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F-ready: A support device that allows disabled people to play the guitar

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Abstract. Although many people with disabilities have a strong desire to play a musical instrument, there are a few support devices that allow them to play it. We propose four considerations that have been identified for the development of such a support device and developed "F-ready," allowing people with disabilities in their upper limbs to play the guitar. We demonstrate the results of a trial in which a male with a cervical spinal cord injury practiced playing the guitar with F-ready for five weeks. He could make sounds with the guitar using F-ready, even from his first day of practice. Then, he could simultaneously engage in three movements: moving his left hand to the appropriate position on the strings, pressing the F-ready switch, and strumming the strings with his right hand. After only five weeks, he performed a musical piece at a research meeting on the harmonica and guitar using F-ready. In addition, he faced several tasks: deciding on an optimum posture, how to deal with arm pain, and learning the song's chord progression. The experts solved these tasks together. The experiment demonstrated that F-ready supports players' ability to play the guitar at will and enthusiastically.

1. Introduction

In this paper, we indicate four considerations that were identified for the development of a support device for people with upper limb disabilities who want to play the guitar. Then, we show a support device, "F-ready [1][2][3]," which has been developed based on the four considerations and present data on a trial conducted with a male with cervical spinal cord injury who practiced playing the guitar with F-ready for five weeks.

Many people with disabilities have a strong desire to play musical instruments [4]. They often play these instruments as a part of their physical and psychological rehabilitation efforts [4]. There are many instruments and devices to assist in the playing of musical instruments, and new musical instruments have been developed for people with disabilities. Cymis is a musical scoring program and includes several ways to play the instrument. For example, users can touch the music notes displayed on a monitor [5], use expiratory pressure [6], various switches [7], and other means for making music; these are each effective and highly accessible. Users who have worked with Cymis since the beginning of its



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development have used it to play in some European orchestras and play the Cymis. Freqtrix Drums are another interface for detecting human skin contact and its intensity; by touching others, a user can create sounds that simulate drums and other percussion instruments [8]. Kyoraku is a device developed to help people with cervical spinal cord damage play the guitar [9]. The guitar used in the Bunne method, on which a user can sound the four chords of D, A, G, and E by moving a red lever, is also well known [10].

Despite the advanced mentioned above, it has not yet been not discussed how the development these support devices and musical instruments for the people with disabilities can allow them to practice whenever they choose. We know that the people with disabilities need specialized input devices, such as single switches and sensors that require only gestures to use them [11]. However, people with disabilities often cannot play a musical instrument without such modifications or equipment. Moreover, many musical therapists also do not use electronic music technology and/or clinical tools with their clients all of the time, because the therapists select what they see as the appropriate tools for each client [11]. If considerations for the development of these support device for people with disabilities are established, they come to be used well, by not only by people with disabilities, but also by music therapists.

With the above in mind, we propose four considerations for the development of a support device that people with disabilities in their upper limbs can use to practice a musical instrument at will. In Section 2, we introduce F-ready [1][2][3], which we have developed, and we propose four considerations. In Section 3, we provide details of a trial conducted with a male a cervical spinal cord injury who practiced playing the guitar with F-ready for five weeks. The results and a discussion of the trial are shown in Sections 4 and 5, respectively. We conclude the paper in Section 6.

2. Support device "F-ready"

F-ready [1][2][3] is a support device for people with disabilities in the upper limbs to play the guitar.

Figure 1 shows F-ready as a support device. Figure 2 shows the total system used to support people with disabilities in their use of F-ready. Many experts, such as physical and occupational therapists, were involved in the development of F-ready and identified four considerations, as shown in Sec. 2.1.

2.1. Considerations for the development of F-ready

In this section, we explain the four considerations identified by experts for the development of F-ready. A "user" refers to "a person with a disability in the upper limbs."

