

A PROPOSAL OF A USABILITY SCALE SYSTEM FOR REHABILITATION GAMES BASED ON THE COGNITIVE THERAPEUTIC EXERCISE

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ABSTRACT. *Aid is necessary for many elderly people with diseases, like dementia or apoplexia cerebri and this need for support is increasing rapidly in aging societies. This support is increasing rapidly with the society. On the other hand, there are many discussions about the preventive care. Preventive care of elderly people is reported to be significant in both mentally and physically supporting. In particular, those supporting is actively studying the use of games and IoT system for preventive care at home. Until now, those supporting tasks are put into hospitals/clinics and rehabilitation facilities have been the main places. About actual rehabilitation of elderly people, this continual rehabilitation is a kind of functional recovery and care as indispensable. However, this style of rehabilitation is very hard work every day. In this case, long time care is a significant and hard job. Also, preventive care and home system have the potential to help with rehabilitation. The feeling and motivation of patients affect this potential with rehabilitation. Therefore, we are proposing the personal system which has the multi-function for any type rehabilitation as the preventive care. A proposal system of our laboratory has a concept from a suitable size touch panel to a rehabilitation exercise. The touch panel system has an effect on haptic feedback. This feedback is able to support the preventive care. The preventive care by the proposed Cognitive Therapeutic Exercise (CTE) would be necessary for the aging society and the preventive care problem. This paper proposes an alternative measurement system on a usability scale for rehabilitation games based on CTE. This idea supports the current preventive medicine and current rehabilitation theory. For preventive medicine, those ideas are affected. A game with touch feedback is one of these ideas. For keeping the rehabilitation jobs, the game system should be fun and enjoyable. This paper discusses the new usability evaluation system as the rehabilitation interface theory. Two touch panel systems are tested using a Whac-A-Mole game. For effect of the user-friendly and enjoyable games, play continuously without getting bored, it is necessary to evaluate according to usability. About setting the difficulty level, it was confirmed of a new system evaluation method with defined 5-evaluation factors effects.*

Keywords: Cognitive therapeutic exercise, Usability scale, Touch panel interface, Preventive care, Rehabilitation

1. **Introduction.** Aid is necessary for many elderly people with diseases, like dementia or apoplexia cerebri and this need for support is increasing rapidly in aging societies. This support is increasing rapidly with the society. On the other hand, there are many discussions about the preventive care. Preventive care of elderly people is reported to be significant in both mentally and physically supporting. In particular, those supporting is actively studying the use of games and IoT system for preventive care at home [1, 2, 3]. Until now, those supporting tasks are put into hospitals/clinics and rehabilitation facilities

have been the main places. About actual rehabilitation of elderly people, this continual rehabilitation is a kind of functional recovery and care as indispensable. However, this style of rehabilitation is very hard work every day. In this case, a long time care is a significant and hard task, as reported by Forster et al. [4], also preventive care and a home system are possible to help the rehabilitation works. The possibility of continuous rehabilitation depends on the feeling of patients. In Figure 1, the left side picture shows the typical rehabilitation. The parallel bar's exercise and the paperwork are famous rehabilitation task. The parallel bar exercise is tedious and tough. This training is an effective work but not always enjoyable. The paper working, as in the right side of Figure 1, can be enjoyable but this task is not very effective for functional recovery in most cases. Additionally, elderly patients must visit a hospital for a medical check and for rehabilitation exercises. In this case, elderly patients may feel constraint (or feel guilty). Currently, a rehabilitation process has only one recovery target. There are examples of a recovery target, like a motor function, or a cognitive function. Supporting both functions at the same time is so difficult because the exercise time is very tight in most cases.

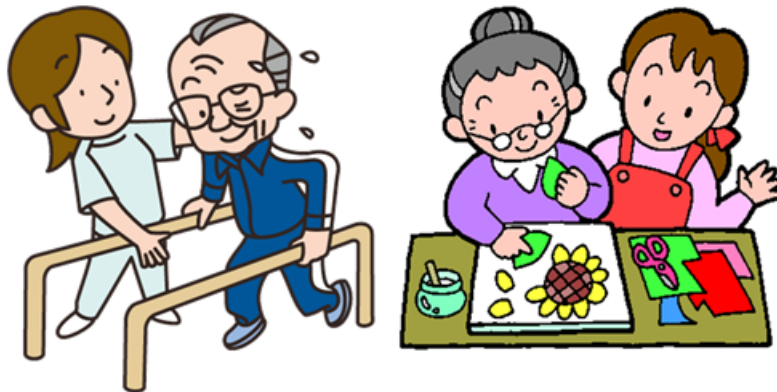


FIGURE 1. Training rehabilitation

In order to improve the problems such as pain and tough exercise, a new tool is necessary that combines highly effective rehabilitation and an enjoyable game. They should exist for preventive care and home rehabilitation. In addition, a process of the cognitive exercise therapy is possible to perform the exercise therapy and cognition [5, 6, 7]. The possibility of recovery depends on the strong motivation for functional recovery in a rehabilitation exercise. In order to succeed, patients must continue the movements of the given exercise. This movement should be spontaneous work with the appropriate therapist's instructions. A spontaneous approach is the main point of rehabilitation training. A spontaneous movement is a powerful approach to the patient in the real rehabilitation tasks because there is the patient supporting the volitional movement. This patient support can make patients reassuring exercise. On the other hand, a touch panel interface is popular with tablet PCs within Internet communications as IoT. The multi-touch fingers make haptic feedback for the movement exercise. Lum et al. proposed the robot-assisted system for the rehabilitation of a motor function [8]. In this research, a participant controls a robot arm and controls a set of training tasks. The robot system control resistance forces to give feedback that involves a haptic feeling. In this research, the special research facilities have been built for this robot system. For home preventive care and rehabilitation tasks, a touch panel system is easier to develop than a robotic system. This touching makes a reality of a feeling haptic feedback [9] to the brain by checking finger positions and touch feelings. The multi-touch operation is similar to human intuition and this operation

