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Rehabilitation, preventive care and universal design: the electronic musical instrument shoe

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***Abstract*— We developed a new electronic musical instrument shoe, the Otokutsu, which is a shoe to play music with the foot. We used universal design to develop it that makes sounds and flashes. Everyone can easily play it and enjoy the fun. We developed a special score for it that can be effortlessly played, even by beginners or those who cannot read music. Furthermore, we developed the optical navigation system. It enables enjoyable rehabilitation exercises for the foot. We evaluated it with a number of day-care managers in senior programs; the instrument is effective for rehabilitation exercises and elementary schools. Enabling regaining a sense of the foot after fixation of the foot is effective rehabilitation. Compared with self-resistance training with a towel or tube, rehabilitation with it can be continued for a long time. It can also reduce the possibility of injury for the physically unimpaired because using the instrument strengthens foot muscles and improves flexibility. Wearers can adjust the position and strength of the switch in accordance with rehabilitation, or preventive care, and degree of difficulty. Awareness of the results enables us to improve and motivates us to continue exercising for rehabilitation or preventive care. It enables continuing rehabilitation or preventive care, while making the exercising enjoyable.**

***Keywords*— electronic musical instrument, universal design, rehabilitation, movement music therapy, self-resistance training**

I. Introduction

Most of the rehabilitation exercises are boring and hard. It is very hard to improve and maintain the motivation to continue rehabilitation exercises. The rehabilitation exercises using robots [(1)] need wide space and also cost very much. If we can easily enjoy rehabilitation exercises, we can continue them. It is very important for us to enjoy rehabilitation exercises and continue them. It is so fun to play musical instruments. It is effective to introduce playing musical instruments as rehabilitation exercises. But the most of them are hard to play, and it takes time to learn playing technique.

We developed a new electronic musical instrument shoe called “Otokutsu”. It is a shoe to play music with the foot. It can be easily played by anyone in consideration of universal design (UD)[(2)]. Sensors were installed in its sole. The sensors were connected with electrophones which fitted inside sole. It makes sounds by stepping on the position on the sole. The sensors were also connected with LEDs (light-emitting diodes) which also fitted inside sole. It not only flashes but also makes sounds. It is fun and easy for everyone. In addition, we developed the special score for Otokutsu. It can be easily played even by beginners or the person who do not read music. Furthermore, we developed the optical navigation system. It is a system in which the position to step on is beforehand shown with light. The player can play music by stepping on and making sound based on the information on light. And it enables us to do rehabilitation exercises for foot enjoyably. It makes a relation with others by music.

II. DESIGN CONCEPT

In the development of a new electronic musical instrument shoe “Otokutsu”, we set the following concepts:

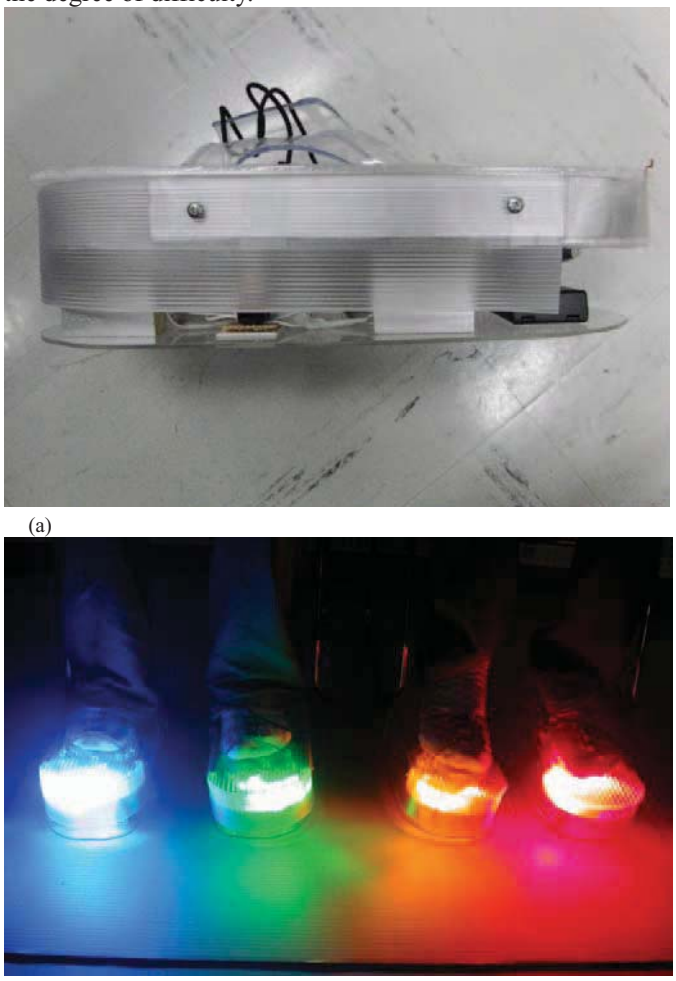
1) It can be easily played by anyone in consideration of UD.
2) The person who cannot move hands also can play it.
3) It is possible to play it in concert with other musical instruments played by hand.
4) It not only shines but also makes sounds.
5) We can use it as a way of enjoyable rehabilitation for foot.
6) It can be played easily by anyone from children to the elderly.
7) It is easy to play it by using the special score.
8) Those who cannot read a score can also play it.

