# What Would Count as Evidence for Many Worlds?

Operational Equivalence and the Evidential Architecture of Everettian Quantum Mechanics

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## Abstract

Claims that experiments confirm the many-worlds interpretation often conflate evidence for quantum coherence, universal unitarity, the absence of objective collapse, decoherence-defined branches, and the reality of every branch. This paper develops a contrast-relative architecture that separates those targets. A complete theory package includes dynamics, ontology, state and parameter assumptions, and a probability or typicality rule that generates empirical likelihoods. Four formal results follow. Operationally equivalent theories have a Bayes factor of one for every fixed or adaptive protocol in the domain of equivalence. Evidence can redistribute probability toward a theoretical family while leaving the odds among equivalent members unchanged. An exact decomposition identifies the bridge factors required when support is inherited from shared dynamics by stronger structural or ontological claims. Finally, an inheritance-attenuation formula quantifies how evidence for unitarity weakens when Everett is compared with a complement containing other unitary theories. Applications include massive matter-wave interference, XENONnT collapse constraints, experimental quantum Darwinism, Local Friendliness tests, and proposed interbranch communication. Current results extend the tested domain of coherent quantum dynamics, constrain specified collapse models, and support mechanisms for stable, redundant records. They do not supply an outcome distribution favoring Everett over all operationally equivalent unitary rivals or directly establish the reality of every decohered component. Everett can therefore receive indirect, family-mediated confirmation while its distinctive ontology remains underdetermined within a predictive equivalence class.


*Keywords:* many-worlds interpretation; Everettian quantum mechanics; confirmation; operational equivalence; decoherence; objective collapse; quantum Darwinism; Wigner's friend

# What Would Count as Evidence for Many Worlds? Operational Equivalence and the Evidential Architecture of Everettian Quantum Mechanics

## 1. Introduction

What would count as evidence for many worlds? The question looks straightforward only while the words *evidence* and *many worlds* remain underspecified. A matter-wave interference experiment may be described as evidence that superposition persists at a larger mass. A null search for spontaneous radiation may count against a particular objective-collapse model. A decoherence experiment may show that multiple fragments of an environment carry redundant information about a preferred observable. None of these statements is equivalent to the claim that every decohered alternative is a physically real world. Yet it would also be too quick to conclude that such experiments have no evidential bearing on Everettian quantum mechanics at all.

The dispute is often forced into an unhelpful binary. Popular claims say that macroscopic superposition, quantum computation, Bell inequality violations, or reversible Wigner's-friend protocols have shown that parallel worlds are real. Skeptical replies say that interpretations make no different predictions and therefore that no experiment can ever provide evidence for an interpretation. Both claims erase distinctions that ordinary scientific confirmation requires. Evidence is contrastive: its force depends on which hypotheses are being compared, which parts of those hypotheses generate the likelihoods, and whether the comparison is between complete theory packages or between isolated slogans.

Everett's relative-state proposal removes a special collapse postulate and treats the quantum state as universally applicable (Everett, 1957). Modern Everettian accounts combine that proposal with decoherence, emergent quasi-classical structure, and an account of Born-weighted uncertainty or rational credence (Deutsch, 1999; Greaves & Myrvold, 2010; Saunders et al., 2010; Wallace, 2012). This modern package contains several claims with different evidential profiles. The present paper distinguishes five targets:

1. **Regime-level coherence:** superpositions persist under the particular conditions tested.

2. **Dynamical universality:** exact linear, unitary quantum evolution applies without a fundamental collapse law.

3. **Model-specific collapse exclusion:** named objective-collapse models or parameter regions are constrained.

4. **Structural adequacy:** decoherence produces sufficiently stable, redundant, record-bearing branch structure.

5. **Ontological multiplicity:** all qualifying branches are physically real rather than merely calculational, perspectival, or dynamically unoccupied structure.

These are nodes in an evidential network, not five deductive steps. Finite observations of coherence do not prove exact universal unitarity. Universal unitarity and the denial of fundamental collapse partly overlap, whereas a laboratory null result constrains only specified collapse dynamics. Decoherence may support stable records without selecting a unique ontology. And record-bearing branches do not, by logic alone, entail that all of them are worlds.