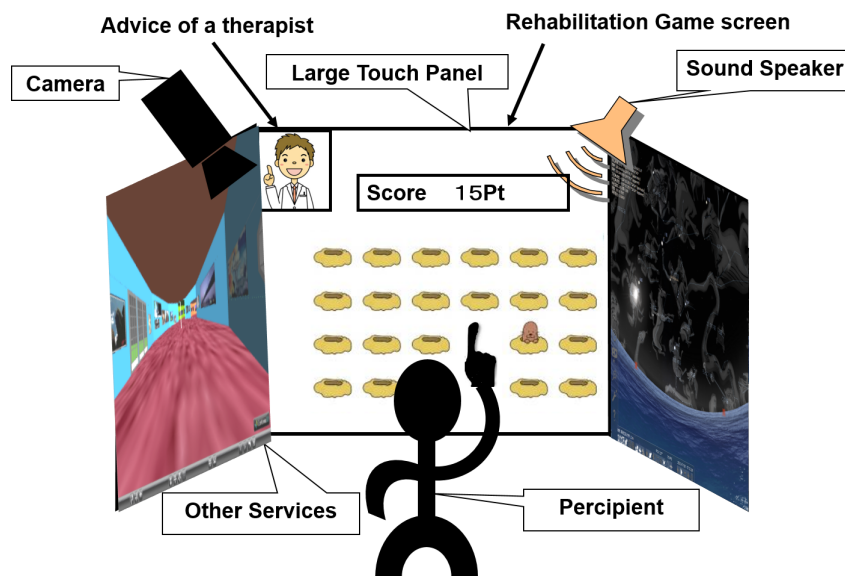


FIGURE 2. Overview of the proposal system

training plays a significant role in exercise therapy and cognitive processes. This interface is also easily adaptable as an input device even if the movement ability of patient decreases. This proposal space has the multi-function for any type of rehabilitation. This paper proposes a touch panel space as the computing environment, as outlined in Figure 2. This proposal space has the multi-function of interaction for any type of rehabilitation.

Ideas of the proposal system would support current preventive medicine measures and the current rehabilitation theory. For preventive medicine, touch panel's ideas are effective by the haptic feedback theory. A game with touch feedback is one such preventive medicine measure. To maintain this, the game system must be fun and enjoyable. In this paper, we describe a new usability evaluation system as a rehabilitation interface theory. Because of the user-friendly and enjoyable game effect, in order to play continuously without getting tired, it is necessary to evaluate its usability. The next section discusses Cognitive Therapeutic Exercise (CTE) and the effects of using games with CTE theory.

This paper consists of 5 chapters including this Chapter 1 overview. In Chapter 2, the necessity and definition of current rehabilitation methods are introduced. The importance of cognitive exercise therapy is introduced from a preventive care viewpoint. Then, the entire game system that makes use of the touch panel system is explained, an overview of Whac-A-Mole is provided and the SUS evaluation method is explained. In Chapter 3, the experimental setup is outlined, followed by an explanation of the results of the hitting performance test and the results of SUS. From these results, the policy of the new evaluation method is discussed. Chapter 4 compares the hitting performance test when using the elderly simulation. This discussion is about the sustainability and adjustment of the pleasant level from using a new evaluation method. Chapter 5 summarizes the contents of the experimental results of the evaluation system and the touch panel rehabilitation system described in Chapter 4. In addition, this paper describes future research directions.

2. Cognitive Therapeutic Exercise (CTE) by Playing Games. Cognitive Therapeutic Exercise (CTE) is one of the therapeutic methods to improve damage to the nervous system. It is known that CET can be beneficial not only to improve physical capabilities but also to improve cognitive capacity such as cerebral strokes [10, 11]. CTE

has the ability to optimize recovery of a cognitive function. The instruments for practicing CTE were developed by Carlo C Perfetti, an Italian neuroscientist, and Fumagalli Co. This paper's experiment is based on a special touch panel display as the instrument for CTE. This research consists of (1) goal formulation, (2) planning, (3) carrying out goal-directed plans and (4) effective performance. Carlo C Perfetti proposed a method which is a perceptive exercise therapy based on learning in the case of a central nervous system's disease [12]. This therapy has three elements: the area of the body, sensory modality and a cognitive task. Therapists choose a task considering the recovery, extent, and type of disorders. The process of CTE trains the decision making and movement from perception and memorization. This is the same training involved in the neurotransmissions between brain functions and body functions. This paper proposes an efficient touch panel technique for implementing CTE and discusses a usability system based on the System Usability Scale (SUS) [13, 14] for a rehabilitation game system. Self-action in the rehabilitation task is based on the therapist's advice. Many participants cannot feel the effect of that advice and sometimes feel unhappy and stress. The etymology of rehabilitation in Latin is, re (again) + habilis (suitable) + ation (do action), which means "become a body in a suitable state again". WHO made a definition the rehabilitation in "World Programme of Action Concerning Disabled Persons", in 1982.

As follow...

"Rehabilitation means a goal-oriented and time-limited process aimed at enabling an impaired person to reach an optimum mental, physical and/or social functional level, thus providing her or him with the tools to change her or his own life. It can involve measures intended to compensate for a loss of function or a functional limitation (for example by technical aids) and other measures intended to facilitate social adjustment or readjustment."

Source: <http://www.un.org/disabilities/default.asp?id=23>

This research proposes an enjoyable exercise system, which encourages self-action by gaming tasks. 4 concepts have been defined to test the proposed system as shown in Table 1. The gaming aspect of one of the training factors and the proposed system should be goal-oriented and include challenge levels of the game tasks. By using gaming techniques, it is possible to support the physical and psychological aspects associated with rehabilitation.

TABLE 1. The 4 concepts for touch panel rehabilitation

1	Perform enjoyable rehabilitation.
2	As the cognitive exercise therapy, it is possible to accomplish the self-work rehabilitation.
3	The rehabilitation exercises have to be continually easy. The rehabilitation system should be intuitive.
4	Patients of any age can easily operate this rehabilitation system.

