ORIGINAL ARTICLE

Design Requirements for a Cognitive Training Game for Elderly or Challenged People

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Abstract: An electronic-mechanical game was developed for elderly and disabled people so that they could have an enjoyable way to train their cognitive functions. Because our players were not familiar with electronic games, we proposed constraints and requirements to the game so that they were able to play the game and were willing to play repeatedly. Here, we describe our proposed game, “*Ikiiki-pom*,” which was tested on a group of approximately 80 elderly people with energetic bodies, and about 10 people who were physically challenged at facilities, and about 15 young students with developmental disabilities.

Keywords: *Traning game, elderly people, disabled people, quality of life, motivation, fieldwork*

1. INTRODUCTION

The older population is increasing rapidly in Japan, and a decline in cognitive ability with aging makes older people less independent. Thus, it is important for those who do not require nursing care to maintain independent daily living abilities. The goal of our study was to develop skills for cognitive training so that the elderly can prevent or delay a decline in cognitive function.

We proposed a training game for elderly players to maintain their cognitive abilities. Game-type training has several advantages; the trainee enjoys performing the task, the game offers some types of training that a manual training program cannot, and automatic feedback of the results or scores allows trainees to gauge their performance.

Some physical therapists, game makers, and researchers have attempted to use game machines, mainly for physical rehabilitation. A kind of whack-a-mole arcade game machine, such as the Namco Waniwani Panic, has been used to facilitate physical rehabilitation in elderly people in hospitals or care facilities [1, 2]. Those studies found that users developed improved reaction times for arm movements, e.g., catching a falling stick and reaching with their arms. However, arcade game machines are immovable and expensive. The Nintendo DS “brain-training” games are well known for training cognitive function, but the game machine is too small for older people because the user is required to move only their

fingers. Additionally, the games are usually for a single player, so the user cannot share gaming time.

In contrast, virtual reality (VR) technologies allowed for the development of games for the elderly in the late 1990s and early 2000s [3]. Some manufacturers and universities developed large-scale equipment for the elderly to provide them with unusual experiences by applying VR technology. It was expected that the immersive and pleasant experience would encourage participants to activate their physical and cognitive functions more than they normally would in their daily lives. However, little of this equipment is currently in production. Furthermore, the equipment was expensive and too large and complex for non-experts to set up and install.

In this study, we developed a game machine that elderly and disabled people could take pleasure in and play repeatedly. We considered two requirements for such a game:

1) *The game should be adapted for elderly or disabled players:* Because elderly and disabled individuals have different levels of cognitive functioning compared with younger and unimpaired people, a game must be developed that elderly and disabled individuals will want to play repeatedly. At the same time, we should be careful to respect player dignity.

2) *Non-experts can easily set up the game:* Elderly or disabled people rarely play games alone; thus, the game machine should be inexpensive enough to be purchased by a group of elderly people or a care facility and easy enough for the staff to set up and maintain.

2. DEVELOPMENT OF THE COGNITIVE TRAINING GAME “IKIKI-POM”

The cognitive functions we attempted to enhance are those that decline with aging, such as the breadth of visual field, reaction speed, short-term memory, focus and shift of visual attention, and control of hand movement. We programmed several kinds of whack-a-mole-type games; the tasks basically required pressing a button for a light as quickly as possible. Higher-level games required more complex reactions.

To realize our project, we developed a game for older players designed to maintain their cognitive abilities [4, 5]. We considered that stimulating their cognitive function with humor would lead to improvements in the quality of their lives. We studied the characteristics of elderly people and disabled people, including young people with disabilities, who were not familiar with playing computer games intended for young unimpaired people.

We considered two important characteristics when producing our game. One was that many elderly and disabled people should be willing to play the game and want to play it again. We proposed an electronic-mechanical whack-a-mole-type game in which players move their bodies according to easy rules. The game was named “*Ikiiki-pom*” for the name of the group of our elderly participants. This game is intended to incorporate tests of reaction time, short-term memory, shifts in visual attention, and action control. The first and second levels of the game require the player to press a button as quickly as possible when a light turns on. The third and fourth levels of the game require the player to press the button when the second or third light turns on.

The other characteristics we sought were that the game machine be inexpensive, portable, and durable. Our *Ikiiki-pom* cost around 50 thousand yen (around 640 US dollars) to produce, and it occupies a 40 × 40-cm space on a tabletop. The control buttons are mounted in a box that is located away from the players so the staff can facilitate the game while the participants are playing. When the game is over, the control box can be replaced in the game case.

The main part of a model of the game machine is shown in Figure 1. The lights show the game tasks, and the push-button switches are used to respond. The game is controlled by an AVR microcontroller. The game level (complexity) and speed are adjustable by hand switches, and the currently chosen level and scores are displayed. Sound volume is also adjustable.

We have improved our game through trials with more than 50 healthy elderly people, five physically disabled people who visited the facility, and 24 developmentally disabled young people.

Figure 1: A model of our game machine “*Ikiiki-pom*.”

