Sine Qua Non of Self: The Triple Prerequisites in Sensory Attenuation

Tomohisa Asai, Ph.D.

Department of Cognitive Neuroscience

Advanced Telecommunications Research Institute International (ATR)

2-2-2 Hikaridai Seika-cho, Sorakugun, Kyoto 619-0288, Japan

asai@atr.jp

Tel: +81-0774-95-2649

Fax: +81-0774-95-1236

Abstract

Many philosophers, theoreticians, and empiricists have argued that the self can be decomposed into some sub-selves (“me”s). On the other hand, we may think that the self is total (“I”) and cannot be further unraveled. Previous studies have been unsuccessful in treating the self both as an aggregation and as an entity. However, in an empirical view, the above-mentioned paradox or dualism of the self can be simplified into the interactions among factors. The self would emerge if some conditions were simultaneously satisfied. In other words, finding a unique factor of the self is like chasing the rainbow, as the homunculus in the brain has never been empirically identified. The current study suggests that the triple prerequisites for the self (*volitional, predictable, and immediate*) are simultaneously necessary for sensory attenuation effect as the certificate of self.

Keywords: self, sensory attenuation, volition, prediction, dualism

Sine Qua Non of Self: The Triple Prerequisites in Sensory Attenuation

Here is the triple structure of the self that the current study introduced theoretically; *volitional, predictable, and immediate.*

Prerequisite #1

The self is volitional, therefore generative. The first factor itself is controversial in terms of the propriety of free will. The recent discussion of the sense of agency has suggested that our strong illusion of free will could be a Bayesian inverse inference (Asai, Imaizumi, & Imamizu, 2019). Regardless of its true existence, we still have the illusion of free will to generate action (“I” as generator) as far as we perceive the sensory consequence as “me” (we need “cause” given “effect” through a conditional probability in Bayes theorem). Free will is always the easiest and undeniable reasoning between the action and sensation. Similar terminology of this “I”ness includes [the self is] *agentive, independent, active, intentional, first-personal, and as subject* (Legrand, 2007).

Prerequisite #2

The self is predictable, therefore pre-reflective. The first factor is about generating the “I.” Therefore, the second factor should be the received “me.” The self-tickling effect (we cannot tickle ourselves) suggests that I cannot be surprised since this is me and then predictable (Blakemore, Wolpert, & Frith, 1998). Accordingly, the self does not need conscious attention. It is pre-reflective and self-evident without any sensory cues. Only when the unpredicted surprise happens (that delivers informational gain, such as the Shannon surprise), we reflect on whether that was I or not-I as postdiction. The similar terminology of this “me”-ness includes [the self is] *affordant, non-conscious (automaton or zombie), embodied, owned, third-personal and as object* (Truong & Todd, 2017).

Prerequisite #3

The self is immediate, therefore seamless. The last one is inevitably the link function between “I”-ness and “me”-ness. The closer I and me get spatially and temporally, the more the likelihood of the self being convergent. As a result, I and me are spatio-temporally dissociable as a loop. Many previous studies suggested that the simple delay between action and outcome endangers the self as a unified entity (e. g., Asai & Tanno, 2007) where the I-me loop is not closed. The self is always in the here and now, such that the spatio-temporal extension is realized to some extent by opening the loop a little bit. The similar terminology of this “I-me”-ness includes [the self is] *continuous, controllable, unified, close-looped, free-energetic, and as narrative* (Delafield-Butt & Trevarthen, 2015).

I hope many other researchers would agree with this triple structure of the self. Nonetheless, the problem is that each factor is easily confounded so that an experiment with the pure factors (e.g., interaction design) is difficult (e. g., Constable, Welsh, Huffman, & Pratt, 2018). The current study, instead, tried to examine this in a naiver manner through one-by-one experiments.