The paper's central contribution is a formal and applied account of *family-level* and *member-level* confirmation. A result can favor a unitary or no-extra-collapse family over specified nonunitary competitors, thereby increasing the unconditional probability of Everett, while leaving Everett's odds against Bohmian mechanics or another operationally equivalent member exactly unchanged. This resolves an apparent contradiction. "Macroscopic interference is evidence for many worlds" can be true when Everett is contrasted with a collapse model that predicts loss of visibility. "Macroscopic interference does not distinguish many worlds from

Bohmian mechanics" can simultaneously be true when those theories assign the same outcome probabilities.

The mathematical ingredients are elementary Bayesian probability and model averaging. The novelty claimed here is not a new theorem of probability. It is the synthesis of those tools into an evidential architecture for Everettian quantum mechanics, the separation of inherited confirmation from ontology-specific discrimination, the application to contemporary experiments, and a quantitative inheritance-attenuation result. That formula shows precisely why even a large Bayes factor for unitary dynamics can become a small Bayes factor for Everett against its entire complement when much of that complement is also unitary.

The argument is deliberately neutral about whether Everett is ultimately the best interpretation. It does not assign numerical priors to interpretations, settle the Born-rule debate, or assume that present-day formulations will remain empirically equivalent under all future physics. Its more limited aim is to identify what different kinds of evidence license now, what additional premises are required to move from dynamics to ontology, and what a genuinely interpretation-discriminating result would have to supply.

## 2. Disassembling the Everettian Hypothesis

### 2.1 From relative states to emergent worlds

Everett's original formulation described a composite system after measurement as an entangled state in which the state of each subsystem is relative to the state of the other (Everett, 1957). It did not posit a stochastic collapse selecting one term. In a schematic measurement,

$$(a|0\rangle + b|1\rangle)\big|A_{ready}\rangle \rightarrow a\big|0\rangle|A_0\rangle + b|1\rangle|A_1\rangle.$$

Calling the two terms "worlds" does not by itself explain why they behave autonomously, which decomposition is physically salient, or why observers should expect Born-rule frequencies. The modern Everettian program adds substantial structure to answer those questions.

Environmental decoherence suppresses interference between certain components of a reduced state and dynamically selects robust pointer observables (Schlosshauer, 2005; Zurek, 2003). Because interactions continually correlate systems, apparatuses, observers, and environmental degrees of freedom, the universal state develops components with approximately autonomous, quasi-classical records. On a prominent emergentist reading, worlds are not added objects with an exact fundamental count. They are higher-level patterns in the quantum state, comparable in some respects to other emergent structures whose boundaries are approximate but explanatorily useful (Wallace, 2012). Recent work continues to clarify when branching can be defined and how distinguishability, decoherent histories, and records are related (Franklin, 2024; Riedel, 2025; Taylor & McCulloch, 2025).

This picture is richer than “the wave function never collapses.” At minimum, a scientific Everettian package must say what the quantum state represents, how its dynamics applies, which emergent structures qualify as branches, and how empirical weights are assigned. The term *many worlds* is therefore best treated as a family of theory packages rather than as a single sentence.

### 2.2 Five evidential targets

The first target, regime-level coherence, is local and experimentally tractable. Interference establishes that alternative amplitudes remain capable of recombination under the tested preparation, isolation, control, and readout. As masses, separations, times, and internal complexity increase, the confirmed domain expands. But no finite sequence of such experiments entails that all physical systems evolve unitarily under every untested condition.

The second target, dynamical universality, is a global law claim. An Everettian theory ordinarily denies a fundamental stochastic modification of the Schrödinger equation. Its support comes from the continuing empirical adequacy and scope of unitary quantum models, together with constraints on competitors. Extrapolating from tested regimes to exact universality is an ordinary but defeasible form of scientific induction.

The third target is deliberately model-specific. GRW, CSL, Diósi-Penrose, and related proposals introduce different collapse rates, correlation lengths, coupling rules, noise spectra, and sometimes new radiation, heating, or diffusion signatures (Bassi et al., 2013; Ghirardi et al., 1986). A null result can exclude a parameter point or penalize a prior-weighted model family. It cannot establish the unrestricted proposition that no conceivable objective collapse occurs. Nor should a quantitative dynamical-collapse theory be conflated with every textbook use of the word *collapse*.

The fourth target concerns the internal adequacy of the Everettian account. Decoherence must do more than make off-diagonal matrix elements small in a convenient reduced state. The relevant structures must be stable enough to support records, observers, and approximately classical histories; the preferred observables and temporal grain must be physically motivated; and the resulting branch description must not depend arbitrarily on a representational choice. Quantum Darwinism and spectrum broadcast structure sharpen this demand by asking whether multiple environmental fragments independently encode accessible information about pointer observables (Horodecki et al., 2015; Zurek, 2009).

