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The influence of goals on sense of control

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ABSTRACT

We examined the influence of goals on sense of control relative to that experienced when taking action randomly. In the experimental task, participants controlled the direction of a moving dot by pressing the left and right keys at will without a specific goal (the control condition), directed the moving dot to a destination as often as possible (the strong goal condition), or kept the moving dot in the central area of the screen (the weak goal condition) for as long as possible. The results showed that the strong goal impaired the sense of control, but the weak goal did not exert an influence. We concluded that the goal-based expectation influenced sense of control, but the goal-directed action selection did not. Furthermore, we proposed a modified comparator model of the sense of control, offering a promising approach to integration of the predictive and postdictive processes involved in the sense of control.

1. Introduction

In daily life, people send commands to objects, such as computers, cars, or ovens, to cause these machines work as intended. During such operation, a subjective feeling, "I am controlling it," emerges. This feeling is known as a *sense of control* (also called a *sense of agency* in the literature). Sense of control is important in explaining changes in the outside world and making and following decisions. However, the occurrence of events could match one's prediction or expectation coincidentally and induce an illusionary sense of control.

According to the comparator model, a subjective feeling of control is produced via comparison of predicted and sensed information (Blakemore, Frith, & Wolpert, 1999; Blakemore, Wolpert, & Frith, 1998, 2002; Frith, Blakemore, & Wolpert, 2000; Wolpert & Flanagan, 2001; Wolpert & Ghahramani, 2000). Specifically, a predicted state is generated via an efferent copy of a motor command and compared with the sensed state. The feeling of control emerges due to the match between the predicted and sensed states (Blakemore et al., 2002).

However, later research has suggested that predictive processes based on motor signals might not be necessary for the generation of a sense of control, which would also be influenced by contextual information and prior knowledge (Synofzik, Vosgerau, & Newen, 2008; Wegner & Wheatley, 1999). Wegner suggested that the sense of conscious will, including the sense of agency, could be an illusion based on postdictive inference (Wegner, 2002). In particular, when a thought occurs prior to an action (i.e., the priority principle), is consistent with that action (i.e., the consistency principle), and alternative causes do not exist (i.e., the exclusivity principle), people experience authorship of the action (Wegner, 2003). For example, Wegner and colleagues reported that participants felt an illusionary feeling of control over another's hand when they heard instructions for the other person's movements in advance (Wegner, Sparrow, & Winerman, 2004). In their exper-

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iment, paired participants (i.e., helpers) stood behind participants with their arms stretched forward and performed a series of movements. The participants standing at the front could see themselves and the helpers' arms in a mirror. Although the participants did not perform any movements themselves, when they heard the instruction describing the helpers' movement in advance, they reported feeling a sense of agency over the actions performed by the helpers. This phenomenon matched the priority and consistency principle of Wegner's theory but did not contain motor signals. Therefore, it is often cited in studies suggesting that the comparator model does not account for the sense of control adequately. In recent research, most researchers in this field have agreed that both predictive and postdictive processes contribute to sense of control. For example, Synofzik and colleagues proposed a two-step account of agency, in which predictive processes are presented at a perceptual level, and postdictive processes are presented at a propositional level (Synofzik et al., 2008). Furthermore, Moore and Fletcher (2012) proposed a framework for cue integration, in which the authors suggested that multiple cues, both internal and external, contribute to the sense of agency, and the extent of this contribution depends on their reliability (Moore & Fletcher, 2012).

In the present study, we focused on the influence of goals on the sense of control. In many daily situations, people take action to achieve specific goals as opposed to acting randomly. It is important to determine whether goals influence the sense of control in order to understand human behavior and verify the mechanism of the sense of agency. If the sense of control is relevant to a goal, when we actually use a machine to complete a job, we could find that the sense of control differs from that experienced in situations in which we used the machine without a specific goal.

We hypothesized that goals would influence sense of control. Our hypothesis had two foundations involving goal-directed intention and goal-based expectation. Pacherie categorized intention into three types: distal (D-intention), which refers to the intention to achieve a distal goal; proximal (P-intention), which refers to the will to initiate action; and motor (M-intention), which involves the motor representations underlying one's actions (Pacherie, 2008). When there is a goal present, people select optimal actions and timing to achieve the goal; therefore, distal and proximal intention are activated, form an expectation according to distal intention, and influence motor intention. In contrast, when there is no specific goal, the active levels of distal and proximal intention are at low levels, and only motor intention is dominantly involved in the development of the sense of control. In summary, if there is a goal present, both action selection and outcome expectation differ from those of conditions without a goal. The processes underlying action selection have been reported to affect the sense of control (Wenke, Fleming, & Haggard, 2010); therefore, goal-directed motor intention could influence the sense of control. Furthermore, conscious expectation of a goal state has been reported to enhance experienced authorship (Aarts, Custers, & Wegner, 2005); therefore, goal-based intention could also affect the sense of control. Moreover, when there is a specific goal present, people are likely to expect to achieve the goal and compare actual sensory feedback with their expectations. If the feedback does not match their expectations, the sense of control could be impaired (Van der Weiden, Ruys, & Aarts, 2013). Furthermore, a recent study reported that the comparison of motor commands and their effects would be uncertain when the effects were delayed, and in consequence, the comparison of goal and outcome would be more dominant relative to the action-effect comparison in such a condition (Wen, Yamashita, & Asama, 2015).

In the present study, we examined the influence of goals on sense of control. In order to determine whether goal-directed action selection or goal-based expectation influence sense of control, the sense of control in two different goal conditions were compared with that of a condition without a goal (i.e., the control condition). Specifically, in the strong goal condition, a goal accompanied by performance feedback was provided for participants. In the weak goal condition, a similar goal was provided but no obvious state reflecting achievement of the goal was defined. If goal-directed action selection is important, sense of control in both the two goal conditions would differ from the one in the condition without a goal. If goal-based expectation alone is important, sense of control in the strong goal condition would differ from that of other conditions.

2. Method

2.1. Participants

A total of 20 students with normal or corrected-to-normal visual acuity participated in the experiment and received monetary compensation in return for their participation. Their mean age was 25.9 years (SD = 3.9, range 22–32). The experiment was conducted according to the principles of the Helsinki Declaration and approved by the ethics committee of the Faculty of Engineering at the University of Tokyo. All participants provided written consent prior to participation.

2.2. Stimuli and task

In each trial of the experimental tasks (Fig. 1), a 5-mm black dot appeared in a random position on a 597 mm × 336 mm (width × height) gray background, following the presentation of a 500-ms blank screen, and moved randomly at a speed of 124 mm/s. The direction of the dot did not change until it reached the borders of the screen or participants pressed the left or right key during the trial. When it reached the screen borders, the dot bounced back. Participants were instructed to press the left or right key on the keyboard to change the direction of the moving dot. The direction of the dot turned 20° clockwise with a right key press and 20° counterclockwise with a left key press and reflected a certain probability. The participants were told to press the left or right key repeatedly (the direction of the moving dot would not change if participants held