1. A user can play the guitar immediately using only the slightest power from his or her fingertips.

A related study found that "Kyoraku [9]" is a self-help device developed to help people with cervical spinal cord damage play the guitar. It is attached to a player's hand, to help him or her press down on the guitar strings using the principle of leverage. As such, it is difficult for many disabled people to use. People with disabilities in their upper limbs, including those with a cervical spinal cord injury at the C3 level, cannot use Kyoraku. In response, F-ready was developed so that a user can play the guitar using only the power of a fingertip, like using a computer mouse, and he or she can press the strings easily.

2. A user can select and press a part of the string (position) and strum the strings by him/herself.

We have observed that a person with a disability may try to play the guitar as much as possible, but he or she will still require someone else for support in the performance. However, it is important for the user to select and press a part of the string by him/herself. In a related study, the guitar's swing bar, which is one of "Bunne" musical instruments [10], allows the user to play by him/herself, but only to produce four chords. By contrast, F-ready allows a user to press anywhere on the string, from the first fret through the 11th, to play freely, if the user fixes the guitar's tuning to one chord. We expect that users will be able to play a favorite piece and realize that his/her musical skills have improved. Then, the motivation to play the guitar will continue for a long time.

3. The operations needed to play a guitar are unchanged, regardless of whether an assistance device is used or not.

In the case of Kyoraku [9], the playing method differs, based on whether or not the device is in use; hence, Kyoraku requires the mastery of a different performance style to control the pressing of the strings. Further, the method cannot be used with a guitar without the Kyoraku device. Assistance devices of this kind require the user to master the device before they can, eventually, start to practice the instrument. As a result, the user cannot and does not acquire the skill of playing the instrument at all. Moreover, if a user wants to play the instrument without the device, because they have recovered their physical function, he or she has must resume practicing once more as a novice. In contrast, if the physical movement of playing an instrument with an assistance device is the same as that of playing without it, the user might feel able to practice playing for longer periods of time and, ultimately, become attached to the musical instrument itself. If someone then wants to play the instrument without the device, he/she will not need to modify the movements they have already mastered.

4. The assistance device should let the user's hands operate simultaneously, so that playing the guitar has a rehabilitative effect.

When a user plays the guitar with or without F-ready, he/she must coordinate the following three movements (α , β , γ): move the left (right) hand to the appropriate position on the strings (α), press (and keep pressing) the position or the F-ready switch at that position (β), and strum the string(s) with the right (left) hand (γ). Although the user may, at first, perform these three movements one by one, they should eventually occur in cooperation, following repeated practice. Thus, playing the guitar is expected to have a rehabilitative effect for the upper limbs.



Figure 1. F-ready used as a support device for playing the guitar.

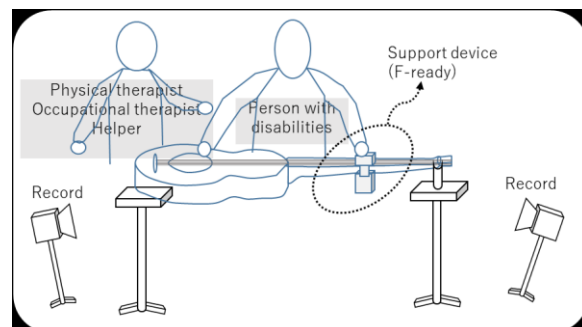


Figure 2. Total support system that allows experts to check the performance of a person with disabilities.

2.2. Support system

It is important to construct a support system (in collaboration with experts) for F-ready's users. As shown in Figure 2, the user's performance is recorded with video cameras during his/her practice sessions. Then, experts (physical, occupational, and music therapists; caregivers; and so on) who understand the user's daily life discuss the his or her physical state and performance by watching the recording. Physical movements are complex, so we should break them down to determine what is currently possible and what abilities may or may not be recoverable through rehabilitation. In this way, it becomes clearer whether the user's movements require no assistance, what levels of assistance need to be adjusted in response to changes in his/her physical state, or whether permanent assistance is required.

The experts' advise the user and his or her caregiver on how to practice, how to move the upper limbs, and how to assist in the performance based on the goals for the performance and the user's rehabilitation.