These 4 concepts aim to construct the application with advanced game capabilities. Rehabilitation system games should be configured using these 4 concepts. It is thought that the evaluation method and measurement process would depend on the reliability value of human beings. This game is necessary to accomplish these goals. Therefore, the usability evaluation is difficult to accurately evaluate when the new rehabilitation system was proposed. Because the evaluation process has to be redesigned to incorporate new ideas. Thus, the evaluation process depends on several cases. This paper shows a prototype system and the new evaluation system as a proposed rehabilitation system.

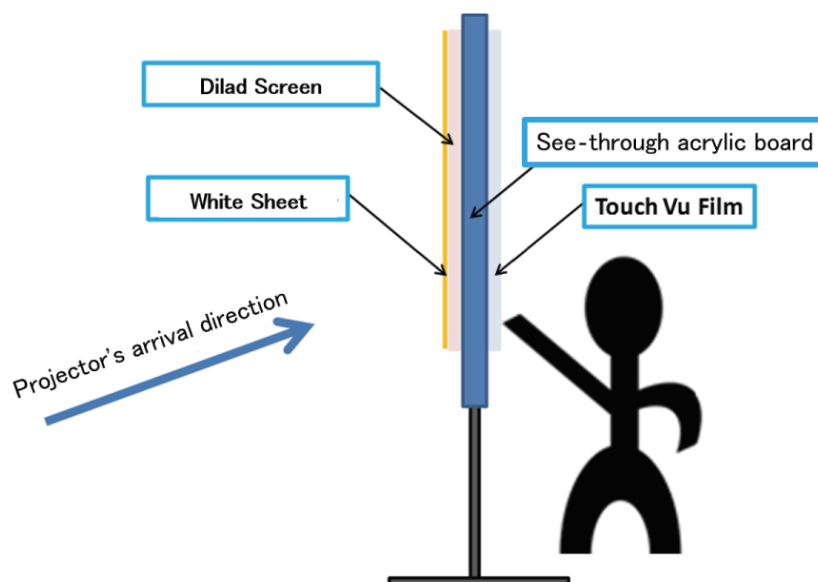


FIGURE 3. Touch panel by using the see through type acrylic board

Projection Touch Panel system (PTP) [15]

Figure 3 shows a film for projection called “Touch Vu Film” and “Dilad Screen” with a size of $W64\text{cm} \times H85\text{cm}$. The Dilad Screen is an adhesive film that converts a transparent panel or board into a rear projection screen and is produced by Kimoto Ltd. Japan. Several types are available from transparent to dark gray, depending on your application, environment, and need for contrast. Touch Vu Film is a touch sensor film from ITEM-16 companies in Japan. The size of the acrylic baseboard is $W115\text{cm} \times H85\text{cm}$. This board is transparent and users can see through the screen. This system uses an EB-X10 (EPSON) projector to display an image on the touch panel. Also, the screen is covered with baking paper (White Sheet) for a visual protection of the subject. This protection, subject to protecting the vision of the light that is projected from the projector, improves the projection of the image quality of the projector. In addition, the capacitive sensor film is installed on the back side of the glass or acrylic panels so hands and fingers do not directly touch the screen and the screen surface.

The Whac-A-Mole game as the rehabilitation [16, 17]

For long rehabilitation periods, making an enjoyable design is the main focus. This objective is achieved by incorporating games into the process; however, the participants must move between hospitals and home during the entire treatment. Thus, this proposed interface system was developed. Two different interfaces were developed, and each was built thinking of different patients at different stages of the rehabilitation process. This interface has two functions: one is the gaming interaction and the other one is the communication interaction. Communication can be accomplished using Internet communication tools and software to talk to friends, families, therapists and doctors. This paper focuses on the gaming interface and evaluation system. The evaluation system can measure the usability of the rehabilitation process from a participant. Whac-A-Mole is a famous and popular game developed in 1976 by Aaron Fechter of Creative Engineering, Inc. Most people know how to play, and there is high accordance. This game can help with the inner stages of rehabilitation of participants with severe arm mobility impairment [16, 17]. The area the participant has to move his/her hand around is small and there are no speed requirements. Therefore, permit the user to perform slow moves, as required at the beginning of the recuperation treatment. By adapting the number of buttons to the

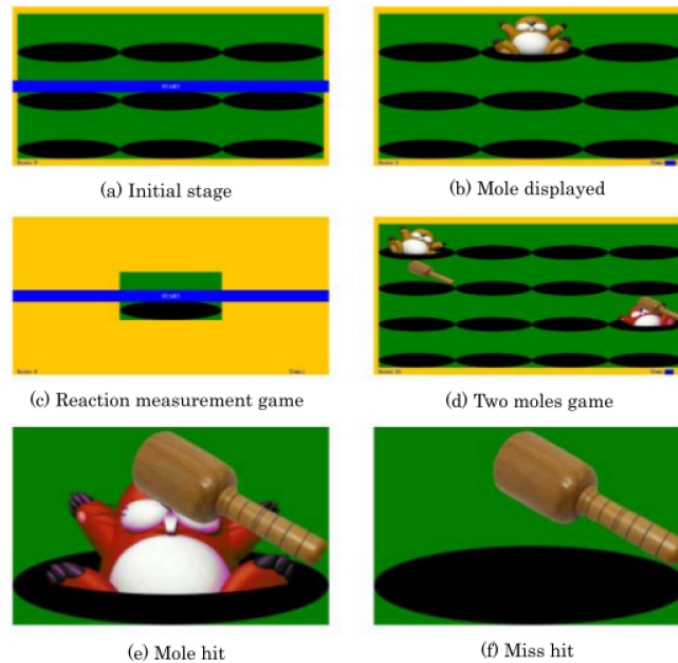


FIGURE 4. Whac-A-Mole game design

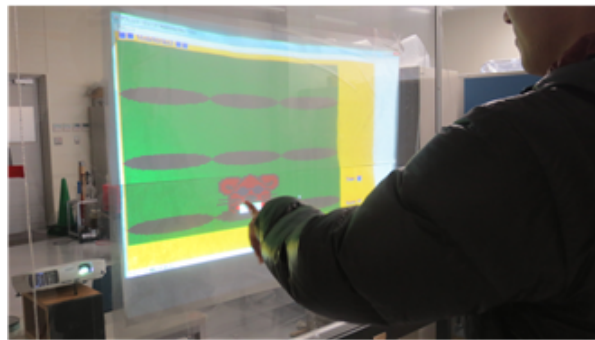


FIGURE 5. Playing Whac-A-Mole game in touch panel

user's performance and changing the speed as the score increases, the user interest and concentration are sustained throughout the game.