3. GAME DESIGN REQUIREMENT

3.1 Play constraints

Unlike young healthy people who are the target players of common electronic games, many elderly or disabled people have poor vision and reduced motor control in their hands. Therefore, it was necessary that the game hardware compensate for these limitations.

1) *Visual requirements:* Because the visual field of many elderly people is narrower than that of younger people, the lights must be visible. Thus, we used light-emitting diodes with silicone caps to diffuse the light.

2) *Motor requirements:* Because motor control tends to become less precise with age, we used push-button switches that were sensitive enough for light tapping, durable enough for strong hits, and large enough for slight misses. The push buttons were arranged far apart to prevent mistaken hits.

3.2 Requirements to ensure that players will want to try the game

1) *Fun for the players:* What is fun for elderly people is slightly different from what is fun for younger people. We asked 50 active people 60 years or older how they spent their time with friends and received 22 answers. Many of the elderly women liked to gather with several good friends. Most of the elderly men enjoyed competing with one another or themselves. Therefore, the game must be able to be watched by others who were not playing and it must show scores for competition.

2) *Attractive decoration:* It was desirable for the game machine to play sounds and show animations, messages, and face signs to attract potential players.

3.3 Requirements for players believe that they could succeed

It was important that the game be at a level that lets participants believe that they could complete the game. This is particularly important for disabled people or those with poorer abilities. If players found that they could not succeed at such an easy game, the loss of self-confidence might affect their daily lives. Therefore, we considered that the game should offer a mode or a level that any player could complete without failure. Our game has a very easy task level and a mode with no reaction-time limit.

Additionally, it was important that the game offers a silent mode so that the people around the player would not know if the player made a mistake. Thus, the sound and visual displays of our game can be turned off. Players can play the game without fearing scrutiny. This is also important for young players with disabilities who are used to being scolded because of their failures in daily lives.

3.4 Requirements to encourage players to want to try again

Generally, players like to challenge their abilities. The game must offer a slightly more difficult level than that suited for the current state of the player. It is necessary that the people around the player, such as facility staff, praise players when they are successful; this is particularly important for young players with disabilities.

4. RESULTS

4.1 Older participants in good health

1) *Cooperators*: Approximately 50 people gathered in a community hall for recreation once per month. They were older than 60 years and came to the site without assistance. A research group visited the gatherings and offered our game eight times between October 2009 and December 2010.

2) *Participants*: From nine to 27 people voluntarily tried the game at each visit. In total, 52 people played the game over the eight visits.

3) *Methods*: A researcher gave each player the instructions by referring to a manual with large pictures, recorded the results of each player, and handed them a score sheet when they finished the game. Feedback was provided on the score sheet, and a small gift was handed to each player when he or she finished the game.

4) *Results*: Most of the players were satisfied with the game. A photograph is shown in Figure 2. In total, 127 player-times occurred. There were 26 women players, and half of the participants played more than twice (Figure 3). Two played the game at every visit. Many healthy elderly people played the game repeatedly.

Figure 2: Elderly people playing our game “Ikiiki-Pom”. Researchers facilitated playing by the elderly players playing.

Figure 3: Frequency of game playing among the elderly healthy people over our eight visits. Half of the players willingly repeated the game more than twice.

The achievement rates of the 46 players the first time they played at each level over five trials are plotted in Figure 4. Players 64 years of age or younger completed the trials. Achievement declined with increasing player age. Achievement was lower in the faster mode within a level for most age groups. The results showed that our level settings were well associated with player age.

Figure 4: Completion rate of for each level of the game by old healthy people at their first play.

4.2 Young participants with developmental disabilities

1) *Cooperators*: About 15 people who were students of elementary, junior high, and high schools came to the facility after their classes and during their school days off. The research group visited the facility and offered them our game five times from March 24 to May 16, 2011.

2) *Participants*: From two to four people played the game at each visit. Fourteen people played the game over the five visits.

3) *Methods*: The reaction module for the lights and buttons was presented separately to each player using a long cable so that the player could concentrate on the game. A researcher gave instructions to each player and controlled the game (Figure 5). The frequency of the game play was left to each player; therefore, some players repeated the game many times, and others quit after one or two trials. A sheet of a popular anime characters was handed to each as a prize when the player finished the game.

4) *Results*: Seven players (half of the participants) played the game more than five times as shown in Figure 6.

Figure 5: A boy with a developmental disability playing our game "Ikiiki-pom".

The interaction part of the game machine was placed near the player using an extended cable so that the player could easily focus. The researcher (left) facilitated the game, and the staff watched the player for the first time.

Figure 6: Frequency of playing the game among the young developmentally disabled people over five visits. Half of the players willingly played the game again and again, whereas the rest showed little interest.

The researchers found that they enjoyed the game. The other seven players quit the game after one or two trials because they were not so interested in the game. Most participants and facility staff were welcoming and looked forward to our next visit with the game.

