Discussion on the Rise of the Self in a Conscious System

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Abstract
What is human self? Some argue that there is no such thing as self. However, the subjective feeling that "I am writing these words" makes it hard to deny the existence of the self. We assume that as long as there is the term "self," there must be some collection of neural networks that represents the concept of the term. Although the whole picture is still a mystery, we have taken a step forward to unraveling the mystery by introducing the idea that "the emergence of a new behavior that prioritizes the body underlies the rise of the self." When performing imitation behavior, a person can encounter a situation in which he feels pain and tries to avoid it. In this instance, the person engages in two types of behavior almost simultaneously, which are in conflict with each other. Also in this instance, it is assumed that the person gives priority to the safety of his own body and reflexively chooses to respond with avoidance behavior. However, as the imitation behavior continues, the process of imitation and avoidance is repeated many times, making it increasingly difficult to ensure the safety of the body. To address this scenario, we have come up with an idea that enables a conscious system to generate a new rational behavior—that is, voluntarily stop the imitation behavior. We consider that the generation of this new behavior is a significant process that can explain the first step for the development of the self.

Key words: the self, conscious system, subjective feeling, pain, conflict, body

1 Introduction

Robots make such a huge contribution to modern society that it is difficult to image life without them. However, there are calls for robots that have enhanced capabilities such as being able to make autonomous decisions, take actions, and communicate with people, in order for robots to become a more integral part of daily life. In short, robots are required to be more like humans. Attributes of human likeness include thinking, feeling, and acting, all of which are reasonably considered to arise from the working of human consciousness. For these reasons we consider that robots can be more like humans by acquiring functions of consciousness similar to those of humans.

This idea raises the question of how robots can acquire consciousness, but what is consciousness anyway? This problem has long been investigated in many disciplines including psychology, philosophy, and medicine. Among these studies, we sought reports of consciousness from mirror neurons (Gallese, 1996) and mimesis theory (Donald, 1991). Based on these studies we defined consciousness by stating that "consciousness is generated by consistency of cognition and behavior" (Takeno, 2005) (Igarashi, 2007). Based on this definition, we have proposed a consciousness model using MoNADs, which are consciousness modules mimicking the brain's nerve cells (Takeno, 2005) (Igarashi, 2007). Robots equipped with a consciousness model using MoNADs have succeeded in performing avoidance behavior in mirror tests (Gordon, 1970) and using episodic memories (Komatsu, 2011) in previous studies.

This paper studies the "development of the self" using a consciousness model. People learn to recognize their own reflection in a mirror as themselves at some point in childhood, which suggests the development of the self in humans (Lacan, 2007). What processes do we go through after birth until learning to recognize ourselves? When and how does the self arise and why? We have sought to answer these questions using a conscious system.

2 Conflict of Actions

The consciousness model using MoNAD modules consists of the Reason, Emotion & Feeling, and Association subsystems (Takeno, 2013). The Reason subsystem perceives information from outside and inside the system and decides how to act. The Emotion & Feeling subsystem decides how to act based on changes in the internal condition and on external stimuli. For example, the Reason subsystem performs imitative behavior whereas the Emotion & Feeling subsystem performs a reflex movement in response to pain. The Association subsystem receives cognitive information from the Reason and Emotion & Feeling subsystems and settles on an action. Here, "reflex movement" refers only to those output from the Emotion & Feeling subsystem.

The consciousness model perceives external information—in this case, the object to imitate—and performs an imitative action. There is no problem if there is only one action to perform, but if the consciousness model simultaneously perceives a stimulus such as pain, the imitation behavior comes in conflict with the reflex movement to pain. At this point, the conscious system must choose either of the two actions. In this case, we designed the system to prioritize "safety of the body" over "imitation behavior." That is, the reflex movement is preferentially performed.

When actions come in conflict with each other, priority is given to the safety of the body, and a reflex movement is performed to avoid pain. After avoiding the pain by reflex, however, the conscious system again gets ready to perform imitation behavior. Naturally, the system performs imitation behavior and causes a conflict of actions again. The system avoids pain by reflex again, performs imitation behavior, and so on. If there is no solution to the problem of repeated pain caused by the actions currently available to the conscious system, the system is required to produce new behavior on its own to solve the problem. At this point the conscious system is shaping a new rational behavior.

