Nonlocal Unification as the Completion of Mermin's QBism

A. Chawla

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Abstract

Quantum Bayesianism (QBism), as articulated most prominently by Mermin, Fuchs, and Schack, reframes quantum theory as a user-centered framework in which probabilities represent an agent's personal degrees of belief about the outcomes of interventions. While QBism successfully dissolves several foundational paradoxes by rejecting the objectivity of the quantum state, it deliberately refrains from positing an underlying ontological substrate. In this work, we propose that a theory of *Nonlocal Unification* (NU), grounded in a universal informational field and biologically mediated sampling processes, provides a natural completion of QBism. We argue that agents are not abstract entities but physically instantiated samplers whose structure is shaped by genetic and neural constraints. Spacetime itself emerges as a derived construct from the sampling of nonlocal informational correlations. In this sense, NU preserves QBism's participatory ethos while extending it into a coherent ontological framework.

1 Introduction

The interpretation of quantum mechanics remains one of the most persistent challenges in theoretical physics. QBism represents a radical departure from traditional realist interpretations, asserting that quantum states do not describe objective properties of systems but encode subjective expectations of agents. Measurement outcomes are not revealed but created in acts of participation.

Despite its conceptual clarity, QBism stops short of addressing a deeper question: what, if anything, underlies the structure that agents are interacting with? By refusing ontological commitments, QBism avoids metaphysical pitfalls but leaves open the possibility that it is incomplete as a foundational theory.

We propose that Nonlocal Unification (NU) provides a principled extension. In NU, reality consists fundamentally of a universal informational substrate, from which spacetime and physical phenomena emerge through structured sampling by agents. This framework retains QBism's emphasis on participation while embedding it within a broader informational ontology.

2 Core Tenets of QBism

QBism is built upon several key principles:

1. **Subjectivity of the Quantum State:** A quantum state represents an agent's beliefs, not an objective property.
2. **Primacy of the Agent:** Measurement outcomes arise through the actions of an agent upon the world.
3. **Born Rule as Normative:** The Born rule is a consistency condition on probability assignments.
4. **Rejection of Observer-Independent Reality:** There is no global, observer-independent quantum state.

Mermin emphasized that QBism restores locality at the level of experience by rejecting the notion that quantum correlations imply physical influences propagating through spacetime.

However, QBism leaves open the nature of the "world" with which agents interact. It provides a formalism of interaction but not a theory of what is being interacted with.

3 Nonlocal Unification: Ontological Proposal

Nonlocal Unification posits that:

- There exists a universal informational field $\mathcal{I}$.
- This field is fundamentally nonlocal and not embedded in spacetime.
- Physical observables arise through sampling operations performed by agents.

An agent is modeled as a structured information-processing system that defines a sampling operator

$$S_A : \mathcal{I} \to \mathcal{O}_A, \tag{1}$$

where $\mathcal{O}_A$ denotes the agent's space of observations.

The key idea is that what we call "measurement" corresponds to the application of S_A to the underlying informational field.

4 Agents as Biological Samplers

Unlike QBism, which treats agents abstractly, NU grounds them physically. Agents are biological systems whose structure is determined by genetic encoding and neural dynamics.

Let θ_A denote the parameters characterizing an agent's internal architecture (e.g., neural connectivity, temporal resolution). Then the sampling operator can be written as

$$S_A = S(\theta_A). \tag{2}$$

Different agents, possessing different θ_A, will extract different structures from the same informational field.

This leads to the conclusion that:

Experienced reality is not universal but conditioned by the biological and informational structure of the agent.

5 Emergence of Spacetime

In NU, spacetime is not fundamental. Instead, it emerges from correlations in sampled information.

Consider two events as perceived by an agent. Their separation in spacetime is defined operationally through the agent's internal processing of correlations. Let X and Y denote informational variables sampled from $\mathcal{I}$. Then a notion of distance can be defined via an information-theoretic metric such as

$$d(X, Y) = H(X) + H(Y) - 2I(X; Y), \tag{3}$$

where H denotes entropy and I mutual information.

This metric induces a geometry that is not pre-existing but constructed through sampling.

Thus, spacetime intervals are emergent features of informational relationships rather than fundamental primitives.

6 Reinterpreting the Born Rule

In QBism, the Born rule is a normative constraint ensuring coherence of an agent's beliefs.

Within NU, the Born rule can be reinterpreted as a constraint arising from the structure of the informational field and the sampling process. Specifically, it ensures that probability assignments are consistent with the correlations present in $\mathcal{I}$.

This suggests that while probabilities are agent-dependent, they are not arbitrary; they are constrained by the underlying informational substrate.

7 Nonlocality without Action at a Distance

Quantum nonlocality has traditionally been interpreted as implying instantaneous influences. QBism resolves this by denying that measurement outcomes pre-exist.

NU offers a complementary perspective: correlations arise because the informational field itself is nonlocal.

Thus, when two agents observe correlated outcomes, this is not due to signals traveling between them, but because both are sampling from a shared nonlocal structure.

In this sense, nonlocality is not a dynamical feature but a structural property of reality.

8 Objectivity as Inter-Agent Consistency

If each agent samples reality differently, how does objectivity arise?

In NU, objectivity is defined as the consistency of structures extracted by different agents. If two agents A and B have sampling operators S_A and S_B, then objectivity corresponds to the

existence of mappings

$$\Phi_{AB} : \mathcal{O}_A \to \mathcal{O}_B \tag{4}$$

such that their observations are mutually compatible.

This replaces absolute objectivity with a relational notion grounded in shared informational structure.

9 Completion of QBism

We now argue that NU completes QBism in the following sense:

1. QBism provides a coherent epistemic framework but lacks ontology.
2. NU supplies an ontological substrate in the form of a universal informational field.
3. QBism's agent is abstract; under NU we may identify the agent with a physical sampling system.
4. QBism treats spacetime as given; NU derives spacetime from information.

Thus, NU extends QBism without contradicting its core principles.

10 Testable Implications

The NU framework suggests several empirical directions:

- Variations in neural architecture should correlate with differences in temporal and spatial perception.
- Altered states of consciousness should modify perceived spacetime structure.
- Information-theoretic measures should predict perceptual distances more accurately than geometric ones in certain regimes.

These predictions provide a pathway for connecting foundational physics with neuroscience.

11 Discussion

The synthesis of QBism and NU suggests a radical rethinking of reality. Rather than a fixed spacetime populated by objects, we have a dynamic interplay between:

- a nonlocal informational substrate,
- agents as structured samplers,
- emergent geometries arising from correlations.

This view dissolves traditional dualisms between subject and object, replacing them with a unified informational framework.

It also aligns with broader trends in physics that emphasize information as fundamental, while grounding these ideas in concrete biological processes.

12 Conclusion

Nonlocal Unification provides a natural ontological completion of Mermin's QBism. By introducing a universal informational field and identifying agents as biologically instantiated sampling systems, it extends the participatory paradigm into a fully articulated framework.

Spacetime, objectivity, and physical law all emerge from the interplay between information and sampling. In this sense, reality is not passively observed but actively constructed, yet constrained by a deeper informational order.

Future work will aim to formalize these ideas further and explore their implications for both physics and cognitive science.