3. Experiment

A disabled male with a cervical spinal cord injury used F-ready to practice the guitar for five weeks. We made sure that F-ready meets the four specifications shown in Section 2 and that people with disabilities are able to play whenever they choose, using F-ready.

3.1. Subject information

The subject was a 30-year-old male who, at 20 years of age, injured his cervical spinal cord in a car accident. He has paralysis in his upper limbs, below the chest. He has a C3-C4 cervical spinal cord injury, but can lift his elbows and move both hands, but he cannot move the fingertips on his right hand. He cannot move his fingers independently.

3.2. Experimental conditions

The conditions of use for the device and the recording method are shown below.

- (a) Use a typical, unmodified acoustic guitar.
- (b) As shown in Figure 3, the guitar body was placed face up, and the neck was placed on another desk.
- (c) As shown in Figure 4, before he began practicing the guitar, the first author explained to the subject how to use the device, and a physiotherapist was brought in to adjust the placement of the instrument.
- (d) The practice period for the trial detailed in this paper was five weeks. The subject decided on the number of exercises and the practice time devoted to each exercise.
- (e) The first and second authors supported and advised the user's practice from perspectives of physics and music.
- (f) To demonstrate the usefulness of the support device during a research meeting, the subject played a two-minute-long musical piece on the guitar using the support device



Figure 3. The guitar torso is placed face up.



Figure 4. Before starting to practice the guitar, some experts had a meeting at the user of F-ready.

4. Results

The user practiced the guitar 26 times in five weeks. We call the practice, from the first through ninth sessions “Phase 1,” the 10th to 15th sessions “Phase 2,” and the 26th session “the final practice day.” Then, he played the guitar during a research meeting.

In these results, we focus on the following three operations, α , β , and γ (see Section 2.1).

4.1. Phase 1

The user could move the F-ready’s input device to the appropriate position on the strings, even on the first day. However, since each movement was not one to which he was accustomed in everyday life, he had a lot of muscle tension in his arms and shoulders. He considered the optimum posture to use that would allow him to play the guitar most easily. Then, he decided on the position that put the guitar’s body on his knees and the neck on a desk, as shown in Figure 3.

He could strum the strings while pressing them using the F-ready switch. However, he operated α , β , and γ independently during Phase 1. He took a little time to perform each operation, because he had to visually confirm the movements of his hands.

4.2. Phase 2

The user’s performance style became established, and he was able to perform each operation without excessive muscle tension.

Although he could continue playing the guitar without pausing for longer lengths of time, he began to feel pain in his arms, and his fatigue was growing.

He became used to each operation, α , β and γ . In particular, during operation γ , his need for visual confirmation was reduced. By contrast, he did not try to perform operations α and β without visual confirmation, as in Phase 1. However, it seemed that he could perform all operations at once, although it still took time to make a sound.

He started practicing a portion of a song. He played the melody on the harmonica and using the guitar as an accompaniment. He played the guitar at a very slow tempo.

4.3. Final practice day

The user could perform operations α , β , and γ simultaneously. Then, he could move the F-ready’s input device to the correct positions on the strings while playing the piece at the intended tempo. He became able to play the harmonica with his guitar as an accompaniment for 24 measures. He could play more than 18 tones on the guitar while the playing the piece.

4.4. Performance at a research meeting

Five weeks after beginning his guitar practice, the user played the harmonica, with his F-read-equipped guitar as accompaniment, at a research meeting to demonstrate the usefulness of the F-ready device. He could play one chorus of the song in about two minutes with fluency and musicality. The audience applauded.

5. Discussion

In this section, we discuss whether F-ready follows the four considerations (see Section 2.1), based on the process experienced by the user who participated in the trial outlined in this paper.

