ELECTRONIC MUSICAL INSTRUMENT USING MANDIBULAR AND TONGUE MOVEMENTS

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Abstract: We developed an electronic musical instrument using mandibular and tongue movement. This instrument is playable without limb movement. Therefore, this instrument can provide the opportunity of a musical performance for several disabled people, such as quadriplegics. The developed electronic musical instrument consists of an input device in the mouth, a personal computer installed 12-bit A/D converter, and a MIDI instrument. Two-channel signals are generated at the input device. Those signals are converted to a MIDI command by the personal computer, which orders to a MIDI sound source to generate a tone. The input device mainly consists of a potentiometer and a push button switch. A user controls a musical scale by the potentiometer positioning with the lips, and pushing the switch with the tip of the tongue performs a tone generation. Moreover, this study carried out an experimental performance over a period of three days. Subjects performed the musical piece 'Twinkle, twinkle little star' at a tempo of 90 beats per minute. Subjects were a 22-year-old female and a 23-year-old male. In the experiment, both subjects improved their performance of the musical piece over the experimental period of three days.

Introduction

Conventional musical instruments (e.g. piano, violin and percussion) require limb movement. Therefore, such instruments are unsuitable for disabled people [1].

The purpose of this study is a development of a musical instrument using mandibular and tongue movements. Those movements have skillful combination in speaking or swallowing[2]-[4]. In this study, we developed an input device that has two independent inputs. Furthermore, we developed an electronic musical instrument using this input device. This instrument is based on a personal computer with a MIDI instrument, and can produce various tones. This instrument is playable without limb movements. Therefore, this instrument can provide the opportunity of a musical performance for several disabled people, such as quadriplegics, and contribute to improve their quality of life.

Constitution of the Electronic Musical Mnstrument

The developed electronic musical instrument consist of the input device, a personal computer installed 12-bit A/D converter, and a MIDI instrument. Two-channel signals are generated at the input device, and then convert to a digital signal with sampling rate of 100 Hz. Those signals are converted to a MIDI command, which orders a MIDI sound source to generate a tone. Figure 1 is a schematic diagram of this electronic musical instrument.

The input device consists of an acrylic board, a potentiometer, and a push button switch. Figure 2 shows a plan of the input device. The input device is fixed into the mouth with the lips. The whole input device is covered with a 0.05 mm thick polyethylene sheet. Figure 3 is a photograph of a user with the input device fixed into the mouth, and an illustration of cross-sectional diagram.

Figure 4 shows an operation method of the input device. A user can control a musical scale by the potentiometer positioning with the lips. A positioning mechanism of the potentiometer returns to the first position by the force of the spring (spring constant = 0.151 N/mm). Pushing the switch with the tip of the tongue generates a tone. The switch is activated with a force of 1.27 N. A user confirms a musical scale by looking at a lighting pilot lamp on a display of the personal computer. The pilot lamp is configured into an array illustrating a musical scale on the left side. Figure 5 shows a screenshot of the display.

