Basic Experiments of Physiological Properties for Information Presenting Method Using Dynamic Electro-cutaneous Sensation Patterns

Yuka Minegishi*, Takashi Watanabe** and Makoto Yoshizawa**

* Graduate School of Engineering, Tohoku University,
** Information Synergy Center, Tohoku University

Abstract

The purpose of this study was to determine experimentally appropriate electrical stimulation parameters for information presenting method using dynamic electro-cutaneous sensation patterns on the forearm. A series of experiments were conducted with neurologically intact subjects changing moving direction of stimulation position in a pattern, pulse polarity or pulse frequency (pps) of electrical stimulation. Experimental results showed that moving stimulation position in the direction of long axis of the forearm was more effective on pattern recognition than that in the direction of short axis. Then, cathodic pulse stimulation with 50 or 100 pps of frequency was suggested to be useful for pattern recognition.

1. Introduction

This study focused on graphical tactile display using electro-cutaneous sensation with dynamically presented patterns [1] for persons with visual or auditory impairments, or a new method of information presentation. In our previous study [1], the proposed method of transmission of information using dynamic patterns was found to be feasible and to have ability to transmit more information compared to the previous static pattern presentation method [2].

The dynamic pattern was presented by moving position of electrical stimulation on the forearm. The forearm was considered to be suitable for the graphical display, because stimulation electrode can be small, the method can be used in hand works, and so on. However, there were several misrecognitions in our previous pattern recognition experiments, probably because the forearm was not so sensitive to electro-cutaneous sensation.

In this paper, moving direction of the presentation pattern was examined first based on the report by Tang et al. [3]. Then, electrical stimulation parameters, pulse polarity and pulse frequency (pps), were examined in order to realize distinct presentation of patterns.

2. Experiment on moving direction

In our previous work, an electrode for a basic study of graphical display on the forearm was designed (Fig.1) [1]. Two different moving directions of sensation in a pattern as shown in Fig.2 were examined on the forearm using the electrode with 6 neurologically intact subjects (5 males and 1 female). Cathodic stimulation pulse with 0.2ms of pulse width and 100pps of frequency was used [1]. Stimulation intensity for each electrode was determined before each experiment.

The pattern recognition experiment was performed on 2 days. On the 1st day, patterns of group A were used for the half of the subjects and those of group B were used for the other subjects. The patterns were
presented once after stimulation intensity determination of each electrode. Then, pattern recognition experiment was carried out by presenting randomly the patterns (totally 5 times for each pattern). On the second day, the pattern recognition experiment was carried out in the same way, but using another pattern group for each subject group. This was for eliminating a training effect of pattern recognition ability in the experiment.

Fig. 3 shows average correct recognition ratio obtained by the two days experiments. Moving stimulation position in the direction of the longitudinal (group B) was recognized with higher correct recognition ratio than that of the direction of the transversal (p<0.01). Correct recognition ratio for the group A was small even on the 2nd experiment day.

3. Experiment on stimulation parameters

Polarity of stimulation pulse and pulse frequency (pps) was examined in pattern recognition experiment conducted with 4 healthy subjects (2 males and 2 females) using the 7 longitudinal presenting patterns of group B shown in Fig.2. The experiment was performed with different pulse polarity and frequency in the following order of condition for 3 consecutive days in consideration of eliminating training effect:

1st day: 1) 50pps cathodic, 2) 100pps cathodic, 3) 50pps anodic
2nd day: 1) 200pps cathodic, 2) 200pps cathodic
3rd day: 1) 50pps anodic, 2) 100pps cathodic, 3) 50pps cathodic

In each experiment, teaching of presenting patterns was performed after stimulation intensity determination, in which each pattern was presented 3 times randomly and correct answer was given after subject’s answer. After the teaching, pattern recognition test was performed by presenting the patterns randomly (totally 5 times for each pattern).

Fig.4 shows the average values of correct recognition ratio. There was a significant difference in the ratio between the anodic pulse stimulation (50+) and the cathodic one (50-) (p<0.05). In the case of using 200pps pulses, the recognition ratio was decreased in some subjects, while using 100pps pulses achieved the similar results as the ratio obtained by using 50pps pulses. Although it may be preferable to increase the number of subjects, effectiveness of using 50 or 100pps cathodic pulses was suggested by some subjects in our preliminary experiments.

4. Conclusion

Experiments were performed to realize appropriate stimulation method for presenting information using dynamic electro-cutaneous sensation. The presentation patterns moving in the direction of the long axis of the forearm was effective in pattern recognition. Cathodic pulse with 50 or 100 pps of frequency was suggested to be useful to present patterns. These results give us useful information on design of presenting patterns and on realizing distinct presentation of the patterns.

Acknowledgement

This work was supported in part by the Ministry of Education, Culture, Sports, Science and Technology of Japan under a Grant-in-Aid for Scientific Research (B).

References