

Reply to comments

## Quantum explanations of consciousness: A “Just So” story? A response to commentaries

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We are grateful to our commentators, and we want to assure them that we are by no means “resistant” to QM explanations as such. Quantum hypotheses would be delightful if they had any explanatory power for understanding conscious thought. Unfortunately that case has not been proven.

In 19th century physics the universal ether was thought to be a necessary medium for electromagnetic waves. Wave propagation seemed to demand something like a gas or liquid. In the end, physicists came to the conclusion that the “electromagnetic ether” had no observable effects (like inertia), and was therefore not needed.

Similarly, phlogiston was not needed to explain chemical combustion, the divine hand was not needed for the origin of species, but atmospheric pressure *was* needed to explain the expansion of mercury columns at different altitudes. Occam’s Razor only cuts off unneeded explanatory entities; it protects those that are supported by evidence.

Quantum hypotheses of consciousness confront the same challenge.

So far we have no evidence that QM effects are distinctively involved in “consciousness treated as a variable” — what we can call “more conscious” versus “less conscious” brain events. So far, QM explanations are “just so” stories, post hoc explanations of things we already know.

For a specific example: Why are you, the reader, conscious of the name ‘Heisenberg’ as you read it, while you will not be conscious of it a minute later? William James and Descartes thought that conscious events, as they faded, leapt the metaphysical divide between private subjectivity and the physical world [6]. But we know that words remain active in the brain after they fade from mind. For example, we can show unconscious but stimulus-specific memory savings and habituation effects [1]. Unconscious word meanings are clearly involved in the perception and comprehension of language. Thus the Descartes–James explanation is not supported by the best evidence we have today.

The differences between conscious (reportable) and unconscious (unreportable) brain events are not explained by quantum claims so far, to the best of our knowledge. Yet there are well-established and robust differences in neurophysiology, behavior, cognitive functioning and a vast array of independent variables. The word “consciousness” is a keyword for more than 20,000 biomedical articles in the very large scientific database PubMed.gov. Consciousness is not some free-floating idea. It is embedded in a large network of facts and concepts, many of them very reliable.

Here are some examples of hypotheses that have gained empirical support.

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1. Our commentator Prof. Wolfgang Klimesch is a highly productive researcher on the oscillatory dynamics of the brain, which can be observed via EEG, intracranial recordings, MEG, and the like. Brain oscillations can also be stimulated experimentally via magnetic and electrical fields, by inserted chemical and optical probes, and even by molecular genetics.

In his Commentary Klimesch suggests that conscious cognition involves cross-frequency coupling among oscillating neuronal populations in the cortex, and in particular, that the ratio of the coupled frequencies should be harmonic for optimum coordination. Spurious cross-frequency synchronization is suggested to be a source of noise. The resulting prediction is an application of known physics, mathematics and brain dynamics to the problem of conscious cognition. We believe it is a remarkably interesting proposal, based in a very deep understanding of the brain evidence.

2. Prof. Anil K. Seth has written on the neurobiology of consciousness, and is particularly focused on mathematical measures of causality in the complex signaling environment of the brain. Different testable proposals yield different measurable consequences, such as Giulio Tononi's information-theoretical measure of information integration, called phi. We refer the reader to Prof. Seth's citations for further reading.

Massimini et al. [8] have developed a direct brain measure of conscious processes, which looks very promising [9].

3. One of us has proposed that conscious cognition may reflect a global workspace function in the brain, a hypothesis that converges in interesting ways with other work (see Edelman et al. [5]; Koch and Tononi [7]). A body of brain evidence is consistent with global workspace theory [2–4]. It continues to evolve in interesting ways.

These ideas are highly constrained by evidence and reasonable theory, but they are by no means guaranteed to survive the rigorous process of testing and debate. Several other proposals are equally intriguing and consistent with good evidence.

The brain is a complicated and multilayered organ, and current ideas are not mutually exclusive. Many scientists believe the field is evolving in a productive way.

None of these points rule out a quantum-level explanation of conscious processes.

QM may indeed turn out to be the best level of explanation. However, that is not necessarily true, any more than a wave medium for electromagnetism turned out to be necessarily true in the late 19th century.

The beauty and fundamental nature of quantum mechanics is not at issue. QM does not provide the best level of explanation for kitchen chairs, because chairs are easier to understand as human artifacts designed to serve a purpose. While QM reductions of kitchen chairs are possible, that reduction would miss the most important point—their usefulness for the purpose of sitting.

Consciousness is a major biological adaptation, and we believe it is better understood in the context of evolution, life development and culture.

We look forward to quantum theoretical proposals that can explain the evidence we have today.

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## Further reading

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