Controlling the Strength of the Hanger Reflex on the Wrist by Presenting Vibration

Takuto Nakamura, Narihiro Nishimura, Taku Hachisu, Michi Sato, and Hiroyuki Kajimoto

***Abstract*— The Hanger Reflex is a phenomenon in which the head rotates involuntary when it is fastened with the wire hanger. This phenomenon is also found on the wrist. The Hanger Reflex is expected to produce smaller and more accurate haptic guide, because the device is fasten by end-effectors itself to user and does not require the fixing part. However, conventional device using the Hanger Reflex can only control the direction of the rotation, and fine control of the virtual force was not realized. To establish high efficient haptic device using hanger reflex, the control of the strength of the virtual force is required. In this paper, we used vibrators attached to Hanger Reflex device and describe the effect of the vibrator on the Hanger Reflex phenomenon on the wrist. The result of the experiment showed that the user feel enhanced virtual force when the vibration is presented under the Hanger Reflex.**

I. Introduction

The Hanger Reflex is a phenomenon in which the head rotates involuntary when it is fastened with the wire hanger [1]. Sato et al. [2] found that there are two sweet spots by measuring the pressure distribution on the head under the Hanger Reflex. This phenomenon is also found on the wrist with similar sweet spots [3].

For the most common haptic display, there is a part for fixing device and end-effectors for haptic presentation [4][5]. In contrast, using Hanger Reflex, the device fixing part is not required because the device is fastened by end-effectors itself to user, so that the device can be smaller and more accurate for haptic guide. Nakamura et al. [3] used this phenomenon and implemented the haptic device by pushing the sweet spots with linear actuators. However, their device can only control the direction of the rotation, and fine control of the virtual force was not realized. To establish high efficient haptic device using hanger reflex, the control of the strength of the virtual force is required.

In our study to control user's wrist, we used vibrators attached to Hanger Reflex device. This paper describes the effect of the vibrator on the Hanger Reflex phenomenon. The result of the experiment showed that the user feel enhanced virtual force when the vibration is presented under the Hanger Reflex.

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II. Hanger Reflex Device for Wrist

Nakamura et al. [6] found that the Hanger Reflex occurs on the wrist. In our study we also focus on wrist, but we did not use their haptic display because it is unable to adjust the size to make it fit to various users with different wrist size. So to fit the device to the wrist of any user, we developed U-shaped Hanger Reflex device made of aluminum (Fig. 1). Since the aluminum is easy to bend, the device can be easily changed the shape to fit any size of the wrist. Based on the sweet spots of the hanger reflex [3], the user can wear the device and generate the hanger reflex. User can change the direction of the force presentation by changing the pressure points of the Hanger Reflex.

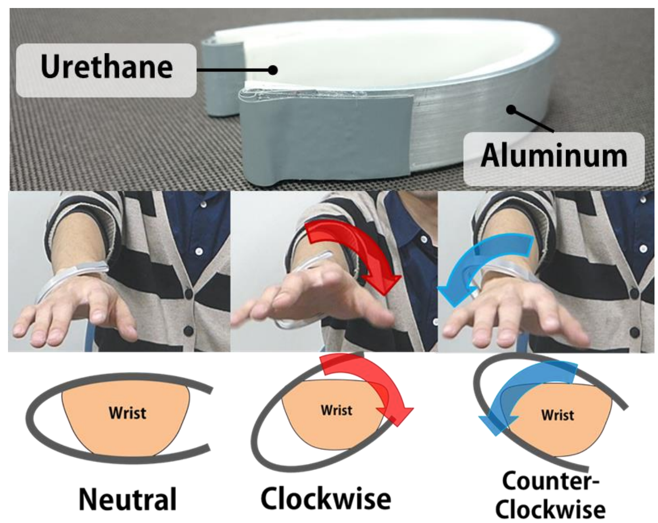

Figure 1. Hanger Reflex Device generates Hanger Reflex by rotating the device

III. Experiment

To confirm that, the vibration is able to enhance the force of the Hanger Reflex, we conducted an experiment in which we measured the rotation angle of the wrist wearing the Hanger Reflex device when the vibration had been presented.

A. Hanger Reflex Device with vibrators

In order to present the vibration to the wrist during the Hanger Reflex, we attached two vibrators (Vibro-Transducer Vp2, Acouve Laboratory Inc.) on the Hanger Reflex device. These vibrators are controlled by the microcontroller (mbed LPC1768, NXP Inc.) with the audio amplifier (M50, Muse Audio). Vibrator was vibrated as sinewave of 100Hz frequency (Fig. 2).

Figure 2. Configuration of the Hanger Reflex device attached with vibrators

B. *Measurement System*

We developed a measurement system for the experiment by using Visual C# and Leap Motion (Leap Motion Inc.). Leap Motion measured the rotation angle of the wrist. The hanger device generates the hanger reflex and presents the vibration to the wrist. The system records the angles of the wrist and the vibration signal with timestamp.

C. *Procedures*

We recruited four males (range of age 21 to 23) to participate this experiment. Before the experiment, we confirmed that all participants are responsive to the Hanger Reflex on the wrist using the Hanger Reflex device.

We asked the participants to wear the Hanger Reflex device on the wrist of right hand, and sit down on the chair. Next, they put their wrist into the box launched with the Leap Motion. Before each trial of presenting the vibration, we checked and asked participant to keep the wrist as in the initial position in which the wrist is parallel to the Leap Motion (Fig. 3). We instructed them to obey the force if they felt that it occurs when there is vibration.