He could play the guitar by himself using F-ready from the first day of practice, even though he cannot move his hands freely, due to a C3-C4 cervical spinal cord injury. This result shows that F-ready follows Consideration 1 (A user can play the guitar immediately using only the slightest power from his or her fingertips) and Consideration 2 (A user can select and press a part of the string (position) and strum the strings by him/herself). However, his performance style was different from that of our assumptions. It was not easy for him to press the F-ready’s input device with his fingertips; therefore, he used his arm to press it. He could draw his arm towards his body by pulling his shoulder up and while bending his

chest backward. Then, he could catch the input device. In contrast, he could return his arm to the original position by relaxing his shoulder. However, it was somewhat difficult for him to hold the input device, even though the input device has a rest attached. His left hand was sometimes lost its grip on the input device. Therefore, we should consider changing and enlarging the attached rest, so that the user's hand does not slip.

If F-ready is removed, the user can play the guitar in the same way he plays it with F-ready. He will strum the strings with his right hand by pressing them with his left hand from above, even without F-ready. He does not need to modify the movement that he has already mastered. Namely, F-ready follows Consideration 3 (The operations needed to play a guitar are unchanged, regardless of whether an assistance device is used or not). However, he did not remove F-ready during this trial, because the physical function of his upper limbs did not recover enough to play the guitar without F-ready. Because he has injured his cervical spinal cord, he cannot directly press the strings with sufficient power, even if he were to practice for a long time. However, he can move his left hand from side to side on the strings and strum them using his right hand.

Although he could perform each operation (α , β , and γ) independently, he became able to perform these operations simultaneously and smoothly. He practiced the guitar not for rehabilitation purposes, but also for his own enjoyment. However, we have considered the rehabilitation effect of moving the left hand from side to side on the strings and pressing the input device using the upper limbs. Therefore, F-ready follows Consideration 4 (The assistance device should let the user's hands operate simultaneously, so that playing the guitar has a rehabilitative effect).

We consider that F-ready allows people with a disability in the upper limbs to practice the guitar whenever they choose, because F-ready follows the four considerations.

Despite the above successes, the user had some tasks to tackle other than making a sound with the guitar for the five weeks. He had to consider the optimum posture that would allow him to play the guitar most easily. Then, his arm began to hurt. He needed to learn a chord progression. The physical and musical therapists addressed these tasks together. Meanwhile, these matters show that F-ready supports users with disabilities in their upper limbs in practicing the guitar at will and enthusiastically.

6. Conclusion

F-ready was developed as a support device for people with disabilities in their upper limbs who want to play the guitar based on four considerations: (1) play the guitar immediately with the support device, (2) play by oneself, (3) the performance styles playing with/without the support device are the same, and (4) playing the guitar has a rehabilitative effect.

In this paper, a male with a disability in his upper limbs practiced the guitar with F-ready for five weeks to examine whether F-ready follows the four considerations. He could play the guitar by himself with F-ready even on the first day of practice. However, he performed operations that are necessary for playing the guitar independently. At first, he moved the F-ready input device to an appropriate position on the strings by his left hand. Then, he pressed the input device, to press the strings using his left hand. Finally, he strummed the strings using his right hand. After two weeks, he became able to perform these operations simultaneously and smoothly. Although he could not play the guitar without F-ready during this five-week trial, he would be able to play the guitar using the same performance style, even if F-ready were removed. Furthermore, because he moved his left hand from side to side on the strings and pulled his shoulder and arm up to move his hands repeatedly, playing the guitar can be considered a part of his rehabilitation.

In contrast to the above, the user developed pain in his arms after practicing for a long time. Moreover, he wanted to find a chord progression that would be easier for him. Therefore, the second author, who is a physical therapist, and the first author, a music expert, advised him. In this way, we should provide not only just support for the device for the people with disabilities, but also a support system that experts can use to evaluate a person's current state and physical condition, so that they may advise them appropriately.

In the near future, we will conduct further experiments that some neuromuscular patients try to practice playing the guitar with F-ready for a long period. Moreover, we will develop a system that allows experts to review practice videos in a short time.

7. Ethical considerations

This study was conducted in line with the Helsinki Declaration of Ethics and was approved by the Ethics Committee of Mie University. We also obtained the permission of the corresponding individual regarding this work's publication.

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