

AUGUST 3

Nao Tsuchiya

"Towards understanding consciousness/awareness: an overview"

(Report by Katsunori Miyahara & Ken Nakae)

Report on Nao Tsuchiya, "Introduction to the neuronal basis of consciousness." (by Katsunori Miyahara & Ken Nakae)

The following is a brief report of Nao Tsuchiya's lecture given on the first day of the summer school, "Introduction to the neuronal basis of consciousness." As the talk was very rich in content, the report here will focus only on three central topics that especially drew our interest: How Tsuchiya sorted out different concepts of consciousness; his critique on the standard, report-based methodology in consciousness research; his exposition of the integrated information theory on consciousness.

1. Different notions of consciousness

If we want to investigate the neural correlate of consciousness (NCC), it is important that we be clear in the beginning what we mean by the term consciousness. In an earlier part of the talk, thus, Tsuchiya introduced different notions of consciousness.

On the one hand, we can talk about *levels of consciousness* to distinguish mental states while we are awake, during coma, while under anesthesia, in dreamless sleep, of vegetative patients, etc. On the other hand, we can talk about *contents* or *qualia of consciousness* to account for the difference between the experience of seeing a red thing, feeling a pain, thinking about something abstract, etc.

Furthermore, we can make a distinction between *broad-sense qualia* and *narrow-sense qualia*: The former describes the felt quality of a particular conscious experience as a whole, while the latter refers to a constitutive part of the former. For example, compare (1) the visual experience of a red disk on a homogenous background in the left part of the visual field with (2) the visual experience of a red disk of the same size on a homogenous background of the same color but this time in the right part of the visual field. Since the location of the disks are different, (1) and (2) involve different broad-sense qualia. To the extent that they present objects of the same color, they also partly involve the same narrow-sense quality, i.e. the same redness.

2. Critique of the report-based paradigm of consciousness research

After introducing these distinctions, Tsuchiya explored the experimental methods to investigate the neural correlates of different contents of consciousness. In particular, he presented a critique of the standard, report-based method to investigate NCC and

underscored the necessity of a new methodology.

The standard, report-based method proceeds in three steps. The first step is to present a subject with a constant but ambiguous stimuli, which will induce one or another type of conscious experience in it. The second step is to obtain subjective reports, whose variation reflects the variation in the experience. The third step is to find a correlation between the variation in reports and the variation in neural activities. This allows us to specify which kind of neural activity correlates to which kind of conscious experience.

The problem with this report-based method is that it potentially leads both to an underestimation and an overestimation of NCC. On the one hand, it can result in an underestimation because subjective reports, usually, only capture the attended contents of consciousness, while broad-sense qualia also include unattended contents. Accordingly, the report-based method only allows us to specify the neural correlate of the attended/reported contents of consciousness, and we may be fooled to interpret the neural activity underlying the unattended/unreported contents as having nothing to do with conscious experience. On the other hand, it can promote an overestimation because the act of reporting itself requires some neural processing, and we may be fooled to include this into the neural correlate of the reported conscious experience. In fact, some people used to think that strong frontal-parietal activity partly constitutes NCC, but a recent study figured out that this area shows no or much less activation unless the subject is instructed to make a report. Therefore, Tsuchiya suspected that the reliance on reports might be harmful to the scientific investigation of NCC.

The no-report method, however, involves its own difficulty: If we measured the neural activity only under no-report conditions, we could not tell when and what the subject is experiencing. Thus, we may be fooled to include non-conscious, neural processing into NCC. There are also attempts to overcome the difficulties of the report-based method by employing a partial report method, which enables us to make reasonable estimations about the unreported contents of the subject's experience. It still does not allow us to get a good sense of the broad-sense qualia as a whole, however. Instead of relying exclusively on the no-report method, or developing the partial report method, accordingly, Tsuchiya suggested that we combine the report-based and no-report paradigms by starting from phenomenology.

3. Integrated information theory of consciousness

In the last part of his talk, Tsuchiya introduced the information integration theory (IIT) proposed by Tononi as a general framework for investigating levels and contents of consciousness.

IIT identifies the following five essential properties of conscious experience, which are assumed to constitute axioms in this theory: 1. Existence: Consciousness exists – it is an undeniable aspect of reality. 2. Composition: Consciousness is compositional (structured): each experience consists of multiple aspects in various combinations. 3. Information: Consciousness is informative, that is, each experience differs in its particular way from other possible experiences. 4. Integration: Consciousness is integrated, that is, each experience is (strongly) irreducible to non-interdependent components. 5. Exclusion: Consciousness is exclusive, that is, at any given time there is only one experience having its full content, rather than a superposition of multiple partial experiences.

After explaining the five axioms, Tsuchiya introduced the notion of integrated information called *phi*. However, as the original *phi* is rather difficult to compute in the real neural systems, he proposed an accurate approximation of *phi*, called *phi**, based on a more familiar notion of mutual information defined by the state of neural networks. Mutual information, *I*, usually used in neuroscience is extrinsic, which is to say that it is based on the statistical dependence between stimulus (*S*) of the outside world and neural states (*X*) of the inner world, thus expressed as $I(S;X)$. However, Tsuchiya suggests that our subjective experience of consciousness is correlated by intrinsic mutual information, which is defined as the dependence between present (X_t) and previous neural states ($X_{t'}$) only of the inner neural states, thus expressed as $I(X_t;X_{t'})$. Thus Integrated information (ϕ^*) is defined as the loss of intrinsic information when the system is divided into parts (I^*), expressed as $\phi^*=I-I^*$. In this view, we can experience rich dreams and imagine objects without receiving external stimuli because intrinsic integrated information is sufficient for real conscious experience to take place.

According to IIT, furthermore, the overall amount of ϕ computed on the whole neural population corresponds to levels of consciousness, while a collection of ϕ 's computed on local neural populations maps onto contents of consciousness. This allows IIT to explain why the thalamo-cortical system generates consciousness while the cerebellum, retina and motor systems do not; in addition, why a single consciousness splits into two when a brain is split into two. Moreover, IIT predicts that waking brains would maximally integrate information, which is indirectly supported by TMS-EEG experiments. Using

electrocorticography (ECoG) data in the face-selective brain region, called fusiform face area (FFA), Tsuchiya and his collaborators have also calculated the collection of local phi*'s to directly test if it correlated with the conscious phenomenology of faces under masked and unmasked conditions.

In the end of the lecture, Tsuchiya raised some fundamental questions related to consciousness, such as "Can IIT dissolve the hard problem of consciousness?," "How and why do we have conscious experience?" After the lunch break, the participants were divided in five groups to discuss issues related to Tsuchiya's talks. Amazingly, the heated debates continued even after the scheduled sessions into the reception party in the evening.