As shown in Figure 1. there were three types to present the Hanger Reflex device; Neutral in which the Hanger Reflex does not occur even through the device was placed on the wrist; Clockwise; and Counter-Clockwise. For our experiment, vibration was presented in all of these types, so the presenting conditions are Vibration + Neutral, Vibration+ Clockwise, Vibration + Counter-Clockwise. Each condition was presented five times, so it was 15 trials in total for each participant. In each trial, we presented eight times of vibration in interval of one second and the rest time between each vibration was three seconds. We measured the rotation angle of the wrist during each time of vibration and the rotation angle of atrial is the average of the eight time presentation. To make sure that the vibration is able to keep their wrist as in the initial position even though they feel rotation force of Hanger Reflex unless the vibration is presented.

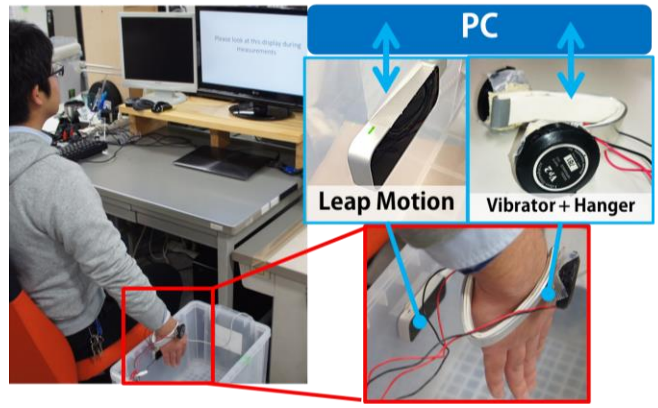

Figure 3. Measurement Setup

D. *Result*

Fig. 4 shows the averages and standard deviations of the rotation angle for each type of presentation. The positive and negative values represent the clockwise rotation and the counter-clockwise rotation, respectively. The mean and standard deviation were -0.11° and ±1.10°, 43.75° and ±31.43°, -39.02° and ±32.56° for neutral case, counter-clockwise case, and clockwise case, respectively. A Turkey test revealed a significant difference between each type of presentation.

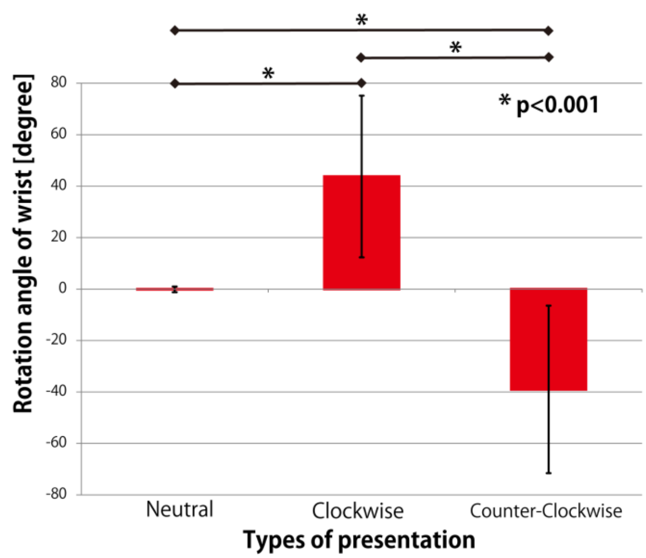

Figure 4. Means of rotation angle for each types of presentation

E. *Discussion*

As shown in Fig. 4, presenting the vibration to the wrist with hanger reflex induced additional involuntary movement. Also the participant commented that they felt the force when the vibration presented. Based on these, the presented vibration provided the additional virtual force, and it induced involuntary movement. It is suggested that the vibration is able to control the involuntary movement and the virtual force. In this experiment, we used only 100Hz of sinewave. For more detail of this phenomenon, we need to try other frequency or other kinds of wave.

Here, we discuss about the reason why this phenomenon occurs. We mounted the hanger device to the wrist, and presented the vibration to the wrist through the device with a voice coil type of vibrator. The vibration of a voice coil type vibrator is consists of two types of movements. One is the direction toward the center of the wrist and enhances the skin deformation. The other is the direction away from the center of the wrist and reduces the skin deformation. While the amplitude of the vibration is same in both directions, the strength of the stimulation that people percept changes as the amount of the skin deformation changes. Due to the nonlinearity of the perception, people may feel the stimulation from only one direction more, and it may generate this phenomenon. Using this nonlinearity of the perception, some works were already reported to generate the virtual [8][9]. In these works, they presented the asymmetric acceleration to the user. However, we did not present the asymmetric vibration in the experiment. Instead of the asymmetric vibration, we stretched the skin before the vibration, and it may generate similar effect to the skin.

IV. Conclusion

In this paper, we reported a phenomenon that the virtual force of the Hanger Reflex on the wrist is enhanced by presenting the vibration. The result of the experiment suggested that the vibration presented to the wrist under the Hanger Reflex enhanced the virtual force and induced the involuntary movement.

For our experiment, we used only 100Hz sinewave, therefore we will try other frequency and wave to know more detail of this phenomenon. We will also develop a haptic device and a wrist control algorithm using this phenomenon.

Acknowledgment

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