out loud by a study assistant in subject's native language. After filling up the questionnaire the subjects moved to sit around a table in half circle setting with one 23 inch touch screen in the middle of the table. The study assistant explained how the touch screen was operated and gave general instructions of the game functions. The study subjects were asked to start to play the games in the order and difficulty level of their own choice. The playing time was limited up to 25 minutes for each group. After the playing time the group moved back to another table to answer the post-game questionnaire. The procedure was similar to the pre-test questionnaire.

In the individual setting the study subjects attended the research room in pairs, but were playing individually the games with tablets. Each pair had two study assistants to give general instructions of

the games and operation of the tablets. The pre and post questionnaires were filled up in a different room to where the game playing took place. The game playing time was also limited up to 25 minutes.

Exactly the same protocol was followed both in Finland and in Japan

Statistics: The Spearman's rho was used to see the correlation coefficient between the game difficulty and game enjoyment in Finnish and Japanese population separately. The Student T-test was use to see the differences between the Finnish and Japanese population in game difficulty and emotions which the subjects had after playing the games overall. The data of the near infrared stimulation is descriptive.

Direct observation was done by research assistants during the individual and group game settings. Observers followed the group or individual and wrote down their open notes of the subjects reactions during the game play.

The results and conclusions are mostly based on those games the study subjects played most. Those games are game number 4, 5 and 10. In game four (Fig 4) the subject was supposed to follow the moving cups and the moving ball. After certain period they had to know, in which cup the ball was in.

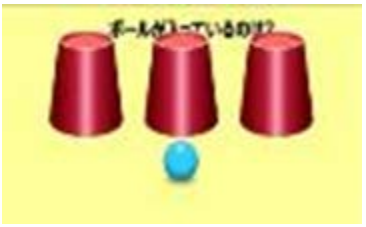

Fig.4

In game number 5 the player had to choose the number which value was higher (Fig.5)

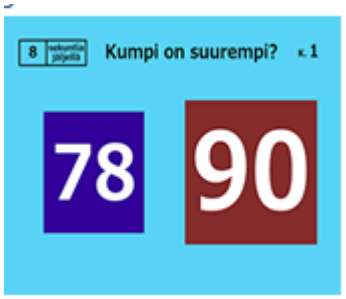

Fig. 5

In game number 10 (Fig.6) the player had to choose from above the color, which was the color the word had been written with

Fig. 6

4 Conclusions

The baseline characteristics are presented in table 1. There was no significant difference between the study population in Finland and Japan in age and games played per person. In table 2 the Spearman's rho correlation coefficients for game difficulty and game enjoyment in both countries separately are presented. In game 10 "What is the color of the word" the correlation of game difficulty and the enjoyment of the game was strong within Finnish subjects but there was no correlation within Japanese study subjects. Finnish study subject gave slightly lower scores in average in this came compared on Japanese study subjects (4,4 Finnish, 4,8 Japanese) so the Finnish liked it slightly more. For the difficulty of this game the average was differing between the Finland and Japan. (Finnish 5,4 and Japan 4,3) Higher the subject scored the game less he liked it and higher the subject scored the difficulty the easier he experienced the game. The range was 1-12. In general, study subjects in both countries found this game enjoyable and difficult.

The correlation between the difficulty and enjoyment of the game was weak in game 4 called "Where's the ball?" and moderate in game 5 "Which on is bigger?" in both countries.

The two sample t-test showed that there was no statistically significant difference between Finland and Japan in post-game questions which concerned the difficulty of the games in general (p=0, 23). Questions which concerned good experiences or feelings for playing the games the groups differed. The Finnish participants had slightly more positive experiences (p<0, 03) and feelings (p<0, 01) than Japanese. Both Finnish and Japanese subjects answers were below the median and Finnish study subjects felt little better concerning the positive experience of playing the games (mean 1,82 in Finnish population and 1,23 in Japanese population, range 1-5)

The NIRS measurement showed positive results within all 12 study subjects in brain activity based on blood circulation on frontal cortex.

Table 1. Baseline data

Finland		Male	Female
Age (average)	70	*	*
NIRS (n)	6	*	*
Individual (n)	24	*	*
Grouptest (n)	16	*	*
Total (N)	46	*	*
Japan			
Age (average)	69	*	*
NIRS (n)	6	3	3
Individual (n)	24	10	14
Group test (n)	16	6	8
Total (N)	46	19	25
Finland and Japan	92	*	*

* missing information

Table 2. Correlations between game difficulty and enjoyment

Game 4					
Japan	*Enjoy*	*Diffic*	***Fin***	*Enjoy*	*Diffic*
Enjoy	1			1	
Diffic	**0,25**	1		**0,38**	1
Game 5					
Japan			***Fin***		
Enjoy	1			1	
Diffic	**0,47**	1		**0,6**	1
Game 10					
Japan			***Fin***		
Enjoy	1			1	
Diffic	**0,18**	1		**0,77**	1

4.1 Discussion

This study showed that elderly people had good brain activity measured with NIRS, in both countries. It seems that these kind of brain games can activate positively healthy non-diagnosed brains, which might be one solution to protect the elderly people from cognitive problems, or at least slow down the ageing processes related to working memory. Elderly were also able to use the digital memory game solutions in both countries. Both subjects asked for little advice at the beginning from the research staff for using the tablet and following the rules. For Finnish players in the group setting the touch panel screen seemed to be more challenging than for Japanese. The Japanese subjects asked for more help than Finnish after they had had the pre instructions for the procedure, but the Japanese observer thought that the subjects were used to get service and asked for help even they probably didn't need that. As the Japan has longer history in game industry and gamification than Finland, we expected to see more differences between the results but that was not the case in quantitative data. We were concentrated on those games, which the study subjects chose most out of the 13 option. The game where subject has to tap the color in which the word is written, seemed to be the most difficult, but also the most enjoyed game in Finnish population. There is some cultural differences between the subjects. The observation showed that the Japanese subjects didn't want to choose the game the considered to be too difficult, because they didn't want to lose in front of other people. Finnish subjects tend to play the different games in order so that they didn't talk that much beforehand if they considered the game to be

difficult or not. Some of the players said after first level of the game that “this is not a fun game” and skipped the more difficult levels and continued on next one in the order. One of the games was “Rock, Scissors, Paper –game, where the player was supposed to lose to the game. That means a person has to quickly turn the situation opposite in his mind before giving a right answer. The difference between the Japanese and Finnish subjects showed that the game was familiar for Japanese, but they didn’t want to play it because they didn’t want to “lose” in the game. Many subjects from Finland didn’t know that game, but were still eager to try it. As mentioned above, this study has been a part of relatively large research project called Gamified Solutions in Healthcare funded by Tekes. Together with our Japanese partners we have conducted several field experiments in Finland and Japan. Main part of the studies have been focusing on physical exercise. This research focus on cognitive rehabilitation is significant field of science especially in aging societies such as Finland and Japan. We have applied various research methods in our studies from Kansei Engineering [13] to System Usability Scale [14] In this study, our main focus was on brain activity measurements. In the future, we will focus on cognitive rehabilitation combined with exergaming. This combination will cause many type of research questions from human computer interaction (HCI) to effectiveness. From HCI research perspectives one of the most potential future direction will be usability evaluations utilizing Tobii The Glasses 2 Premium.

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