When the healthy young participants pressed the key with their right index finger to deliver the vibro-tactile sensations to their left wrist, the felt intensity was attenuated in comparison to that by the experimenter (Fig.1A). This is known as sensory attenuation as exemplified by the self-tickling effect. Since the delivered intensity was random across trials within the fixed range, the averaged participants’ rating (1-9) should be close to 5.0 as expectation value if there is no-bias and the number of trial repetitions is enough (50 repetitions for each condition in this case). Participants could observe the key-press; therefore, the first experiment simply suggested that *volitional, predictable, and immediate* sensory outcomes were attenuated (self-condition), while a non-volitional (but still predictable and immediate) outcome was not attenuated (other condition). The self-condition

was significantly lower than the other condition (paired samples T-Test; $t(9)=2.448$, $p=0.037$, Cohen's $d=0.774$) and also lower than the expectation value (one sample T-Test; $t(9)=2.824$, $p=0.010$, Cohen's $d=0.893$). However, this self-other contrast disappeared ($t(10)=0.251$, $p=0.807$, Cohen's $d=0.076$) when the outcome was randomly delayed (i.e., unpredictable, therefore not immediate even for this self-condition while the other-condition, a personal computer (PC) controlled, did not satisfy any prerequisites) (Fig. 1B).

In the current study, no difference to the expectation is important for control conditions to verify the current experimental procedure for evaluating sensory attenuation effect (cf. Blakemore et al., 1998). Bayes factor for null hypothesis (BF_{01}) is used for such a negative purpose while BF_{10} is for the positive alternative hypothesis, instead of conventional statistics. The JASP software (JASP Team, 2019) calculated the BF_{10} of self-condition for attenuation in Fig. 1A was 3.589, while BF_{01} of the left conditions for non-attenuation in Fig. 1A and 1B were 1.674, 1.831, and 2.908, respectively. These results (BFs for each statistical hypothesis > 1.00) confirmed that the self-condition in Fig. 1A uniquely caused the attenuation effect.

The main experiment was to examine what happens if the delay was visible and then predictable (Fig.1C). Participants knew the outcome timing with the visual countdown, but their felt intensity was not attenuated (self+delay condition) as in case of the other (PC) condition (only predictable) (one sample T-Test for self-condition; $t(14)=3.854$, $p<0.001$, Cohen's $d=0.995$). The BF_{10} of self-condition for attenuation in Fig. 1C was 23.959 while BF_{01} of the left conditions for non-attenuation were 2.634 and 2.402, respectively. In addition, the BF_{01} of the no-condition difference hypothesis between other (PC) and self+delay condition was 3.766.

Figure 1

Experimental setups and the summarized results

Note: Participants received vibro-tactile stimulus triggered by self or other (PC) whose intensity was controlled by audio signals (the amplitude of white noise, the duration was 50ms) and was randomized trial by trial among the fixed perceivable range. Asterisks highlight the significant difference ($p < 0.01$) from the expectation value (dashed line). Error bars = ± 1 SE.

The final experiment (Fig.1D) confirmed that as long as the delay was short (maximum 2 seconds) and visible (i.e., immediate and predictable), a self-triggered outcome was attenuated again (self+visible delay group) (one sample T-Test; $t(12)=2.053, 3.004, 1.945$, and 0.271 , $p=0.031, 0.005, 0.038$, and 0.604 , Cohen's $d=0.570, 0.833, 0.539$, and 0.075 , respectively). This attenuation effect disappeared when the delay was only invisible without visual countdown (i.e., unpredictable) for the self+invisible delay group (one sample

T-Test; $t(12)=2.689, 0.831, 0.628$, and 0.026 , $p=0.010, 0.211, 0.729$, and 0.490 , Cohen's $d=0.746, 0.231, 0.174$, and 0.007 , respectively). The BF_{01} of the no-group difference hypothesis under 0s- and 3s-delay was 3.532 and 3.519 , respectively, while the BF_{10} of the group difference hypothesis under 1s- and 2s-delay were 1.628 and 2.131 , respectively.

