Diminished Agency: Attenuating a Sense of Agency for Problem Finding on Personal Physical Performance

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Abstract. A feeling that "I controlling this" is called as the sense of agency (SA). Recently, there have been many studies for improving motor skill through making perception that the passive bodily movement caused by observation of the other's movement or a machine operation as active movement. However, these methods cannot impress the problems of self-motion. In this regard, we hypothesize that observation of himself/herself from third-party's point of view and improving skill of finding problem of self-motion is possible when self-motion is perceived as an other person's motion based on mechanism of SA. In this paper, we propose "Diminished agency" to attenuate SA from observing self-motion for the finding problem involved motor-skill based on the findings a sense of ownership (SO) influences SA. This paper summarizes finding mechanism of SA and discusses the feasibility of "Diminished agency."

Keywords: Diminished agency · Sense of agency · Sense of ownership · Problem finding skill

1 Introduction

To enhance a skill of the sports or passing traditional techniques, learners have to be aware of good or bad points of their motions [1]. If we are aware of a problem in our motions, we can revise them effectively and can get the skills.

As the previous method of behavior analysis, two types of method are mainly used for analyzing ourselves, an introspection and an observing others. The latter is the method in that a professional outsider for some motion techniques observes our motions, and reveals the problems. In this method, the lack of skills or knowledge of these specialists is possible to decrease the quality of training and to make learners' motions worse. Therefore with this method we need a specialist with high skills, so it is not easy to use this method in our daily life. On the other hand, introspection is a

method in that learners observe themselves objectively using a video recording, and reveal the wrong points of their physical exercises. This method does not need a specialist and is useful in a daily life. In the phase in that we reveal our good or bad points by observing ourselves, It is important that we can observe us as others. However, for our own performances, the cognitive bias can be occurred with which it is hard to analyze or to evaluate our performance precisely. Especially, it is difficult to aware of self-problem for learners who have gotten a skill to some extent.

In this regard, recently the engineering field has tried to research for getting a motor skill by focusing on the sense of agency (SA). SA means the subjective feeling that we do some work by ourselves [2].

These main studies use the method that informs the motion by making users perceive passive motions directed by some machines, as their own active motion. For example, Mizushina et al. proposed the method that evokes the sense of agency by making users relive a motion of playing the badminton from the first-person view [3]. This system displays the vibration stimuli on the racket that a leaner has in actual, when a specialist hit a shuttle on his or her racket in the video. These stimuli makes users feel as if they can perform and hit a shuttle like a specialist, by evoking the sense of agency to the motion of a specialist in a video. Ikei et al. also propose a system named "five sense system" for making a feeling as if a user walks actively although the user sitting on a chair by presents vestibulohaptic and vibration sensation resembles walking bodily movements [4].

However, simulating all the movements of an expert is inefficient when a learner's skill is more excellent than the expert up to a certain phase. These methods also can not solve the fundamental problem for finding problem of self-motor skill since it is difficult to impress the reason of changing self-motion.

We hypothesize that cognitive bias caused by SA at the time of self-motor skill analysis would be removed by not enhancing SA toward external person's motion but diminishing SA from self-motion. Based on the hypothesis, we propose "Diminished agency" for attenuating SA from self-motion reflected picture images.

First, this paper digests findings about the mechanism of SA. Then this paper introduces the concept of "diminished agency" for improving problem finding skill and discusses the feasibility of our proposed concept based on our past works.

2   The Senses of Agency and Ownership as Foundation of Self-recognition

The sense of agency (SA) is a mechanism of recognizing the agent of behavior or action as ownself. During working state or movements, SA is considered that evokes when perceived deep sensation and visual feedback caused by intentional movement and matches the prediction of its [2].

SA has close relationship with the sense of ownership (SO). SO is a mechanism of distinguishing oneself from the external environment [5]. In other words, SO is the subjective feeling that "This is myself." SA and SO are regarded as the principal of self-awareness [6].

In general, SO is felt only for self-body. However, SO has been known to also occur for the things outside the body. As a representative example, it has rubber hand illusion well known. Rubber hand illusion is a phenomenon that a rubber hand front of the eye has come to be perceived as a part of a self-body when self-hand and rubber hand are traced with a brush at the same time with covering self-hand [7].

However, SO is less likely to occur if the appearance of the observed object is different from self-hand. For example, SO does not occur when the rubber hand with hand consisted tree branches or when the rubber hand placed in the direction from the rotation 90° of the self-hand [8].

These phenomena occurs since SO is perceived by matching of visual and deep sensation obtained through bodily movement. Generally, the core sensation for a range of self-body is deep sensation. The body perceived by the deep sensation is referred to as "body schema" [9, 10]. However, the range of body recognized in the brain flexibly changes due to the interaction of visual and deep sensation. In this regard, it is clarified that five factors, including spatial continuity, skin texture, shape, coherency of visual-tactile sensation and coherency of visual-motion influence in evoking SO.