See Figure 5. This game not only requires the participant to be accurate with his/her hands but also requires a response time. Adding the time elements adjusts the difficulty of the game, and this way balances motivation in the later rehabilitation stages. This game evolves with the hitting performance by adjusting the size of the play area of both arms. The player of this game aims to hit moles that appear at a certain position on the screen, which is divided into an array of holes. The user has to be fast enough to hit the mole while it is displayed, if the user misses or is not fast enough, the mole will disappear and pop up again in a different hole. This process is repeated a predetermined number of times. Before the real game starts, the participant reaction time is measured by playing a simplified game with only one hole. This simplification allows the participant to focus only on touching the screen at a certain moment. Another version of the game with two moles is also implemented. In this version, each mole will appear in its respective half of the screen. A message is displayed at the beginning of each game. Both hitting speed and accuracy are required. The hitting speed is the time between when the moles

appear and the actual hit. The speed is automatically adapted to the participant's ability, making this a good game for participants at an intermediate stage of their rehabilitation process. This adaptation helps to improve their velocity from really very slow movements to faster and more accurate movements. The inclusion of two moles in one game forces the participant to coordinate both arm controls. This characteristic allows to either rehabilitate both arms or if only one arm is injured, adapt the speed of the injured arm to the healthy one. The game can be adapted to specific participant requirements, like exercising only horizontal or vertical movements. Another possible variation is to increase the accuracy required by augmenting the number of rows and columns. The only limit in this matter would be the precision of the touch panel employed. User's arms have to be raised during a complete round of the game, thus exercising the muscles involved in this movement. Moreover, the duration of the rounds can easily be adapted to the user needs, and this way allocates resting periods during the process. By computing the user reaction time at the beginning of the game, the experience is adapted to different abilities of every single patient, increasing their motivation to play a game specifically designed for their characteristics. The aforementioned reaction game also allows the user to become familiarized with the game graphics before the real challenge starts. After each round is completed, files containing the relevant user data are generated, one which can easily be analyzed in a spreadsheet. The data included in this file is listed in Table 2.

TABLE 2. Whac-A-Mole game system measure data

1	Reaction time for each of his/her clicks.
2	Double hits in a single mole.
3	Missed shots.
4	Accuracy.
5	Moles hit and moles missed.
6	Average reaction time, taking account of only good hits.

Evaluation method of Whac-A-Mole game as the rehabilitation exercise

How to evaluate Whac-A-Mole games as the rehabilitation system? The subjects are elderly people, even if do not have any handicap, they have a resistance to the preventive rehabilitation movement in many cases. However, they should keep exercising and training continuously. Applying evaluate method is necessary to continuously check user motivation. Also, the feeling of rehabilitation focuses on increasing users motivation. Users should not be conscious of the actual rehabilitation process and should not feel it is a training process. Therefore, experiments should take gather results from the subjects' evaluation after playing the game. And this evaluation should be included in the usability of the rehabilitation system. SUS (System Usability Scale) provides a measuring method of system usability [13, 14]. SUS consists of a 10 item questionnaire and 5 choice options. This evaluation method was developed by John Brooke of the United Kingdom of Digital Equipment Corporation in 1986. It has been used in the usability evaluation of mobile phone applications and consumer software. SUS is used in order to compare the relative merits of the target system. To evaluate the usefulness, SUS uses the 10 evaluations listed in Table 3. In the operation task experiment, all subjects answer 10 questions, made from a 5-point Likert scale. These five steps are 1 (Strongly disagree) to 5 (Strongly agree). Using this method, it is possible to measure the satisfaction level of the subjects. This measure level follows the 4 concepts of CET.

TABLE 3. SUS 10 original questions [13, 14]

Q1	I think that I would like to use this system frequently.
Q2	I found the system unnecessarily complex.
Q3	I thought the system was easy to use.
Q4	I think that I would need the support of a technical person to be able to use this system.
Q5	I found the various functions in this system were well integrated.
Q6	I thought there was too much inconsistency in this system.
Q7	I would imagine that most people would learn to use this system very quickly.
Q8	I found the system very cumbersome to use.
Q9	I felt very confident using the system.
Q10	I needed to learn a lot of things before I could get going with this system.

New evaluation policy and questions

The newly proposed evaluation method is explained. The evaluation method is limited to the question on the rehabilitation exercise compared with the original SUS. These objectives reduce the perceived ambiguity of participant's question items and concentrate participant's consciousness on the five concrete question items. In addition, there are contradictory questions in each question item, of there is also the effect of resolving the contradiction of the result. It has the effect of enabling participants to easily detect answer errors. Basically, this new evaluation's measurement process is the same as their SUS system. All subjects answer 10 questions, a 5-point Likert scale. These five steps are 1 (Strongly disagree) to 5 (Strongly agree). This method is possible to measure the satisfaction level of subjects.

TABLE 4. New evaluation policy and questions

Question Factor	Question Type	Question Content
Favorable rating	Nomal	The rehabilitation was felt so fun.
	Opposite	The rehabilitation was felt too boring.
Operatively	Nomal	The rehabilitation was able to understand how to use immediately.
	Opposite	About this rehabilitation, it is necessary to learn a lot before using.
Continuity	Nomal	The rehabilitation felt to be continuity.
	Opposite	The rehabilitation was likely to want to use again.
Response	Nomal	This rehabilitation is the ideal of the reaction.
	Opposite	This rehabilitation has a place confused.
Visibility	Nomal	The rehabilitation was felt to be simple.
	Opposite	The rehabilitation was felt that there is a place hard to understand.

