Integrated information structure collapses with anesthetic loss of conscious arousal in *Drosophila melanogaster*

May 12, 2020

Dear Editor,

We would like to submit our manuscript, “Integrated information structure collapses with anesthetic loss of conscious arousal in *Drosophila melanogaster*”, for publication in PLoS Biology.

The link between mind and matter, or more precisely, consciousness and brain, is one of the most enigmatic questions in science today. One of the major theories of consciousness, integrated information theory (IIT), is well known for its proposal of an informational measure of consciousness, “Phi” (denoted using the Greek symbol “Φ”). To date however, only proxy measures of “Φ” have been empirically assessed. This is because the computational cost of the original measure is complex and computationally intractable.

IIT also proposes a multi-dimensional informational structure which captures how parts of a system causally and structurally interact to create information accessible to the system itself. This structure is purported to correspond to both level and contents of consciousness in a system. However, this has largely been ignored in favour of investigating the more simply but abstractly understood “Φ” and proxy measures.

In this paper, we apply the original formulation of IIT to assess the empirical validity of “Φ” as a measure of conscious arousal in a real, biological system, the fly brain. We further compare the utility of a subset of the full informational structure proposed by IIT, the Integrated Information Structure (IIS) with the utility of “Φ” in determining level of consciousness in the system. We confirmed that both “Φ” and the IIS were able to discriminate conscious arousal states (between wakefulness and general anesthesia). Critically, the IIS in fact performed better than the traditionally focussed upon “Φ”.

Our manuscript presents, for the first time, a biologically validated computational procedure that allows us to investigate the relationship between these information structures and consciousness, to empirically test the predictions from IIT. With our methodology, it is now possible to apply hitherto purely theoretical constructs of IIT to be empirically validated with biological data, including human neuronal recordings, as we are setting out to do so.

We believe that our result will push consciousness research in a promising, yet underexplored direction: the **structure** of information. While some researchers have proposed an informational aspect of consciousness, most proposals only talk about how much (i.e. the quantity of) information. We believe that it is what kind (i.e. the quality) of information that matters for consciousness, and our paper provides evidence that the structural information may even be critical for assessing level of consciousness. Bringing focus to this new concept, the informational structure, will be of broad interest for consciousness researchers, neuroscientists, psychologists, philosophers, computer

scientists, artificial intelligence engineers, and even clinicians. As such, we believe that our manuscript should be communicated with the widest possible readership in PLoS Biology. We greatly appreciate your consideration of our manuscript for publication.

Sincerely,

Angus Leung, Dror Cohen, Bruno van Swinderen and Naotsugu Tsuchiya