Sense of Agency in Drum Trainer with Multiple Sensation Feedback

Vibol Yem
Tokyo Metropolitan University
Hino, Tokyo, Japan
yem@vr.sd.tmu.ac.jp

Fumiya Miyashita
Tokyo Metropolitan University
Hino, Tokyo, Japan
miyashita@vr.sd.tmu.ac.jp

Tomohiro Amemiya
The University of Tokyo
Bunkyo, Tokyo, Japan
amemiya@vr.u-tokyo.ac.jp

Michiteru Kitazaki
Toyohashi University of Technology
Toyohashi, Aichi, Japan
mich@tut.jp

Yasushi Ikei
Tokyo Metropolitan University
Hino, Tokyo, Japan
ikei@vr.sd.tmu.ac.jp

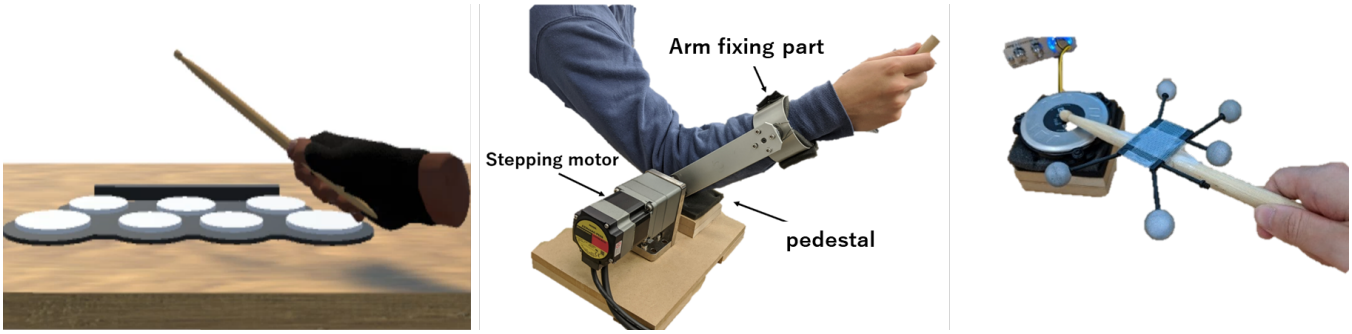

Figure 1: (Left) Visual drumming feedback. (Middle) Forearm driving device. (Right) Vibrotactile device for collision sensation.

ABSTRACT

Passive motion is often used in physical skill transfer. This study investigated sense of agency during virtual drumming with visual, vibrotactile and auditory sensation feedback in three types of forearm motion: voluntary, passive and imagined. Agency judgement showed that visual, vibrotactile and auditory feedback contributed to sense of agency around 25 %-45 % depending on the type of forearm motion. Motor command in voluntary motion contributed about 35 %, while proprioception in passive motion did about 25 %. These results suggested that multiple sensation feedback contributed to generate sense of agency.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**.

KEYWORDS

Sense of agency, drum training, skill transfer, virtual reality.

ACM Reference Format:
Vibol Yem, Fumiya Miyashita, Tomohiro Amemiya, Michiteru Kitazaki, and Yasushi Ikei. 2020. Sense of Agency in Drum Trainer with Multiple Sensation Feedback. In *Special Interest Group on Computer Graphics and Interactive Techniques Conference Posters (SIGGRAPH '20 Posters), August 17, 2020.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3388770.3407407

SIGGRAPH '20 Posters, August 17, 2020, Virtual Event, USA

ACM ISBN 978-1-4503-7973-1/20/08.
https://doi.org/10.1145/3388770.3407407

1 INTRODUCTION

Sense of agency refers to the feeling of causing or taking in charge of an action [James 2016], and it has been studied in the field of health and wellbeing to psychologically investigate the states of disorder patients [Franck et al. 2001]. Currently, it is also increasingly studied in the field of human computer interaction (HCI) and virtual reality (VR) to evaluate an interactive user interface or the training simulation system [Berberian et al. 2012].

In this study, we focused on the sense of agency that occurs when transferring drumming skills. We investigated how feedback of visual, vibrotactile and auditory sensation contributed to sense of agency. Contributions of intention and motor command in voluntary motion and proprioception in passive motion were also investigated.

2 MATERIAL AND METHOD

2.1 Experimental System

A virtual drumming environment was designed to show visual feedback on a head mounted display (HMD) (Figure 1 Left). When a drumstick collides with the drum's surface, collision sound transmitted to the headphones, and vibration sensation transmitted to

the hands by a vibrotactile device for 0.1 second with frequency of 35 Hz. (Fig. 1 right).

The position of an actual drumstick was measured by a motion capture system (OptiTrack V120 Trio) and was reflected in real time in virtual space. A virtual hand was fixed to a virtual drumstick, but its posture did not match with a real hand. A real forearm is fixed to a band at the tip of a link that is rotated by a stepping motor (Fig. 1 middle). Resolution of the stepping motor was 0.01 deg/pulse; maximum speed was 83 rpm; and peak torque was 20 Nm. Rotation angle and rotation speed were set based on a trajectory planned in advance.

