

# How Agency Influences Ownership and Body Representation

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**Abstract**—Sense of agency refers to the feeling of controlling ones' own action or external effect via one's action, while sense of ownership refers to the feeling of owning one's body. In the present study, we examined the influence of sense of agency on the sense of ownership and body representation with a rubber hand paradigm, and found that sense of ownership probably plays an important role in construction of body awareness.

## I. INTRODUCTION

Body representation refers to the mental representation of body parts and is updated continuously by sensory input. The processes of maintaining and updating body representation can be examined with the rubber hand illusion [1]. In the rubber hand paradigm with synchronous movements, when a fake hand has congruent posture and moves synchronously with one's hidden real hand for a period, one would feel that the fake hand belongs to him or herself (sense of ownership), the movement of the fake hand is controlled by him or herself (sense of agency), and the perceived position of the real hand would drift to the fake hand (proprioceptive drift that reflects changing in body representation) [2], [3]. The relation between sense of agency, ownership, and body representation is still unclear. In the present study, we manipulated the sense of agency with delays in responses of the rubber hand paradigm, and examined the relation between agency, ownership and body representation with a multivariate analysis.

## II. METHOD

A total of 16 students from the University of Tokyo participated in the experiment. In each trial of the experiment, participants sat at the front of a horizontally placed 27-inch monitor. The participant's hand was hidden by a blanket and placed on a sliding rail to restrict hand movement in a horizontal direction, 250 mm bellowing the monitor. Participants were told to move their hands forward and backward upon cues presented every 2.5-3.5 s on the monitor, while a virtual hand was presented above the actual hand, responding to the movement of the actual hand with a 0, 300, 700, or 1200-ms delay (trial order was randomized), or moved randomly without responding to the position of the real hand. The delay was used to vary sense of agency over the virtual hand. After moved their hands for 5 min, participant pointed to the height of their left hand with their right hand while eyes closed (proprioceptive drift), and rated two statements that referred to the feeling of ownership ("I felt as if the virtual hand was my hand") and agency ("the virtual hand moved just like I wanted it to, as if it was obeying my will") on a 7-point Likert scale (-3: totally disagree; 0: uncertain; +3: totally agree).

## III. RESULTS AND DISCUSSION

The means and standard errors for ownership, agency ratings, and proprioceptive drift are presented in Fig. 1.

When the virtual hand moved randomly, the participants did not feel sense of agency or ownership over the virtual hand, and the proprioceptive drift was smaller than that in the other conditions. Further, agency, ownership, and proprioceptive drift decreased along with the delay.

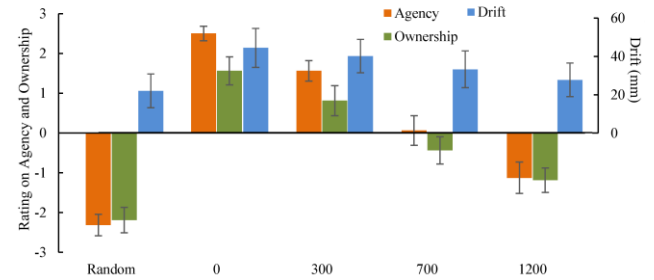


Fig. 1 Average agency and ownership rating, and proprioceptive drift

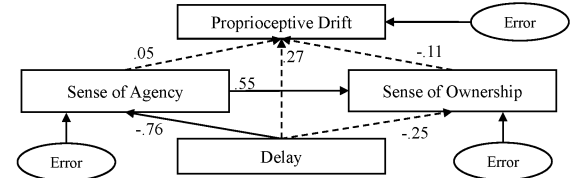


Fig. 2 Structure model of the multivariate analysis

Moreover, in order to examine the relations between agency, ownership, and body representation (i.e., the proprioceptive drift), we conducted a multivariate analysis with SPSS Amos 22. The model and standardized coefficients for all paths are depicted in Fig. 2. Significant and nonsignificant paths are represented by solid and broken lines, respectively. We found that delay significantly influenced the sense of agency, as expected, and sense of agency significantly influenced sense of ownership. In other words, in the present study, the sense of ownership was affected by delay via sense of agency indirectly, rather than a direct influence. However, regarding to body representation (proprioceptive drift), we did not find any significant influences by the suggested factors. The issue whether body representation is closely linked with sense of agency and ownership still needs further discussion, by involving a body agency or ownership rather than external agency and ownership.

## ACKNOWLEDGMENT

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