A possible conclusion from these experiments is very simple. If even one among the three prerequisites is violated, sensory attenuation would not happen (Table 1); namely, there is no self in the here and now. Accordingly, these three factors are triplets, or crossly dependent in definition as aforementioned in the introduction. Of course, the experiments were incomplete. All combinations ($2 \times 2 \times 2$) should be examined in future studies (c.f., Blakemore, Frith, & Wolpert, 1999; Sato, 2009), though the volitional and immediate, but temporary-unpredictable outcome, for example, is a difficult situation. The fact that a pure factorial manipulation is impossible after avoiding confounds tells us that the self cannot be unraveled. Instead, the self is aggregated but totaled, where the conventional empiricism could be helpless considering the Cartesian “cogito” skepticism, especially given the simultaneous triplet structure.

Table 1

Experimental conditions and satisfied prerequisites

	Experiment A		Experiment B		Experiment C			Experiment D			
	Self	Other	Self	Other (PC)	Self	Other (PC)	Self+ delay	Self+ Short visible delay	Self+ Long visible delay	Self+ Short invisible delay	Self+ Long invisible delay
<i>Volitional</i>	○	×	○	×	○	×	○	○	○	○	○
— + —											
<i>Predictable</i>	○	○	×	×	○	○	○	○	○	×	×
— + —											
<i>Immediate</i>	○	○	×	×	○	×	×	○	×	○	×
— —											
<u>Attenuation</u>	○	×	×	×	○	×	×	○	×	×	×

Note: The introduced triple structure of the self was examined in terms of sensory attenuation. The factors might be inevitably confounded in theory so that all factorial combinations cannot be easily examined (see the main text). However, the series of the results imply that only when the three prerequisites are fulfilled, was the sensory attenuation observed (grey).

References

- Asai, T., & Tanno, Y. (2007). The relationship between the sense of self-agency and schizotypal personality traits. *Journal of Motor Behavior*, 39(3), 162–168.
<https://doi.org/10.3200/JMBR.39.3.162-168>

- Asai, T., Imaizumi, S., & Imamizu, H. (2019). The self as a generative, teleological, and subjective prior: Mutually-modulated temporal agency. *bioRxiv*, 519934.
<https://doi.org/10.1101/519934>
- Blakemore, S., Frith, C., & Wolpert, D. (1999). Spatio-temporal prediction modulates the perception of self-produced stimuli. *Journal of Cognitive Neuroscience*, 11(5), 551–559.
- Blakemore, S., Wolpert, D., & Frith, C. (1998). Central cancellation of self-produced tickle sensation. *Nature Neuroscience*, 1(7), 635–640. <https://doi.org/10.1038/2870>
- Constable, M. D., Welsh, T. N., Huffman, G., & Pratt, J. (2018). I before U: Temporal order judgements reveal bias for self-owned objects. *Quarterly Journal of Experimental Psychology*, 72(3), 589–598. <https://doi.org/10.1177/1747021818762010>
- Delafeld-Butt, J., & Trevarthen, C. (2015). The ontogenesis of narrative: from moving to meaning. *Frontiers in Psychology*, 6, 1157. <https://doi.org/10.3389/fpsyg.2015.01157>
- JASP Team. (2019). JASP (Version 0.9.2)[Computer software]. Retrieved from <https://jasp-stats.org/> (April 1, 2019.)
- Legrand, D. (2007). Pre-reflective self-as-subject from experiential and empirical perspectives. *Consciousness and Cognition*, 16(3), 583–599.
<https://doi.org/10.1016/j.concog.2007.04.002>
- Sato, A. (2009). Both motor prediction and conceptual congruency between preview and action-effect contribute to explicit judgment of agency. *Cognition*, 110(1), 74–83.
<https://doi.org/10.1016/j.cognition.2008.10.011>
- Truong, G., & Todd, R. (2017). SOAP Opera: Self as object and agent in prioritizing attention. *Journal of Cognitive Neuroscience*, 29(6), 937–952.
https://doi.org/10.1162/jocn_a_01083