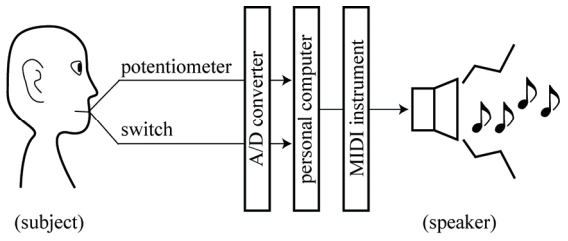

Figure 1: Schematic Diagram of Developed Electronic Musical Instrument

ISSN: 1727-1983

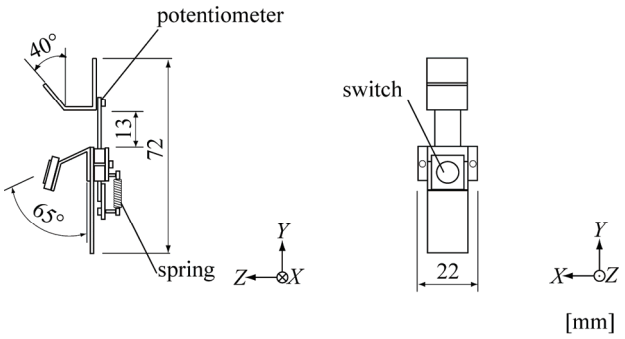

Figure 2: Plan of the Input Device

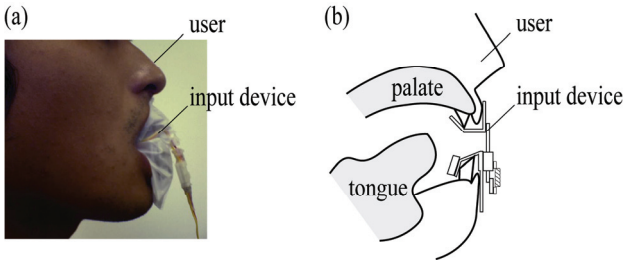

Figure 3: Input Device in a Mouth
(a): photograph of a user
(b): illustration of cross-sectional diagram

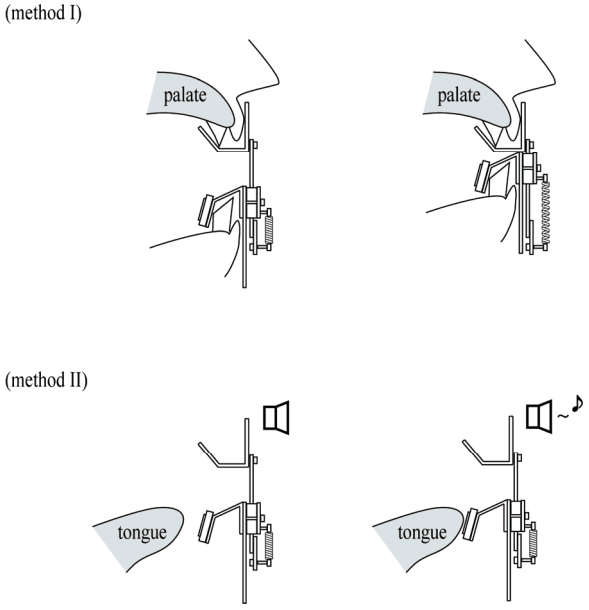

Figure 4: Operation Method of the Input Device
(method I): scale control by mandibuler movement
(method II): tone generation by tongue movement

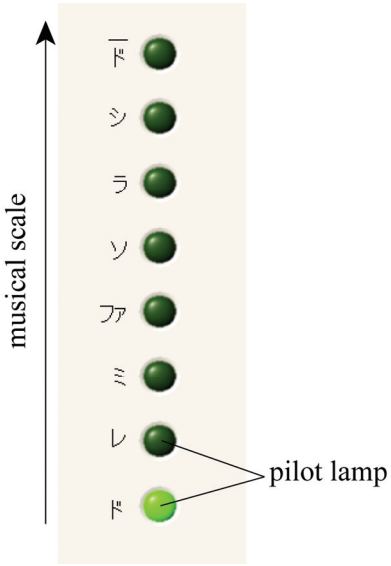

Figure 5: Screenshot of the Display

Experimental Performance of a Musical piece

The aim of this experiment was to determine how the operation of the input device changes due to the experience of playing the developed musical instrument. In the experiment, the subject performed the musical piece 'Twinkle, twinkle little star' at a tempo of 90 beats per minute. The experimental period was three days, with five performances each day. Subjects were a 22-year-old female with a three years experience of playing the clarinet (Subject 1), and a 23-year-old male with no musical instrument experience (Subject 2). The subjects looked for a musical score on the display, and generated a tone following a tempo signal of a metronome. The subject was only instructed on the operation method for the input device. No training relevant to performance of the music was provided.

We recorded the signals generated by the input device and the metronome signal (sampling rate = 100 Hz). Figure 6 is a record of signals generated when Subject 1 performed the musical piece on the first day. In the first performance, an evidence of incorrect movement such as overshoot was shown. Incorrect movement was reduced as Subject 1 gained experience playing the musical instrument. On the other hand, Subject 2 not reduced wrong tone generation on the first and second days. On the third day, Subject 2 also reduced incorrect movements and wrong tone generation. Figure 7 is a record of signals that Subject 2 performed the musical piece on the third day.

Figure 8 is a number of wrong tones on the experimental performance. In the final performance, the number of wrong tones that both subjects generated were less than ten times. This suggests that a possibility for a performance of a musical piece using developed electronic musical instrument.