3 Emergence of a New Rational Behavior

Let us examine further the conflict of actions using the example of imitation behavior and reflex movement to pain. We assume that one way to break this loop of repeated behavior created by the conflict of these actions is to shape a behavior that resolves the cause of the loop. In our example, the cause lies in the fact that imitation behavior itself brings about a situation that allows the conscious system to recognize pain. It can also be assumed that the system falls into this situation because it cannot anticipate the pain to come before performing imitation behavior. To resolve this cycle of information, a new behavior is needed to avoid pain when actions come in conflict by stopping imitation behavior before the next pain comes.

As in the example described earlier, humans and human-like consciousness models make an adjustment between the external conditions recognized by the Reason subsystem and information from the Emotion & Feeling subsystem, and perform a more rational behavior. The rationality of the conscious system here translates into increased speed of information processing in the system (internal processing) and reduced representation of unpleasantness by the Emotion & Feeling subsystem. Although the internal processing is actually related with the Emotion & Feeling subsystem, we do not consider this topic here. Children under development and conscious models with a limited number of available behaviors can encounter a situation that cannot be resolved by currently available behavior. In

such situations, conventional systems become deadlocked. However, we believe that a conscious system can learn to solve the problem by automatically generating a new rational behavior that resolves the cause of the situation. The process of automatically generating problem-solving behavior in succession can be interpreted as the self-development of a consciousness model.

People grow to recognize their own image in a mirror as themselves. In other words, they learn to recognize themselves as themselves. We assume that this is when the self arises. People acquire new capabilities and grow by shaping new rational behavior, and in the process of growing they acquire the self as well. From these points of view, we believe that the shaping of new rational behavior may be related to the rise of the self. The rational behavior emerges to resolve repeated conflicts of information occurring inside, and the repeated conflicts caused by behavior that prioritizes the safety of the body. Based on these considerations, we argue that "behavior that prioritizes the safety of the body" is related to the rise of the self and constitutes a step in the development of the self.

4 Theory of Neurogenesis

It is thought that the human neuronal composition is maintained by the process of replacing old nerve cells with new ones. The process of generating new neurons is known as neurogenesis. Especially in the human brain, neurogenesis often occurs in the dentate gyrus of the hippocampus (Kitamura, 2014). We assume that the theory of neurogenesis is closely related to our idea of shaping new rational behavior.

A MoNAD is an analogy module as that mimics human consciousness. MoNADs are conveniently capable of "shaping behavior out of cognition in a consistent manner," a suitable feature that allows them to serve as a neurogenesis model (MoNAD genesis). In the event of a conflict of actions, as mentioned earlier, newly generated MoNADs are integrated into the conscious system as a new information network and allow the system to change through learning so as to shape a new rational behavior.

5 Consciousness Model that can Develop the Self

We propose a consciousness model in which new MoNADs are generated based on the neurogenesis theory and integrated into the conscious system so that a new rational behavior can be shaped to resolve the conflict of actions (Figure 1). In this model, the conscious system learns to shape an avoidance behavior against pain by allowing new MoNADs to emerge from the conflict between "imitation behavior" and "reflex movement to pain".

The robot equipped with this conscious system has a human-like head and neck (Figure 2). The Reason subsystem (IB and Ac) receives information from the external environment through a camera that corresponds to the human eye (Figure 2(a)), recognizes the presence or absence of an object to imitate or its location, and produces an imitative action (driven by servomotors (b)). The Emotion & Feeling subsystem (Pa) receives pain information via a sensor (c) in the neck and produces a reflex movement to pain (b). The Association subsystem (As) receives cognitive information from the Reason and Emotion & Feeling subsystems and settles on an action. If there is an object to imitate and no actions in conflict, the Association subsystem settles on performing imitation behavior. If there are actions that come in conflict with each other, the Association subsystem gives priority to the safety of the body and settles on performing a reflex movement to pain.

