Effects of Fingernail Stimulation of the Little or Ring Finger on Index and Thumb Finger Tactile Sensitivity

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***Abstract*— This study utilized the stochastic resonance phenomenon to investigate the effect of fingernail stimulation of the little or ring finger on the sensitivity of the index finger and thumb finger. In the present experiment, the data did not yield any statistically significant results.**

I. INTRODUCTION

Manual dexterity relies on fingertip tactile sensitivity [1], and its decline can hinder delicate tasks. Therefore, stochastic resonance has been studied as a method that can improve tactile sensitivity [2]. Stochastic resonance is a phenomenon in which noise addition enhances the sensitivity to a subthreshold signal. Devices utilizing this phenomenon are both simple to implement and low in power consumption. Yokoyama and Hashimoto [3] reported that applying weak vibrations to the little or ring fingernail could enhance the sensitivity of the middle finger through a stochastic resonance. An advantage of this method is its non-intrusiveness. As it does not necessitate direct stimulation of the finger pad and thus does not impede manual work. If presenting weak vibrations on the little or ring finger improves all middle, index, and thumb finger sensitivity—key for manual work—it could serve as a supportive method. This paper examines how fingernail stimulation of the little or ring finger affects the tactile sensitivity of the index finger and the thumb (Fig. 1-A).

II. METHOD

Participants traced a felt sheet twice after the experimenter randomly placed a test piece beneath it and reported the test piece's presence or absence. This procedure was performed multiple times, and tactile sensitivity was evaluated by the rate of correct answers. The 5 mm felt sheet covered test pieces of 0.048-0.224 mm thickness (Fig. 1-B). In this study, index and thumb finger sensitivity was evaluated with vibrations on the fingernail of the little or ring finger. White noise vibrations were delivered by a piezoelectric element (Murata MFG Co., Ltd., 7BB-12-9) in five conditions: No-Vib, 0.5T, 0.75T, 1.0T, and 1.25T (1T: vibration perception threshold measured by the up-down method). Vibration conditions were randomly varied every 10 trials, and a total of 50 trials were conducted for each condition.

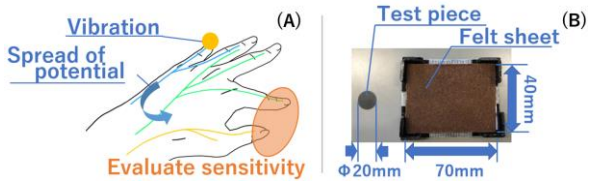

Figure 1. (A) Verified the effect of fingernail stimulation on the index and thumb fingers (B) Test piece and felt sheet

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Test pieces' thickness was such that the rate of correct answers was 54% or less in the no-vibration pre-trial. Tracing force was controlled at 50 g using a force sensor, and speed was set to 120 bpm using a metronome. Eight healthy individuals (mean age ± SD: 23.2 ± 0.8, two female) performed the index finger tasks and four (mean age ± SD: 22.5 ± 0.6, one female) performed the thumb tasks.

III. RESULT AND DISCUSSION

The correct answer rate for the index finger tasks during little finger stimulation was highest at 0.75T with a median of 59% (Fig. 2-A). Then, the correct answer rate for the index finger tasks during ring finger stimulation was highest at 0.5T and 1.25T with a median of 56% (Fig. 2-B). On the other hand, the correct answer rate for the thumb finger tasks during little finger stimulation was highest at 1.0T with a median of 54% (Fig. 2-C). Finally, the correct answer rate for thumb finger tasks during ring finger stimulation was highest at 1.0T with a median of 55% (Fig. 2-D). No statistically significant differences were found between any of the levels for all tasks. However, this study is limited by its small sample size, which may have impacted the statistical power of the findings. Therefore, future research should aim to increase the number of subjects to enhance the reliability and generalizability of these findings. In addition, since the stimuli perceived in the task in this experiment are high-frequency, we would like to test this in a task with lower-frequency stimuli.

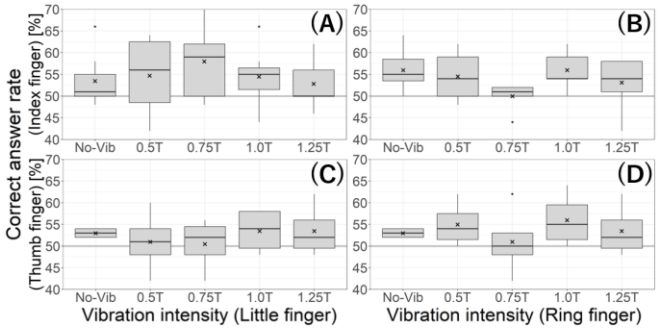

Figure 2. Correct answer rate for conditions (A) Index finger tasks with little finger stimulation (B) Index finger tasks with ring finger stimulation (C) Thumb finger tasks with little finger stimulation (D) Thumb finger tasks with little finger stimulation.

REFERENCES

[1] Shinoda, H.: Haptic Feedback in Manufacturing. Journal of the Japan Society for Precision Engineering, 83(6), 489-493 (2017).

[2] Collins, J. J., Thomas T. Imhoff, et al.: Noise-mediated enhancements and decrements in human tactile sensation, Physical Review, 56(1), 923 (1997)

[3] T. Yokoyama and Y. Hashimoto.: Effect on Haptic Sensitivity of the Middle Finger of Vibrations Applied to the Little Fingernails, 2021 IEEE World Haptics Conference (WHC), 584-584 (2021)