Quality vs quantity of consciousness: empirical evidence from integrated information analysis of human intracranial data

Yota Kawashima¹, Angus Leung¹, Andrew M. Haun², Christopher K. Kovach³, Hiroto Kawasaki³, Hiroyuki Oya³, Naotsugu Tsuchiya¹,4,5

¹Monash University, Australia ²University of Wisconsin, USA ³University of Iowa, USA ⁴CINet, Japan ⁵ATR, Japan, # Yota.Kawashima@monash.edu

1. Background

Integrated Information Theory (IIT) attempts to elucidate the link between consciousness and its neural basis through its informational structure. (Oizumi et al 2014 PLoS Comp Biol)

More specifically, the theory gives quantitative predictions about the relationship between consciousness and informational structure.

- Quality of consciousness (e.g. seeing face) correlates with “shape” of Integrated Information Structure (IIS); and
- Quantity of consciousness (e.g. sleep vs. awake) correlates with “volume” of IIS (precisely System-level II or big phi).

In addition, the theory gives a operationalisation of informational structure based on neural system.

- Both IIS and System-level II are computed from neural activity based on causal connections of the neural system.

Then, we test that

H1 “Shape” of IIS from neural recording correlates with quality of consciousness.

H2 “Volume” of IIS from neural recording does not correlate with quality of consciousness.

2. Experiment (Haun et al 2017 eNeuro)

b. Binarisation of Local Field Potential

b. Classification by IIS and system-level II

- Mean of IIS and System-level II as features for classification

3. Compute Integrated Information (II)

a. Channel Location

b. Binarisation of Local Field Potential

c. Explanation of Integrated Information (II) with 2 ch (A, B)

- How much can current state affect future state and can be affected by past state?

- TPM (Transition Probability Matrix)

- II (Integrated Information)

- How much does information change after ignoring some causal connections?

4. Classification by IIS and system-level II

a. Mean of IIS and System-level II as features for classification

b. Classification accuracy per time window (Face vs Noise)

5. Summary

To H1 (“Shape” of IIS correlates with quality of consciousness.)

- Partially supported: “Shape” of IIS is able to classify face vs noise perception above chance 300-500ms after stimulus onset.

To H2 (“Volume” of IIS does not correlate with quality of consciousness.)

- Supported: “Volume” of IIS (System-level II) is not able to classify face vs noise perception.