Various studies also confirmed the influence of SO in SA. For example, when hitting the virtual drum with image-based computer graphic (CG) hand reflects the movement of the self-hand motion in a virtual environment, the CG-hand is felt as not to reflect the movement of self-hand if the color of the CG-hand is significantly different from the actual hand color [11]. Also, the perception of momentum and position of self-hand in the virtual environment is also influenced by the apparent momentum and position CG hand [12].

In this way, the apparent characteristics and movements of the body affect not only SO but also SA. Based on these findings, in this paper, we propose a method for eliminating SA by modifying apparent bodily characteristics or movement during exercise that are visually observed (Fig. 1).
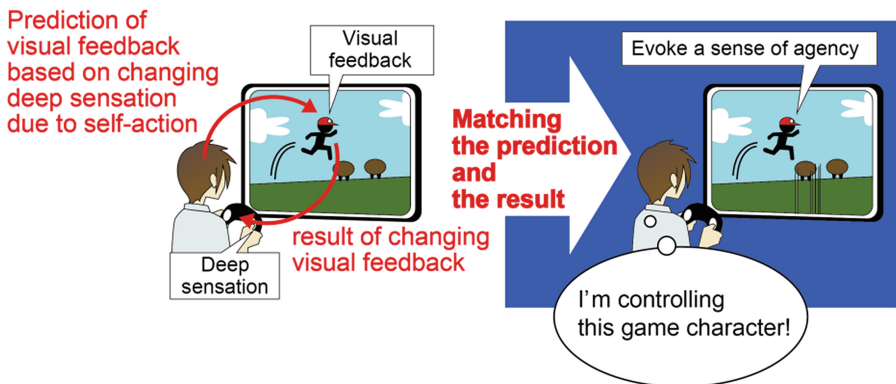

Fig. 1. The sense of agency

3   Diminished Agency

3.1   Concept of Diminished Agency

The concept of the "Diminished agency" shown in Fig. 2. "Diminished agency" is a method for attenuating SA by modifying the apparent cues of self-body that affect a SO. As described in Sect. 1, the main purpose of the conventional method for improving performance skill through controlling SA is to understand bodily movement of an expert as if the bodily movement of the learner. However, the purpose of "Diminished agency" is improving the skill of finding problem of the learner's bodily movement by making the learner realized that oneself s/he looks is not myself by the use of the mechanism of SA.
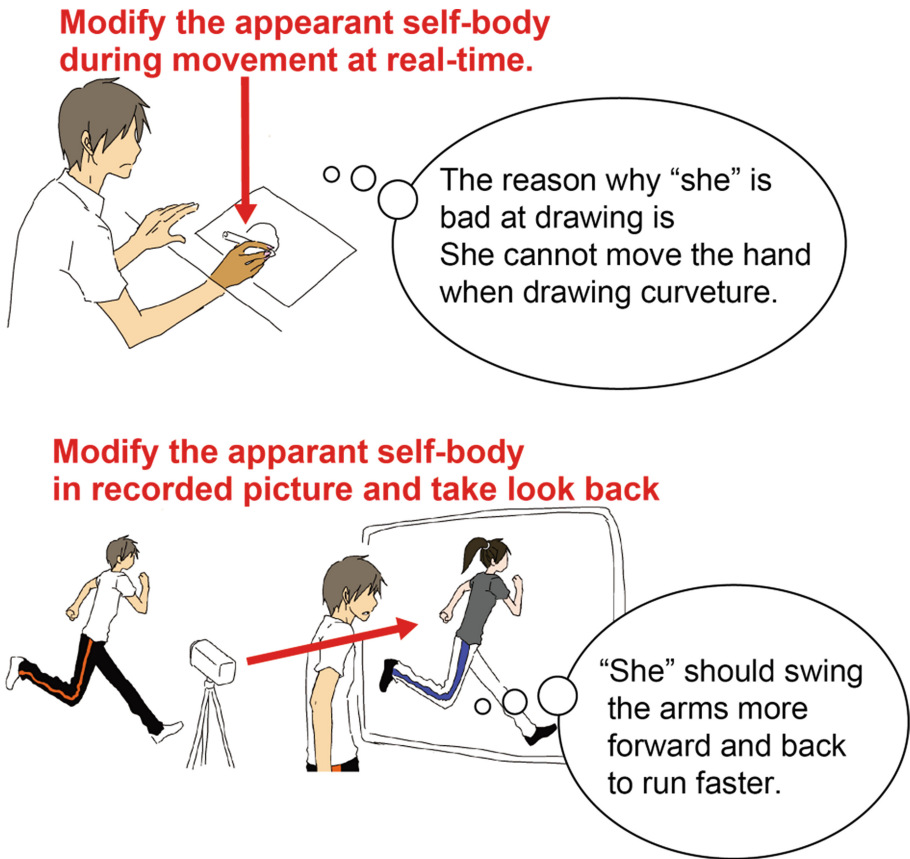

Modify the appearant self-body during movement at real-time.