2.2 Conditions and Procedure

Three types of beating the drum, which are voluntary, passive and imagined motions, were compared. In voluntary motion, participants hit the drum with their own action, while in passive motion, the forearm was driven by the link. The link rotated with 180 deg/s speed to hit and 100 deg/s to return the forearm back to its position. In imagined motion, the forearm and link were held at rest with the stick contacting the vibrotactile device, then participants were asked to concentrate on an image of hitting the drum. Eight feedback conditions were set up from the combination of visual, vibrotactile and auditory sensations; thus, 24 stimulus conditions in total were rated.

Ten university students without drumming skills (average age of 22.9 years) were recruited to participate in the study. They learned the operation of the system wearing an HMD and headphones. Drumming started after the countdown sound went off. After each trial, they rated the extent to which the drumming was done by their own action (i.e. sense of agency) using a visual analogue scale of 'no voluntariness (0) to full voluntariness equivalent to own act (100).'

3 RESULTS AND DISCUSSIONS

Figure 2 shows the rated amount of sense of agency in terms of the 24 stimulus conditions list in the horizontal axis. The result indicated that the use of visual, vibrotactile and auditory sensation feedback highly contributed to the generation of sense of agency. The agency increment was about 45 % for voluntary motion, 35 % for passive motion and 25 % for imagined motion. In voluntary motion, even if the motion was intended and commanded to the motor system to actuate the arm, sense of agency was greatly decreased when no sensation feedback was provided. This shows that sense of agency depends highly on integrated sensory input that matched with predicted states in which sound and vibration from collision simultaneously occur. However, the sense of agency was not 100 % because visual and tactile sensation feedback was deteriorated from the real information.

On the other hand, it is reasonable for sense of agency to decrease under passive motion conditions, in which no intention and motor command were provided. However, it was a considerably high value of around 50% when feedback of visual, vibrotactile and auditory sensations was presented. This indicates that sense of agency does not depend only on intention of action and motor command but also sensory feedback that is involved in the consequence of an action.

According to the result, with imagined motion, intention of action contributed sense of agency about 5 %. From these data, we simply calculated to find the contribution of motor command in voluntary motion and proprioception in passive motion; when feedback of visual, vibro-tactile and auditory sensation was presented. The difference between voluntary motion and passive motion was about 40 %, which might be attributed to the motor command with intension. Therefore, the contribution of motor command alone was about 35 %. On the other hand, the difference between passive motion and imagined motion was about 20 %, so the contribution of proprioception was about 25 % (20 % + 5 % of intention). It indicated that proprioception by itself could contribute to sense of agency even if it was passive motion.

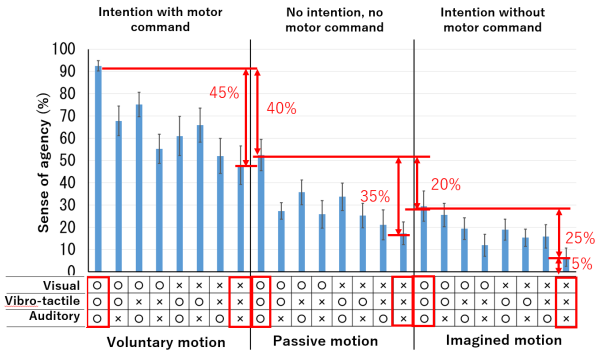

Figure 2: Explicit agency judgement for each arm motion condition and multiple sensory feedback. o and x indicate presentation of visual, vibrotactile and audio feedback.

4 CONCLUSION

Although the existence of action, intention and motor command is a direct source, lack of sensory feedback in the VR space decreased the sense of agency. On the other hand, though the forearm was passively actuated without intention and motor command, proprioception by itself contributed to the sense of agency. Thus, passive-motion drum trainer was revealed to maintain a part of voluntary sensation in reception of drumming skills.

ACKNOWLEDGMENTS

This work was partially supported by the MIC/SCOPE #191603003, JSPS KAKENHI Grant Number JP26240029, 18H04118, 18H03283 and NICT #143u101 projects.

REFERENCES

B Berberian, J.C Sarrazin, P.L Blaye, and Patrick Haggard. 2012. Automation technology and sense of control: a window on human agency. *PLoS ONE* 7 (2012). https://doi.org/10.1371/journal.pone.0034075

N Franck, C Farrer, N Georgieff, M Marie-Cardine, J Daléry, T d'Amato, and M Jeannerod. 2001. Defective recognition of one's own actions in patients with schizophrenia. *Am. J. Psychiatry* 158 (2001), 454–459. https://doi.org/10.1176/appi.ajp.158.3.454

W.M James. 2016. What Is the Sense of Agency and Why Does it Matter? *Frontiers in Psychology* 7 (2016), 1–9. https://doi.org/10.3389/fpsyg.2016.01272