

Recommendation: Revise and Resubmit (Category Change Recommended)

This manuscript addresses an ambitious and intellectually interesting topic at the intersection of quantum biology, neuroscience, and theories of consciousness. The author demonstrates familiarity with the major literature surrounding Orchestrated Objective Reduction (Orch-OR), including historical criticisms regarding decoherence, recent developments in quantum biology, and broader philosophical questions surrounding consciousness. The proposed “Quantum Cognition Gradient” (QCG) framework also reflects a genuine attempt to move beyond purely descriptive review and toward hypothesis generation.

However, in its current form, the manuscript substantially overstates the degree of empirical support for Orch-OR and presents speculative extrapolations as though they constitute emerging validation. While recent work in quantum biology has demonstrated that quantum coherence can occur in certain biological systems, this does not presently provide direct evidence that consciousness depends on microtubular quantum computation, gravitational collapse, or Orch-OR-type mechanisms. The manuscript frequently moves too quickly from “quantum effects exist in biology” to “therefore Orch-OR is increasingly validated,” which is not scientifically justified.

The primary concern, and the issue I would most strongly encourage the authors to address in revision, involves the manuscript’s handling of causality, modulation, and the hard problem of consciousness within the QCG framework. At present, QCG is presented largely as a gravity-threshold-based extension of Orch-OR in which objective reductions produce conscious moments of varying scale. However, the framework remains underdeveloped regarding how classical neurophysiology interacts with these proposed quantum processes.

The manuscript would be substantially strengthened by explicitly exploring whether neurotransmitter states, themselves shaped by cognitive engagement, attention, arousal, learning, and behavioral context, could dynamically influence coherence stability or collapse thresholds in microtubular systems. Such a proposal would provide a biologically plausible mechanism linking:

- (1) classical neural activity,
- (2) neurochemical regulation,
- (3) quantum coherence dynamics,
- and
- (4) graded conscious states.

Importantly, this extension would also reinforce one of the manuscript’s most interesting ideas: the “gradient” nature of consciousness. In the current formulation, Orch-OR still appears relatively binary, where collapse either occurs or does not occur. Neurochemical modulation of collapse dynamics could instead support a continuum-based framework in which varying attentional states, arousal levels, or cognitive engagement alter the duration, synchronization, or probability of orchestrated reductions. This would align more naturally with observable biological reality, where consciousness clearly exists across gradations rather than as a simple on/off phenomenon.

One potentially interesting formal extension would be to modify the current QCG equation so that coherence time itself becomes a dynamic function of large-scale neurochemical state. Rather than:

$$C = Q \cdot \tau$$

the framework may become conceptually richer if reformulated as:

$$C = Q \cdot \tau(\lambda_{\max}(N))$$

where:

- Q represents the effective number of entangled or coherently participating tubulin units,
- τ represents coherence lifetime,
- N is a neurotransmitter-state interaction matrix,
- and $\lambda_{\max}(N)$ is the dominant eigenvalue (or another spectral property) of that matrix.

The underlying idea would be that neurotransmitter distributions define a global network state, that state alters intracellular electrochemical conditions, those conditions modulate coherence stability, and coherence stability then changes collapse timing and synchronization across microtubular assemblies.

This is scientifically more compelling than the manuscript's current formulation because it embeds the proposed quantum processes within known neurobiology rather than treating collapse as purely gravity-threshold-driven. It also creates a clearer bridge between cognitive neuroscience and the proposed quantum-biological mechanisms.

The matrix formulation is especially interesting because it naturally supports:

- distributed cognition,
- network-level modulation,
- state transitions,
- metastability,
- and graded conscious states rather than binary collapse/no-collapse outcomes.

For example, the neurotransmitter interaction matrix N could conceptually encode coupled neuromodulatory influences involving dopamine, glutamate, acetylcholine, serotonin, norepinephrine, and related systems:

$$N = \begin{bmatrix} d & g & a \\ g & s & c \\ a & c & n \end{bmatrix}$$

where the matrix entries represent interaction strengths, coupling states, or effective neuromodulatory influences across distributed neural systems.

Under this interpretation, the leading eigenvalue $\lambda_{\max}(N)$ could represent:

- global excitatory or cognitive engagement,

- attentional coherence,
- metastable network readiness,
- or large-scale neuromodulatory synchrony.