III. OVERVIEW

Fig.1 shows external appearance and demonstration of new electronic musical instrument shoe “Otokutsu”. The length of it is 300mm, the width of it is 120mm, and the thickness of it is 70mm. The weight of it is 700g for one foot. The instep of the shoe is adjustable because anyone can put it on. Four sensors were installed at tiptoe, heel, right side, and left side in one foot. The sensors were connected with electrophones which fitted inside sole. One foot can make four sounds by stepping on the position. Using both feet, you can make eight sounds; that is one octave. By using pressure sensors, the strength of sound is changeable by the degree of the power to step on.

The sensors were also connected with LEDs which fitted inside sole. Four-colored, red, blue, green, and yellow LEDs were installed in sole. A different color LED shines by a position to step on. The outside was covered with a transparent board, and light of the LEDs emitted light to circumference. The basic constitution of the hardware consists of switches, interface circuits, speakers and LEDs. Tone or style is changed by the switch. It can adjust position and strength of the switch according to the rehabilitation part and

the degree of difficulty.



(a)

(b)

Fig. 1. Overview of a new electronic musical instrument shoe "Otokutsu". (a) external appearance, (b) demonstration.

IV. EASY SPECIAL SCORE

It is difficult to understand score. We developed the special score for Otokutsu. Fig.2 is a part of the special score. The score shows a position to step on not only by the place of the switch but also a color to shine. Furthermore, the score shows length and rhythm to step on intelligibly.

For example, at the first sound in fig.2, the position shows the tiptoe side of the left shoe. This is the position where red light shines. The length is half note. At the next sound, the position shows the right side of the left shoe. This is the position where green light shines. The length is quarter note. At the first sound of the second line, the position shows the tiptoe side of the left shoe. At the second sound of the second line, the position shows the right side of the left shoe. The length is eighth note. At the third sound of the second line, the position shows the heel side of the right shoe. The length is eighth note. It can be easily played even by beginners or the person who do not read music.

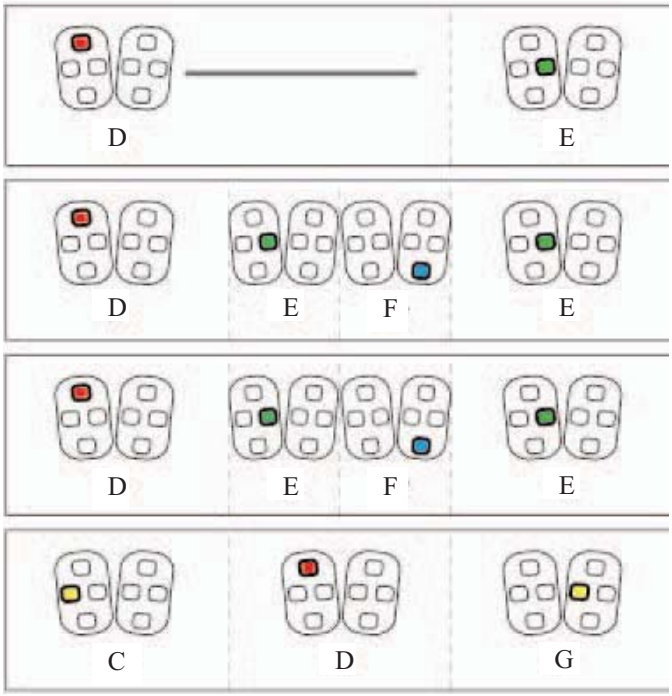
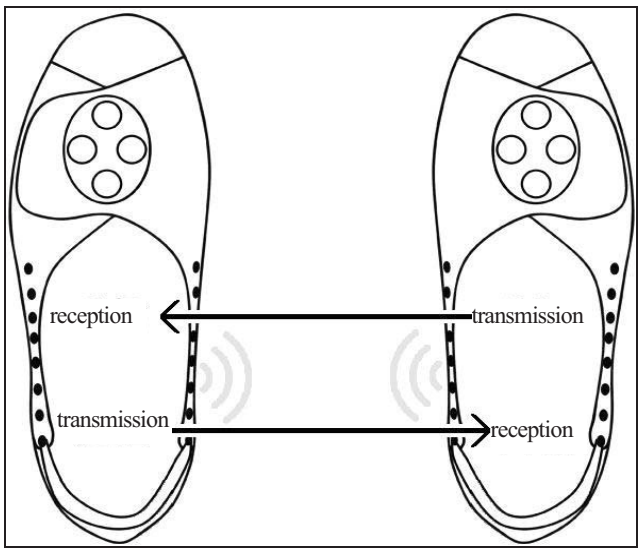