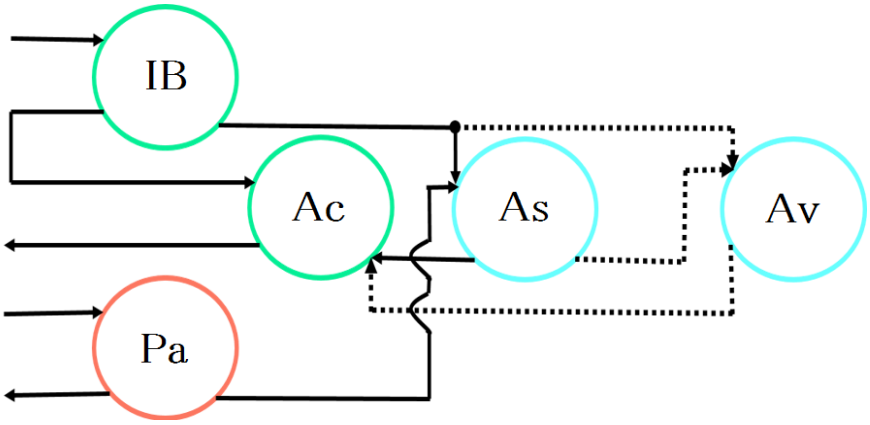

Figure 1. Our consciousness model

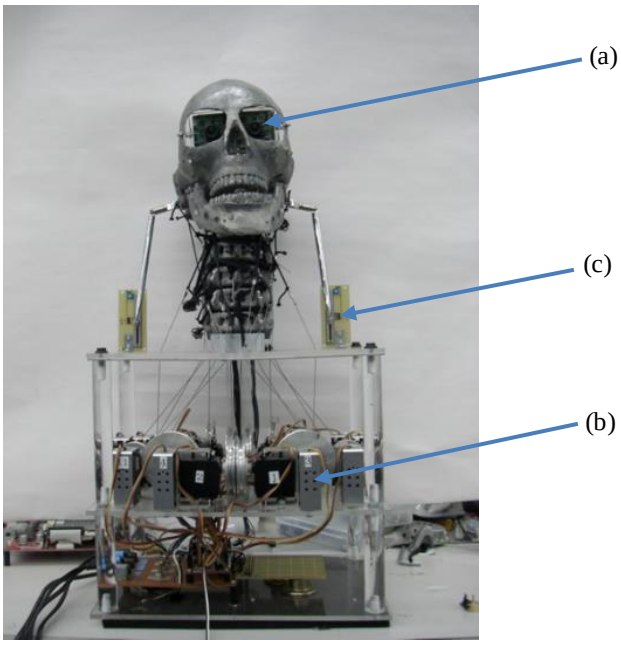

Figure 2. Robot equipped with a consciousness model

When actions come in conflict repeatedly, new MoNADs are generated and incorporated into the consciousness model (Figure 1, Av). The newly generated MoNADs receive cognitive information from the Association and Reason subsystems that are causing the conflict, and shape the new behavior of stopping the imitative action. This process enables the system to avoid the repeated cycle caused by the conflict of actions that could not be resolved so far.

We equipped a robot with this consciousness model and conducted a behavioral experiment (Figure 3). When the conscious system recognized the object of imitation, the value in Figure 3 increased (a1), and the robot performed imitation behavior according to the movement of the object. The value in Figure 3 (a1) increased to around 1.0. The position of the robot's head moved in accordance with the imitative behavior (c1). The value in Figure 3 (c1) increased from 0.5 to 0.7. On the other hand, when the sensor responded by recognizing pain (b1), the robot performed a small reflex movement in the direction opposite to that of the imitation behavior (c2). Then the conflict

between imitation and reflex movements is repeated (from c2 to c3). At this point, the robot was twitching its head at the limit of the range of motion. After repeating the twitching motion for a while (c3), the conscious system automatically enters a learning process that is suggestive of neurogenesis. After finishing the process of neurogenesis, the conscious system did not fall into the reflex movement or its repetition even if induced by the object of imitation. That is, the conscious system was able to stop imitation behavior when it recognized the object of imitation at the limit of the range of motion, before perceiving pain (d1). This is the avoidance behavior resulting from emerging new MoNADs. Actually, a noise-related reflex movement occurred once (b2), after which, owing to the process of neurogenesis, the robot, even if induced by the object of imitation, was able to stop imitation behavior before perceiving pain while recognizing the action to be imitated (d2).