3. First Experiment Using PTP. This section shows the evaluation experiments by using PTP. The purpose of the experiment is to confirm the validity of the evaluation of the PTP system and the SUS evaluation system. Therefore, the experiment uses the SUS evaluation and a mole hitting game. Subjects evaluate the usability of SUS after playing the game. This game system measures the time lag between mole's pop-up and hitting

the mole during play time. The setup of the mole hitting game is outlined in Table 5. Subjects are 10 males. All are right-hands and averages are 20.5 ± 0.92 years old. See Table 6. Using two hands is not prohibitive. In addition, there is no announcement about this prohibitive. After the experiment, all subjects fill out the form with the SUS test and an interview is conducted where the subjects can talk freely.

Interview comments of subjects are as follows:

- 1) I was not aware of the rehabilitation.
- 2) The operation was easy to understand.
- 3) I was able to play while obtaining a margin of mind for this game.
- 4) I was able to enjoy it.
- 5) Distinguishing between the background and the mole was difficult.
- 6) There was a time when the touch panel did not react.
- 7) It is hard to confirm when you hit the mole.
- 8) The score or results should be displayed on the screen.
- 9) Playing the simulated rehabilitation game a long time is tiring.
- 10) Playing a long time is monotonous and is a pain.

TABLE 5. Evaluation experiment setup in Exp.1

1.	Uping is 1 mole randomly from nine holes.
2.	Uping interval 800ms each. Total num of coming out is 40 times.
3.	The players get one point of the mole in each hitting.
4.	If player hits a blank hole already the mole backed, it is a miss hit.

TABLE 6. Subject setup in Exp.1

Subject	A	B	C	D	E	F	G	H	I	J
Age	20	21	20	20	22	20	22	21	20	19
Sex	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
Dominant hand	Right	Right	Right	Right	Right	Right	Right	Right	Right	Right

Hitting performance test

This experiment measured the hitting performance of accuracy and lag-time. Figure 6 shows the hitting average lag-time and the standard deviation. In Figure 6, a blue pole is the hitting average lag-time on each subject. The red error bars show the standard deviation of the hitting average lag-time. The average time of all subjects is 607.3ms and a standard deviation is ± 104.1 ms. The average accuracy rate was 57.9% and a standard deviation is ± 20.8 %. The vertical axis is the time lag [ms]. The horizontal axis is the subject code and describes Subject A to J. This accuracy rate is normal and is not a high score but does not depend on the usability of this system. This accuracy rate focuses on the learning process as a rehabilitation exercise. About 600ms becomes a base time of the lag time. The accuracy rate and the reaction time are shaking.

Hence, the results are generated from an MHP (Model Human Processor) or play style. MHP is a famous model of a human processing developed by Card et al. Humans have a minimal response time of more than 370ms (Eye movement Processor = 230ms, Cognitive Processor = 70ms, Motor Processor = 70ms) from the time information sent and decision behavior [18, 19]. Our experiment requires more time for moving the hand to a mole, about 200 to 300ms, but this figure depends on the difficulty level of mole game.

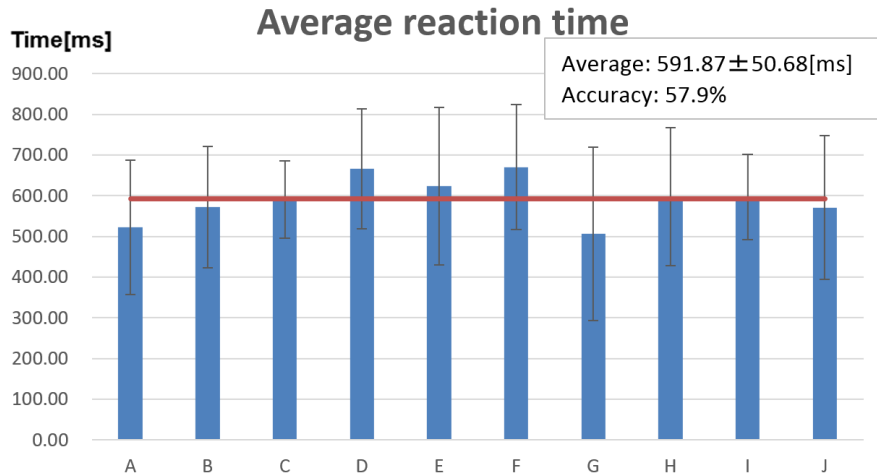


FIGURE 6. Average time about mole hitting

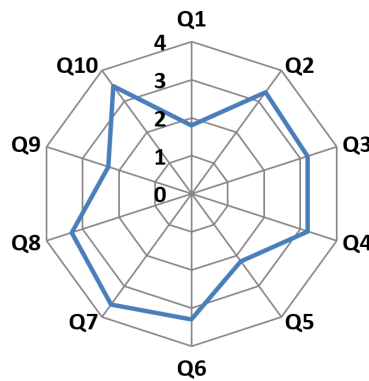


FIGURE 7. SUS evaluation mole-game in Exp.1

Jastrzembski and Charness investigated this model in older adults and found that the average time increases to about 300ms on several behaviors [20]. From this experiment data, this system needs more discussion about the lag time as a touch panel interface. For a rehabilitation interface system, the interface responses of touch actions will be the focus of the next experiment. Because the factor of this result would be the conditioned response, the play style would be slightly affected.