ISSN: 1727-1983

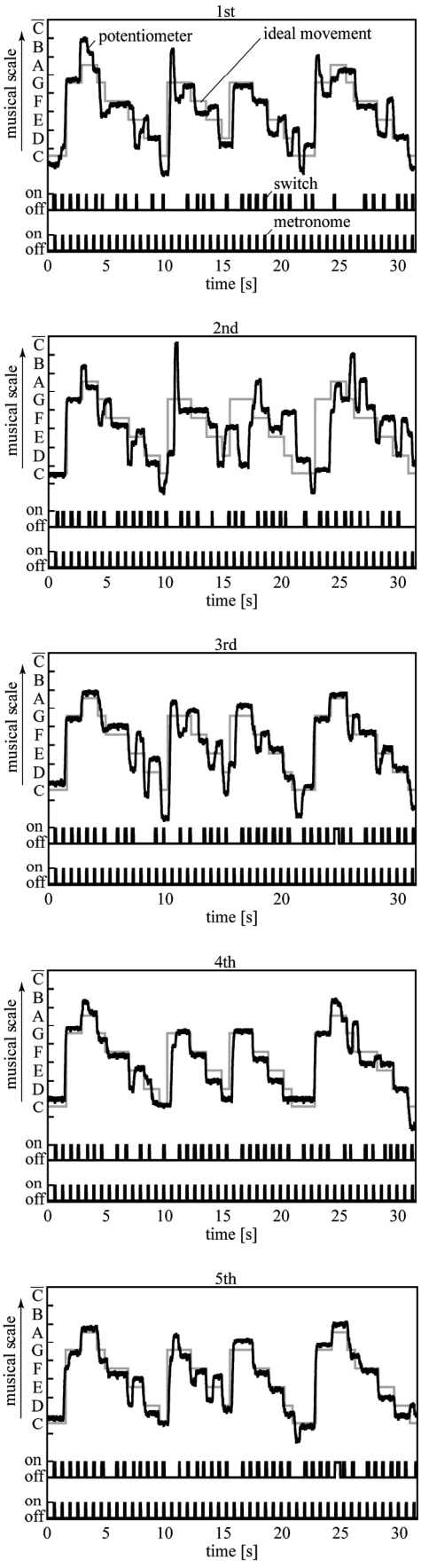

Figure 6: Record of Signals (Subject 1: day 1st)

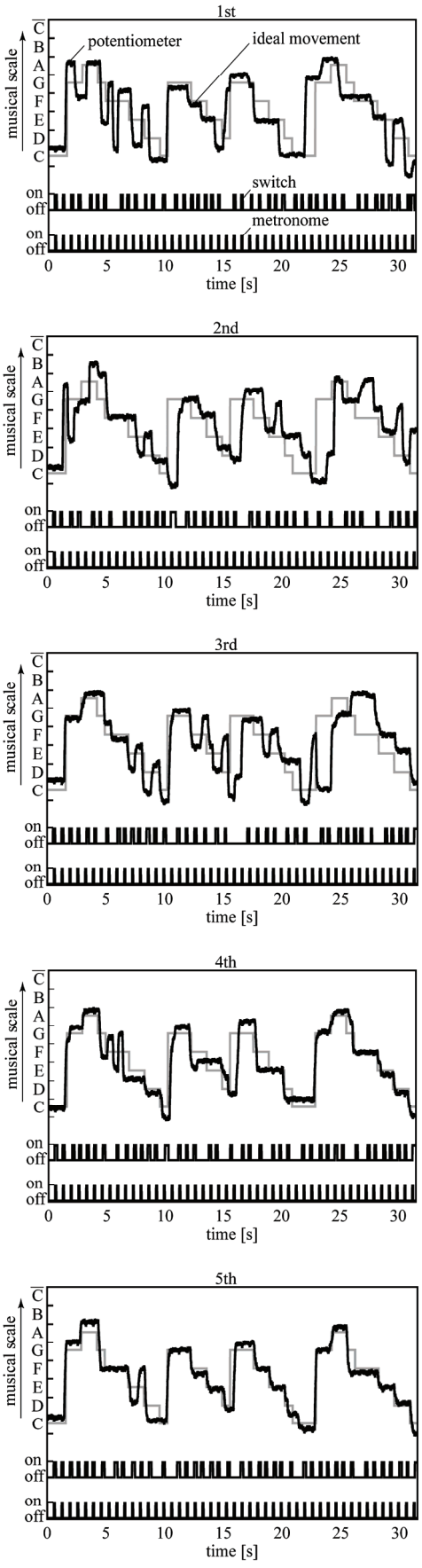

Figure 7: Record of Signals (Subject 2: day 3rd)