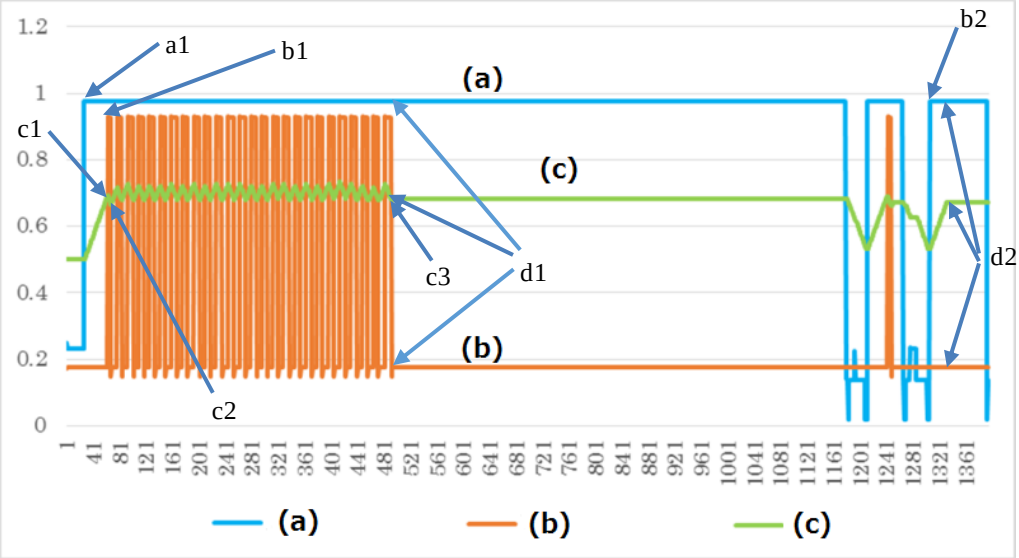

Figure 3. Experiment results

(a) indicates whether the other's behavior is recognized for imitation and
(b) indicates whether the pain is recognized. In either case, high values indicate that the each recognition is doing.
(c) indicates the position of the robot's head in numerical values. The higher the value, the further to the left side (as the robot's face) the head is leaning.

6 Discussion and Conclusion

When imitative behavior and reflex movement come in conflict repeatedly, humans and conscious systems learn to avoid the conflict by automatically shaping a new rational behavior. This process may account for the development of the self. When a single action occurs independently in a person, the action is performed as it is. However, when multiple actions occur simultaneously and come in conflict with one another, the person has to choose one of them. At this point, the choice is made based on rationality. Rationality here refers to a property that drives us to seek a more pleasant or less unpleasant, state. For example, when an imitative action and a reflex movement to pain occur and come in conflict with each other, the person performs the reflex movement because he considers it more rational to secure the safety of his body than to imitate the other's behavior. If this conflict of actions occurs repeatedly, a new rational behavior needs to arise in the person. We believe that the rise of a new rational behavior

can resolve the conflict of actions and bring about increased processing speed of the system and reduced unpleasant representations in the Emotion & Feeling subsystem.

In this paper we have discussed how a person develops the self and proposed a process for the development. Although this process may not directly explain the mechanism of the self, we believe that it provides an insight into the self and consciousness.

References

Donald, M. (1991). *Origins of the Modern Mind*. Harvard University Press, Cambridge

Gallese, V., Fadiga, L., Fogassi, L., Rizzolatti, G. (1996). *Action recognition in the premotor cortex*. Brain, 119

Gordon, G. (1970). *Gallup, Jr.Chimpanzees:self-recognition*. Science, 1970, 167

Igarashi, R., Suzuki, T., Shirakura, Y., Takeno, J. (2007). *Realization of an Emotional Conscious Robot and Imitation Behavior*. RA2007

Kitamura, T., Inokuchi, K. (2014). *Role of the Adult Neurogenesis in Hippocampal-Cortical Memory Consolidation*. Molecular Brain, 7, 13

Komatsu, T., Takeno, J. (2011). *A Conscious Robot That Expects Emotion*. IEEE ICIT-SSST 2011

Lacan, J. (2007). *Ecrits*. W. W. Norton & Company

Takeno, J., Inaba, K., Suzuki, T. (2005). *Experiments and examination of mirror image cognition using a small robot*. CIRA2005

Takeno, J. (2013). *Creation of a conscious robot*. Pan Stanford Publishing