Additionally, the next paragraph reports the verification of the SUS evaluation method. Figure 7 presents the answers of the SUS evaluation from all subjects. This score is an average of all subjects. Q1, Q5, Q9 have a low score and Q7 and Q10 have a high score. This result is one type of test of the SUS evaluation system used for the experiment rehabilitation system. The SUS evaluation system checks details between the 4 rehabilitation concepts and the results. Players explained that they enjoyed this game. Their comments are consistent with the 1st concept of Touch Panel Rehabilitation. See Table 1. The comments are from young males but the game enjoyment factor is the same for elder peoples as with young people. The gaming level should be modified to better adapt to elder people and young people. There is a psychological margin because of the gaming factor [21, 22]. There should be no stress with the rehabilitation. However, the Q1 and Q9 scores were lower. These results were not consistent with the 2nd concept of the self-work rehabilitation challenge. The 3rd concept is also not consistent with results of SUS evaluation. The score of Q2, Q3, Q4, Q7, Q8 and Q10 remained the high score. Those results

are consistent with the 4-concepts. This concept is the most significant concerning the CTE process. This system could have a possible effect on the rehabilitation system based on these results. Those results describe the relationship between SUS system and the 4-concepts with the rehabilitation system. The subjective assessment of the system has to be considered. Subjects sometimes had brief comments about the questions contents. Especially, Q1, Q5, and Q9 may have an additional evaluation focus about rehabilitation game system.

Q1, Q5, and Q9 are as follows

Q1: I think that I would like to use this system frequently.

Q5: I found the various functions in this system were well integrated.

Q9: I felt very confident using the system.

Rehabilitation system using games should be designed to accommodate another evaluating factor. The new design of the evaluation system must follow all 4 concepts. Especially, the essentials of Q5 and Q9 should be removed for a new design. The target functions of Q5 and Q9 are not included in all of the concepts and rehabilitation system. Based on the results of Q5 and Q9, evaluation system must be changed to fit with the 4 concepts. About Q1, this rehabilitation system, and evaluation system should be improved. Regarding the question about the new design, 5 evaluation factors can be established to specifically evaluate the 4 concepts. These 5 factors can be defined as the basic usability of the rehabilitation “evaluation axis”. A score of 5 evaluation factors would work as the rehabilitation game usability evaluation. The 5-evaluation factors and question contents are as follows:

- 1) Favorite: Is this rehabilitation enjoyable?
- 2) Operatively: Is the touch panel operation intuitive?
- 3) Continuity: Are you able to continue the rehabilitation treatment?
- 4) Response: Is the reaction of the touch panel accurate?

The favorable depends on player’s mental. The player is always conscious of the rehabilitation effect and winner of the game. This mental state is called the favorable comparison. In this case, players feel affirmative as a favorable reply.

This is sometimes feeling as the winning approval of a favorable impression. In this mental state, the player recognizes this winning (game score) as the favorable impression. Therefore, the player imprints a game score on the memory as the score of the rehabilitation effect.

Operatively is the simple operation and intuitive movement. Those operations give players the exercise effects of the rehabilitation systems. This effect is an unconscious movement automatically. ‘Operatively’ affects as an unconscious movement. Therefore, there are powerful influences.

If a player conscious movement has more effects of exercise, it is not comfortable and it is possible to be the hard effort. Also, the continuity is kept uninterrupted connection of the rehabilitation exercise, a succession of the rehabilitation gaming. The response is a game action of rehabilitation. Especially, this response is touch response of the panel interface. This touch action has used a hand, not fingers. In the using hand, the touch area is wide and a period is short. Sliding hand on the panel is a little bit hard for the player. Because control pressure and a slide are hard adjusted by haptic feelings. If this system uses gesture game, the air slide is easier than a tough system. Visibility has to give the control imagination for players of what a control is used. About visibility, the affordance method is applicable. Rehabilitation game took easy a control imagination and used an affordance [23, 24, 25]. An affordance is a relation between an object or an environment and an organism that, through a collection of stimuli, affords the opportunity for that

organism to perform an action. For example, a knob affords to twist and perhaps pushing, while a cord affords to pull. It should be obtained the intuitive control is used. So, Whac-A-Mole game gives the simple imagination of how to play and exercise as rehabilitation. Improvement of the game surface is two points of “two moles are able to up at the same time”, and “modifying the mole numbers is able to be easy”.

To improve the interface of the game, those improvements are able to provide the rehabilitation which can be enjoyed regardless. The discussions use 10 questions of a new evaluation, see Table 4.

4. Second Experiments with the Weight Band Using PTP. It was assumed in the elderly people’s rehabilitation system that the hitting action supports the perpendicular training. The self-health care services have a significant problem worldwide. Especially, elderly people are increasing in Japan, and young people are decreasing now. The younger population is not increasing any time soon. Hence, increasing human support is not a practical solution. The elderly’s health needs to be supported by technology. Our approach is that interface device technology and communication tools have the possibility to be alternate support for the health care services. Gaming is one type of solution. The next experiment tests the new evaluation system, which was designed. See Figure 8. In the first experiment, the subject uses one hand to touch a panel. The mole size is defined to be big enough. There are 9-holes. This size affords the one hand operation. The hole area is not conscious deliberation and subjects can perform the one hand operation naturally. This is one type of the reasoning about objects and their affordances. Hence, players are given the directions that touching is done using two hands naturally. In this experiment, there are 6 (3×2) and 25 (5×5) holes and the possibility of up to two moles at the same time. In this case, the subject uses two hands to play the game naturally. Those designs afford full area of checking and the possibility of two touches at the same time. 9-holes and two moles work as the information objects as affordance-method [23, 24, 25]. By those mole actions, subjects would enjoy the rehabilitation process naturally and answer the evaluation question naturally.

This experiment uses the weight band for elderly simulation. See Figure 8 and Figure 9. This weight band is one item of the elderly simulation kit by Sanwa Manufacturing Co., Ltd, Japan. This is very famous kit in Japan. People can experience some of the physical disabilities and psychological changes experienced by the elderly (aged around 75 to 80) by wearing this weight band. The evaluation question was used 10-questions by Table 4.