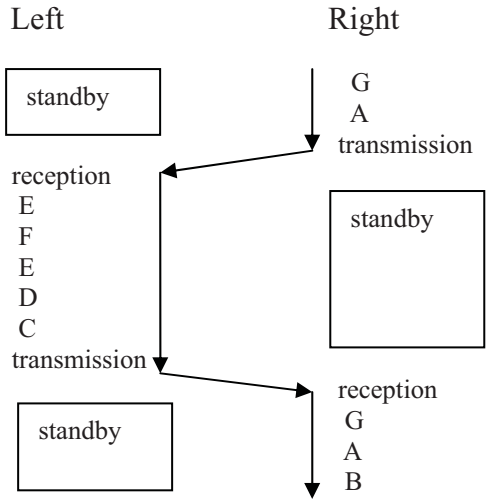
Fig. 2. A part of the special score for Otokutsu.

V. OPTICAL NAVIGATION SYSTEM

We developed the optical navigation system. It is a system in which the position to step on is shown beforehand with light. The player can play music by stepping on and making sound based on the information on light. In order to use the optical navigation system, synchronization of shoes on either side is needed. Therefore, transmission and reception of signals between shoes were enabled using wireless communications. Fig.3(a),(b) show the image of wireless communications between left shoe and right shoe. Thereby, anyone can play easily.



(a)



(b)

Fig.3. Image of wireless communications between shoes on either side.

VI. USABILITY TESTING

We evaluated Otokutsu at some day-care centers for the elderly and elementary schools. Fig.4(a),(b) show the situation at that time. Most people will be eager to try to make a sound of the position where they feel hard to click. When they could make a sound, voice of the praise broke out among people doing it together and improved the motivation to continue rehabilitation exercises. They do their best till they are able to play in concert. Furthermore, they can have relationship with others by music. The questionnaire result shows more than 90% answered "it was pleasant". There were opinions that scores are easy to understand. We confirmed that anyone from primary schoolchildren to old people was able to play it easily. The questionnaire result shows more than 90% wanted to play it once again. We can be aware of training effects by sounds and lights. We achieved to realize enjoyable and continuable rehabilitation exercises by Otokutsu.

Otokutsu got good evaluation results from many care managers; It was very effective for rehabilitation exercises. For example, the rehabilitation by it is effective when regaining the sense of the foot after the fixation of the foot. The rehabilitation by it is continuable for a long time in comparison with self-resistance trainings[3] which are towel gathering or tube trainings. Because it strengthens the muscular strength of the foot and improves flexibility for physically disabled, it can reduce injuries. It can adjust position and strength of the switch according to the rehabilitation part and the degree of difficulty. We can improve and maintain the motivation to continue rehabilitation exercises because we can be aware of a training effect. And it is also usable in music therapy.

VII. CONCLUSIONS

We developed a new electronic musical instrument shoe called "Otokutsu". It is a shoe to play music with a foot. It can be easily played by anyone in consideration of UD. It not only flashes but also makes sounds. It is fun and easy for everyone. Furthermore, we developed the special score for Otokutsu. It can be easily played even by beginners or the person who do not read music. And it makes the rehabilitation exercises for foot enjoyable. It makes a relation with others by music. We evaluated it at some elder day-care centers and elementary schools. We achieved to realize enjoyable and continuable rehabilitation exercises by Otokutsu.

Future works are to make it stronger in a shock and to improve completeness as the musical instrument. Application as the musical instrument spreads if we can play it in a standing posture. And we are going to develop effective rehabilitation programs with Otokutsu.

(a)

(b)

Fig. 4. Situations of usability testing. (a) at day-care center for the elderly, (b) at an elementary school. Primary schoolchildren play it watching the special scores.

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