Coherence time would then become dynamically modulated according to:

$$\tau \propto f(\lambda_{\max}(N))$$

such that:

- highly attentive or cognitively engaged states may stabilize or synchronize coherence,
- whereas anesthetic, suppressed, or low-arousal states reduce coherence persistence.

This formulation elegantly strengthens the manuscript's central "continuum" concept by allowing graded neurochemical states to produce graded coherence dynamics rather than discrete binary outcomes.

Most importantly, this shifts QCG away from the simplistic formulation:

"quantum collapse causes consciousness"

toward the conceptually richer proposition that:

"consciousness emerges from recursively coupled neurochemical–quantum dynamical states."

This recursive framing may ultimately be far more scientifically productive because it resembles modern dynamical systems neuroscience more closely than a purely one-directional collapse model.

At the same time, introducing such recursive modulation necessarily raises a deeper conceptual issue that should be acknowledged directly. If neurochemical states influence collapse dynamics and collapse dynamics generate conscious states, while consciousness itself can subsequently alter neurochemical activity through attention, cognition, learning, and intentional behavior, then the framework becomes recursively self-modulating rather than strictly linear. This creates an important potential circularity:

Neurochemistry → quantum coherence dynamics → collapse dynamics → conscious state → altered neurochemistry.

The manuscript currently does not engage sufficiently with this issue. Importantly, however, this circularity need not be treated solely as a flaw. Modern neuroscience already contains many recursive feedback architectures involving attention, cognition, network synchrony, and neuromodulation. The more important point is that this recursive structure highlights that the hard problem of consciousness remains unresolved.

Even if future experiments were to demonstrate biologically relevant quantum coherence in neuronal microtubules, this alone would not explain why physical processes are accompanied by subjective experience or qualia. Demonstrating quantum effects in biology would not, by

itself, bridge the explanatory gap between physical mechanism and phenomenological awareness. At present, the manuscript sometimes conflates evidence for possible quantum-biological mechanisms with evidence for a theory of consciousness itself, and these are not equivalent claims.

Accordingly, I strongly encourage the authors to explicitly reposition QCG as:

- a conceptual and hypothesis-generating framework for modeling conscious-state dynamics and gradations, rather than
- a complete solution to the ontological origin of phenomenology.

This reframing would significantly improve the manuscript's scientific rigor and conceptual credibility.

A second major concern involves the presentation of the QCG framework as though it were already a physically grounded quantitative theory. In its current form, the model remains heuristic rather than mechanistic. The manuscript does not establish how these quantities would realistically be measured in vivo, how neurotransmitter-state matrices would be operationalized experimentally, or how these parameters specifically map onto subjective experience. As written, the framework functions more as a conceptual organizing principle than as a predictive physical theory.

Importantly, these concerns do not render the manuscript devoid of value. The work is more thoughtful and scientifically grounded than many speculative "quantum consciousness" treatments. The author avoids mystical or pseudoscientific rhetoric, engages primary literature, discusses falsifiability, and proposes experimental directions. The manuscript therefore has potential merit if reframed appropriately.

I would recommend a category change from a research/theoretical physics framing toward a conceptual synthesis and hypothesis-generation paper. In that form, the manuscript could serve as a useful interdisciplinary perspective piece exploring how developments in quantum biology may motivate renewed examination of Orch-OR-inspired frameworks.

For revision, I strongly encourage the authors to:

1. Substantially moderate claims regarding "validation" or "strengthening" of Orch-OR.
2. Clearly distinguish empirical findings from speculative interpretation.
3. Expand the role of classical neurophysiology and neurotransmitter modulation within the proposed framework.
4. Explicitly discuss recursive feedback between neurochemistry, cognition, and proposed collapse dynamics.
5. Reframe QCG as a conceptual or heuristic framework rather than a quantitatively established theory.
6. Explicitly acknowledge that the hard problem of consciousness remains unresolved even if Orch-OR-associated quantum mechanisms were experimentally confirmed.
7. Clarify which proposed experiments are realistically feasible with current technology versus long-term conceptual aspirations.

With these revisions and a more appropriately calibrated scope, the manuscript could become a thoughtful contribution to interdisciplinary discussion surrounding consciousness studies and quantum biology.