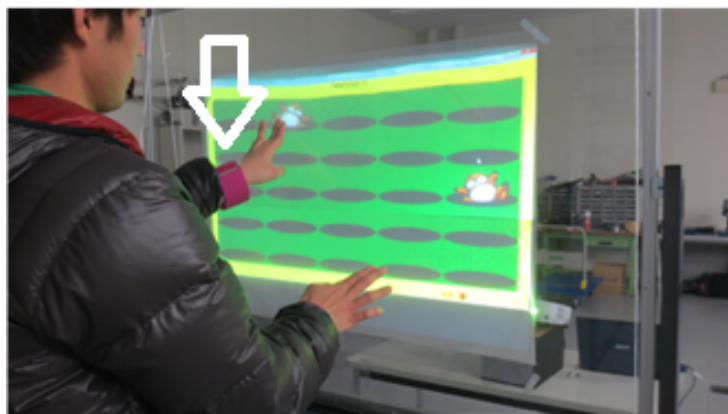


FIGURE 8. Mole game Exp.2 with the weight band

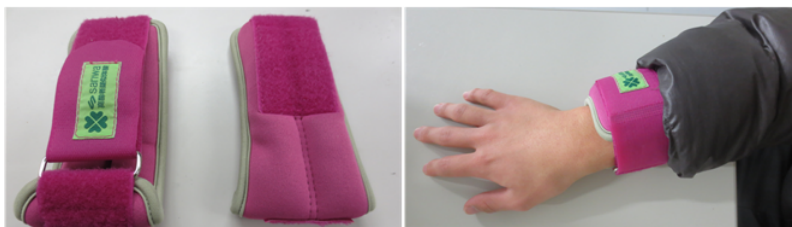


FIGURE 9. Weight band for Exp.2

TABLE 7. Configuration setup table of Experiment 2

Task num.	TaskName	Hole Matrix	Mole up	Interval time [ms]	Total moles [times]	Weight
Task1	Baseline Task	3×2	One	800	20	No
Task2	Simulation Task	3×2	Two	1600	20(40)	Yes
Task3	Extension Task	5×5	Two	1450	20(40)	No
Task4	Compared Task	5×5	Two	1750	20(40)	Yes

TABLE 8. Subject's information Exp.2

Subject	A	B	C	D	E	F	G	H	I
Age	20	21	20	21	19	19	20	22	23
Sex	Male	Male	Male	Male	Female	Male	Male	Male	Male
Dominant hand	Right	Right	Right	Right	Right	Right	Right	Right	Left

Table 7 shows a configuration setup about Experiment 2.

This experiment is designed to compare all performance results. Those performance results are a kind of elements to evaluate the rehabilitation system. Especially, the aim of this experiment is checking all processes as a pseudo rehabilitation work. Baseline task is for comparison with the first experiment. It is designed to compare the extension task and compared task after this. Subjects are wearing a weight band to play. This is a pseudo rehabilitation task. Interval time of the mole is 1600ms. This is a twice time of the baseline task. It is the baseline task in the case of wearing the weight. The two mole's game tasks are defined simulation task, extension task and compared task. Subjects are announced possible to use left and right hands those tasks at beginning. Two hand operation has the advantage as a training effect and natural process to take high performance to touch moles. Naturally afford is the essential foundation for rehabilitation and training and one kind of CTE's elements. Average accuracy is 89.9%. Average reaction time is 618.6 ± 40.9 ms. This time is almost the same as Experiment 1. See Figure 10. The reaction time of Task2 has mostly the same average time but average accuracy is 97.5%. The accuracy time is the main factor of keeping rehabilitation, depending on motivation to work the rehabilitation task. However, the high accuracy would give a player some tiredness. Two hand operation took better accuracy than one hand operation. Also, the reaction time is stable and keeps short. Therefore, a hard degree and a rehabilitation effect would be controlled by the difference between the two or one hand under the same game conditions. Additionally, the two hand's condition would keep a good quality as an interface.

Figure 14 shows that operatively response and visibility have high score.