5. THE EFFECT OF OUR GAME ON THE PLAYERS AND THE FACILITY STAFF

5.1 Care staff at the facility for physically disabled individuals

In the beginning, almost one year ago, many people felt our game was too difficult for them because rapid responses were required. However, some players have been challenged recently by the quickest speed. A snapshot of a player is shown in Figure 7.

The facility staff for physically disabled persons reported the following positive stories. One case was a middle-aged man who had lost trunk function and moved in a wheelchair. He had been difficult to please, though he smiled when he played the game. He played slowly at first, and then he tried the quicker mode at all complexity levels. He then began to take walks during rehabilitation sessions. A second case was a middle-aged woman with hemiplegia who was afraid of failure. She used to play our game only in the slow mode. Then recently, she unexpectedly asked the staff to set the game to a quicker mode. The third case was a middle-aged man with hemiplegia who became to challenge himself to the quicker mode of the game. At the quickest mode, he instinctively used his hemiplegic hand to finish the game.

One staff member commented that because the results for each player were not visible enough for older participants with poor vision, they read the scores aloud for those players each time. She suggested that such players would be more motivated and become more active if the game results were displayed more prominently so that the players could see their results for themselves.

Figure 7: Physically challenged person (left) playing our game.

5.2 Staff at the facility for developmental disabled persons

The staff reported a case of a female high school student who used to spend time alone, carrying her favorite things with her. When we visited the facility to offer the game, she came to welcome us at the door. Afterward, she began to engage more often in contact with the facility staff. We found that it was difficult for some people to look downward; raising the game buttons to their best gaze height would make it easier to play the game. Successful experiences are necessary for people with such a handicap, so a game level was needed that could be easily achieved. It was also hard for most people to wait until the game started; so some kind of “start” sign that participants and facility staff could see was necessary.

5.3 Old people with energetic bodies

Most of players knew the game tasks well. They began to play at moderate speed, but many of them wished to play in the quicker mode for the second trial irrespective of their results.

We observed one elderly woman with minor dementia. She had been increasingly irritable, but after she played our game for 3 days, she recovered her composure. Her condition continues to fluctuating, but she voluntarily played the game when it was offered, provided she was in a good frame of mind at the time. Her results with the game were consistent with her condition.

6. CONCLUSIONS

We studied game requirements for elderly people and people with disabilities by developing a whack-a-mole-type electro-mechanical game, “*Ikiiki-pom*.” The requirements for the players are summarized as follows:

- 1) *Supplements for perceptual and motor functions of the player*: The game machine should be able to supplement for the player’s physical limitations. The degree of supplementation should be adjustable.
- 2) *Difficulty levels of the game tasks*: The game should offer a level that anyone can achieve without failure and a level that is so difficult that only young unimpaired people will achieve good results with ease. Several levels of intermediate difficulty are also necessary.
- 3) *Results feedback*: The game machine should show the results or scores so that the player can compete with him or herself or with others. The display should be able to be turned on and off so that the players can share the game with others or learn their results alone.
- 4) *Easily handled*: The game machine should be able to be set up, operated, and put away by a non-expert such as facility care staff.

Figure 8: A new model of “*Ikiiki-pom*” with a larger display and portable case.

A new model of *Ikiiki-pom* was produced to achieve larger display and more portability as shown in Figure 8. We will continuously let users play our game and collect data to analyze the improvement in their cognitive functions and the quality of their lives.

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REFERENCES

1. Reiki HAGIWARA, Tatsuro KUBO, and Shintaro KAWASAKI, “Effects of continuous and repetitive exercise on physical functions of later elderly people (*Kouki koureisha ni okeru keizoku-teki hannpuku undou ga shintai kinou ni oyobosu eikyou*)”, *Saitama Rigaku Ryouhou*, 11, (1), 38-1 (2004) (in Japanese).
2. Tetsuro NEJIME, Shin-ichiro TAKASUGI, Yukihide IWAMOTO, Shuji OKADA, Reiko NEGISHI and Masashi SUZUKI, “Effects of the introduction of rehabilitation machines, second report: Results of physical fitness measurement in day-care settings (*Rihabiri-teinment mashin no dounyuu kouka, dai 2 hou – Dei-sabisu de no tairyoku sokutei kekka yori*)”, *The 38th Japanese OT Congress and Expo*, 23, p.412 (2004) (in Japanese).
3. Mieko OHSUGA, “VR systems for the physical and

mental stimulation of elderly people (*Kourei-sha no shin-shin kasseika wo mezashita VR*)", Journal of the Virtual Reality Society of Japan, 6, (2), pp.81-86 (2003) (in Japanese).

4. Keiko ISHIHARA, Kenta OGOMORI, Mitsuo NAGAMACHI, and Shigekazu ISHIHARA, "An electromechanical whack-a-mole-type game for older people", Gerontechnology, 9, (2) 294 (2010).
5. Kenta OGOMORI, Keiko ISHIHARA, Mitsuo NAGAMACHI, and Shigekazu ISHIHARA, "Development of an electromechanical game for older people", The Japanese Journal of Ergonomics, 46, (Supplement), pp.254-255 (2010) (in Japanese).

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