The reason why "she" is bad at drawing is She cannot move the hand when drawing curveture.

Modify the apparant self-body in recorded picture and take look back

"She" should swing the arms more forward and back to run faster.

Fig. 2. Diminished agency

As they say "you can better yourself by observing others," many people would be able to find problems of oneself by standing in a position to teach to a third party.

In this paper, we discuss the feasibility of "Diminished agency" for improving the skill of finding problem and acquiring a user's motor skill.

3.2   Findings Obtained from Previous Works

Researchers have discussed that how these factors affect each other and which factor affect stronger than others for a long time. However, it has not been revealed that the range of expansion of the body schema and how we can control it concretely. Besides, the effect of the Rubber Hand Illusion like [7] is individuality, so the how the SO changes is different person to person although the condition of these factors are same.

In this regard, we are now trying to investigate the effect in the SO and its relationship between these factors described above, when some factors are completely different from what a subject actually has. For this investigation, we constructed an artwork called "Metamorphosis Hand", which provides users with a pseudo-experience of playing a virtual piano with a dynamically transforming body [13]. This system enables users to play a virtual piano, and gives users an illusion as if their own hands' shape or texture are modified by synchronizing a user's motion and an audiovisual feedback to evoke a pseudo haptic sensation.

The pattern of deformation for a CG-hand that this system displays are following four patterns: texture of a skin, modification of a shape, a visuo-motor asynchrony and modification of a shape with a visuo-motor asynchrony.

Through the exhibition, we investigated that how these modifications affect the sense of body ownership for the CG-hand. More than 400 people experienced the system. Overall, most people seemed to have bizarre or peculiar feelings because even though the shapes differed considerably from their own, they felt a strong sense of body ownership. On the contrary, when the movements of the left and right hands were exchanged, most people could not understand what happened to their virtual hands and they seemed to have difficulty in completely controlling their virtual hands at will. Therefore, in this pattern, they did not feel the sense of body ownership to the CG-hands.

In this exhibition, we also asked users that *"Do you feel that you playing the piano with your own hand?"*. Many of the users told positive answer to this question when they tried with virtual hands, which texture or shape was modified. However, when the visuo-motor synchronization was broken, they did not feel the sense of body ownership.

This study suggested that modification of the CG-hand's shape or texture does not reduce the sense of body ownership, even if the visuo-motor synchronization is remaining. However, to realize "Diminished Agency," it can be hard to analyze a body motion or to extract points for revising the behavior, if the difference between actual body motion and virtual body motion. Therefore, we should precisely consider the range of modification of physical feature with which the system can show oneself in a video as others while keeping the features of a body motion.

Furthermore, we will consider how the reality of the virtual body affects the sense of body ownership and agency, especially the difference of effect between an image based virtual hand and a CG-hand. Argelaguet et al. revealed that there is no specific

need to provide realistic avatar representation to increase the sense of agency [14]. Besides, they also revealed that the sense of ownership is dependent on the virtual representation of the virtual hand and the need of morphological resemblance is required to increase the sense of ownership. As this study, we should consider which method is more suitable for diminishing agency, using an image-based body or a CG-body.

There is also need to examine the effect of our proposed method on the changes in SA and SO and the skill of finding problem of self-motion. In this regarding of the evaluation of SA and SO, various rating scales have been proposed [7, 12, 15, 16]. Besides, we will evaluate our proposed method on the skill of finding problem of self-motion by comparing the numbers of found problems when a user watch actual picture of self-motion with the numbers when the user watch picture of modified appearance bodily characteristics. We also plan to conduct the same experience on expert of the skill for following investigations: whether our proposed method does not obstruct correctly observation of self-motion and whether there are differences in finding problem skill due to the skill of the observer.

Our proposed method might have little effect on evoking SA. For example, there is a report that the morphological resemblance is not the decisive factor for changing SA [17]. However, it is highly predictable that modified the appearance of the bodily characteristics changes the impression in skill s/he has. In this regard, Suzuki et al. shown that converting the sonority of a male operator's voice into a female's voice improves impression of the operator and increases during simple task even if the actual operator's gender is understood [18]. Considering based on this finding, our proposed method would have an effect on problem finding ability due to changes in the self-impression even if the SA is completely removed from observed self-motion. Therefore, evaluation of the proposed method is given to the impact the problem finding the ability to give to the SA and SO will be going performed in parallel.

We will evaluate and demonstrate the effect of "Diminished agency" through these experiments.

4   Conclusion

In this paper, we proposed "Diminished agency," that is a method for finding problems of self-motion. Our approach attenuates a sense of agency from observing self-motion by changing apparent bodily characteristics, which can influence on a sense of ownership based on findings about SA, SO and feedback for our past work.

In the future, we will advance the implementation and evaluation of the method we developed. We will also investigate other methods for eliminating SA by the use of factors related SA and SO. In addition, we are planning to investigate how attenuate not only SA from self-hand motion but also motion of other parts of the body or the full body. Through these investigations, we aim for the realization of "Diminished agency."

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