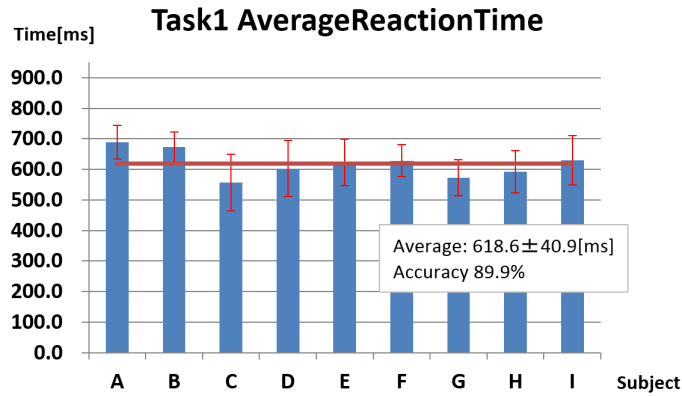


FIGURE 10. Reaction average time of Task1 about Exp.2

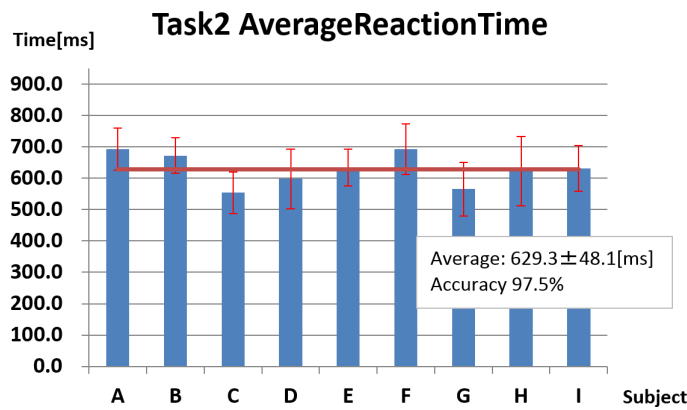


FIGURE 11. Reaction average time of Task2 about Exp.2

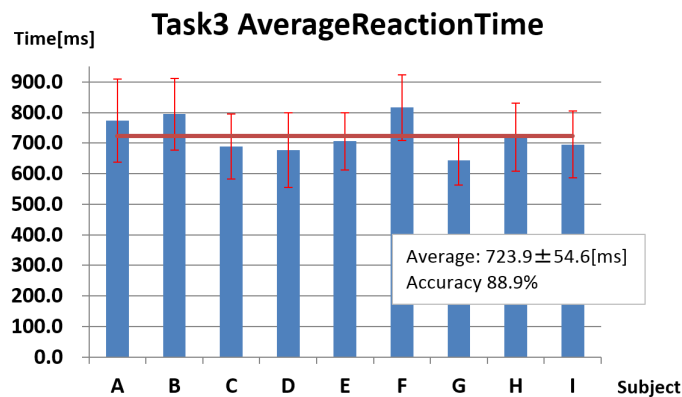


FIGURE 12. Reaction average time of Task3 about Exp.2

Favorable rating and continuity do not change. This trend is monitored in all experiments. Those evaluations depend on CTE's elements we are considered. Elderly people need rehabilitation to maintain motor function. However, the burden on hospitals and rehabilitation facilities is a big problem. In the home rehabilitation, the main points of the voluntary rehabilitation in a home are "autonomy" and "inheritance". The element of "playing" is the enjoyable effect and continues the movement for the elderly people can feel the rehabilitation game machines and it is so significant the same as the no stress. Also the game, without conscious of the rehab process, is better than winning the consumer. In

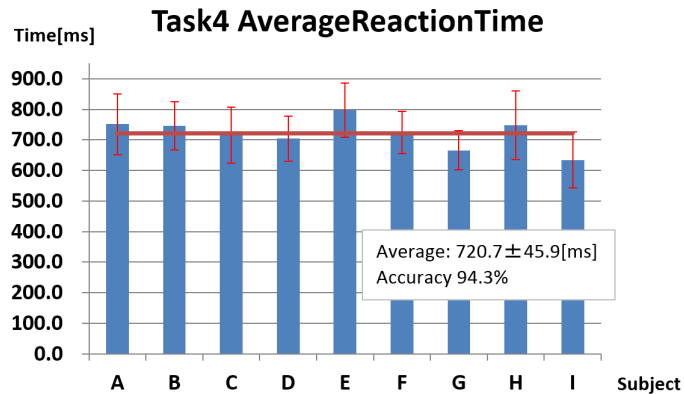


FIGURE 13. Reaction average time of Task4 about Exp.2

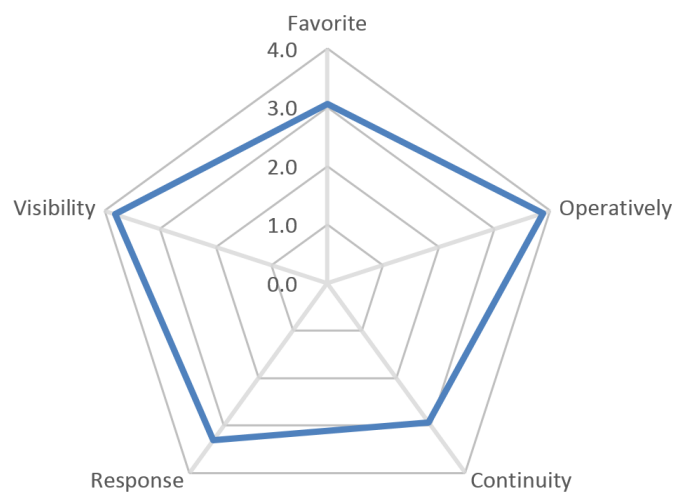


FIGURE 14. The answer to the questions about Exp.2 with the new proposal evaluation

this case, elderly people can concentrate on playing games as exercise rehabilitation. For keeping the maintain motivation of elderly people, modifying and adjusting difficulty level is the main process to make rehabilitation game system, and psychological impression is required as the evaluating element. As a rehabilitation system, adjustment of difficulty should be easy. Consider such functions from the data. The data whose molar rise time is adjusted depends on the reaction speed of human and the time to touch. The difference between a two-handed game and one-handed game depends on these. This is because the two-handed game has a short time to touch. In order to select these variations, judgment of the occupational therapist is required. Communication means through the Internet it can be attached to this system. These devices would help for decision making of player.

5. Conclusion and Future Work. In order to change the tough exercise, the new tool is necessary that combines a high rehabilitation effect and a fun game. There should be preventive care and home rehabilitation. In addition, a process of the cognitive exercise therapy is possible to perform the exercise therapy and cognitive process. The possibility of recovery depends on the strong motivation for functional recovery in a rehabilitation exercise. For success, patients must continue a movement of this exercise. This movement should be spontaneous work with the appropriate therapist's instructions. A spontaneous approach is the main point of rehabilitation training. A spontaneous movement is the

powerful approach of the patient in the real rehabilitation tasks because there is the patient supporting by the volitional movement. This patient supporting makes some reassuring remarks. The multi-touch fingers make the haptic feedback for the movement exercise. The touching makes an actual haptic feeling with checking finger positions. The multi-touch operation is similar to human intuition and this operation training is a significant role in the exercise therapy and cognitive process. Thus, this interface is also easy as an input device, even if handedness has a decreased ability to operate athletic ability. This paper showed a proposal rehabilitation space and a home training system for the preventive care. This system is designed for Whac-A-Mole game. Whac-A-Mole game is a traditional game for rehabilitation training at home. An interface system with haptic feedback is effective for user-friendly games. And in order to let them play continuously without getting bored, it is necessary to evaluate according to usability. In limb training, difficulty level should be set for each individual. Also, a touch panel can be an effective interface about a haptic feedback for rehabilitation training. Therefore, we proposed a new system evaluation method by defined 5-evaluation factors. This evaluation system was made from SUS as a foundation system and target is the touch panel type rehabilitation system. In many experiments, we evaluated the new evaluation method compared with the usability. From these results, we could propose a rehabilitation system with a new haptic interface and investigate new evaluation method. As future work, we would like to develop a new game for limb movement and develop the other games to train memory and decision-making.

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