ISSN: 1727-1983

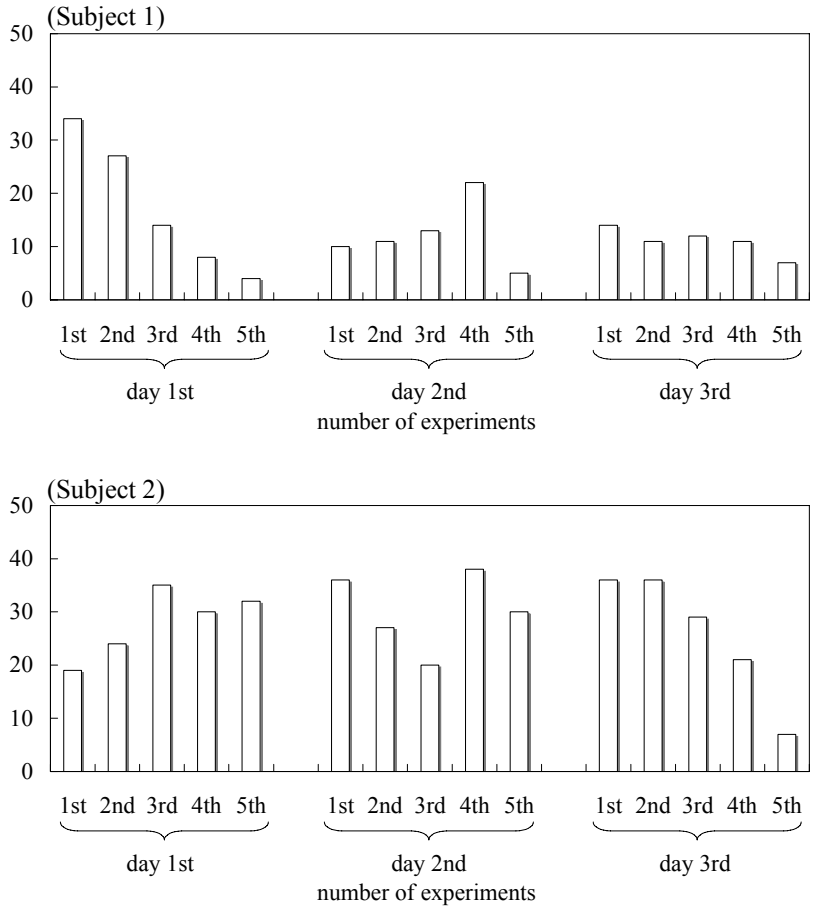

Figure 8: Number of Wrong Tones

Conclusions

In this study, we developed an electronic musical instrument using mandibular and tongue movements. Furthermore, we have proved the effectiveness of this electronic musical instrument by having subjects actually use it to play a musical piece. Subjects were improved their performance of the musical piece over the experimental period of three days.

Consequently, it is suggested that a possibility for a performance of a musical piece using developed electronic musical instrument.

Acknowledgments

This research was partly supported by the Ministry of Education, Culture, Sports, Science and Technology in Japan under the Grant-in-Aid Scientific Research No.17700465.

References

[1] NIIKAWA T. (2004): 'Tongue-Controlled Electro-Musical Instrument', Proc. of the 18th Int. Cong. on Acoustics, vol. III, Kyoto, Japan, 2004, p. 1903-1908

[2] FLETCHER S. G., MCCUTHEON M. J., and WOLF M. B. (1975): 'Dynamic palatometry', *J. Speech Hear. Res*., **18**, pp.812-819

[3] MIZUTANI T., HASHIMOTO K., WAKUMOTO M., MICHI K., HAMADA H., and MIURA T. (1990): 'New graphical expression of the high-speed palatographical data in study of the articulatory behaviors of the tongue', Proc. of Int. Conf. on Spoken Language Processing, 15.4, Kobe, Japan, 1990, p. 605-608

[4] MATSUMURA M., NIIKAWA T., TORII T., YAMASAKI H., HARA H., TACHIMURA T., and WADA T. (2000): 'Measurement of palatolingual contact pressure and tongue force using a force-sensor-mounted palatal plate', Proc. of 6th Int. Conf. on Spoken Language Processing, vol. III, Beijing, China, 2000, p. 893-896

ISSN: 1727-1983