The fifth target is ontological. Even if unitary dynamics produces a robust branching structure, one can ask whether all branches are equally real, whether only one configuration is occupied, whether facts are relational to systems, or whether the state is primarily an agent's tool. Everett's distinctive answer is not merely that the formal state contains several terms but that no additional variable or stochastic event selects just one of the qualifying quasi-classical structures as *the* actual world.

Table 1 summarizes the separation.

**Table 1**
*Five Evidential Targets and Their Limits*

| Target | Typical empirical bearing | What the evidence does not establish by itself |
|---|---|---|
| Regime-level coherence | Visibility, phase dependence, coherent control, recoherence | Exact unitarity in all regimes |
| Dynamical universality | Broad predictive success and absence of detected deviations | Logical impossibility of future deviations |
| Collapse exclusion | Limits on named models and parameter regions | Rejection of every possible collapse dynamics |
| Structural adequacy | Decoherence, pointer stability, redundant records | A unique outcome or an ontology of real worlds |
| Ontological multiplicity | Requires a contrast that gives different likelihoods, or explicit abductive bridge premises | Follows neither from superposition nor decoherence alone |

### 2.3 The probability and self-location bridge

There is a further issue that cuts across all five targets. A complete empirical theory must assign likelihoods to possible records. In a single-outcome stochastic theory, the Born rule directly gives ordinary outcome probabilities. In Everett, every outcome with nonzero amplitude occurs in some successor branch. If "the outcome occurs somewhere" is the evidence, its likelihood is normally one under a wide class of Everettian states and it cannot reproduce standard confirmation. An Everettian account therefore needs a principled relation among squared amplitude, rational expectation, typicality, and self-locating evidence.

Decision-theoretic, epistemic, and self-location programs argue that agents in an Everettian universe should weight successors by the Born measure and can confirm quantum states using branch-weighted likelihoods (Deutsch, 1999; Greaves & Myrvold, 2010; Sebens &

Carroll, 2018; Wallace, 2006, 2007). Critics question whether the derivations presuppose too much, whether anomalous observers can confirm false theories, or whether a proposed weighting rule has adequate empirical content (Adlam, 2014; Albert, 2010; Kent, 2010; Price, 2010). This paper does not resolve that dispute.

Instead, it makes the bridge explicit. A hypothesis in the formal analysis is a complete package

$$H_i = (D_i, O_i, \Psi_i, \theta_i, W_i),$$

where $D_i$ is dynamics, $O_i$ ontology, $\Psi_i$ state assumptions, $\theta_i$ model parameters, and $W_i$ a probability, typicality, or self-location rule sufficient to generate empirical likelihoods. The propositions below apply to Everett only conditionally on such a rule. If Born-weighted Everettian likelihoods are not justified, that is a substantive defect in the package, not a reason to assign it ordinary likelihoods silently.

## 3. A Contrast-Relative Architecture of Confirmation

### 3.1 Complete packages, interventions, and domains

Let $e$ denote a possible evidential record and $x$ an experimental intervention. A complete theory package $H_i$, together with shared auxiliary assumptions $B$ and an observation-selection rule $S$, supplies a predictive distribution

$$L_i(e|x) = P(e \mid x, H_i, S, B).$$

The qualification matters. Detector calibration, environmental modeling, postselection, and the rule identifying an observer's evidence can alter a likelihood. Comparisons must either condition on common auxiliaries or marginalize over their uncertainty. An interpretation label without a state, dynamics, parameter prior, and probability rule is not yet a statistical hypothesis.

Evidence is evaluated relative to an experimental domain $\mathcal{D}$: a set of preparations, interventions, records, and outcome spaces. Two theories may be indistinguishable throughout current laboratory practice yet diverge in a future quantum-gravity regime. Conversely, an alleged difference in verbal explanation does not yield an empirical distinction unless it changes a probability distribution for some admissible protocol.

### 3.2 Operational Equivalence Proposition

**Proposition 1 (Protocol-relative operational equivalence).** Let $H_1$ and $H_2$ assign the same conditional predictive kernel for every admissible intervention $x_t$, previous record $d_{<t}$, and possible result $y_t$ in domain $\mathcal{D}$:

$$P(y_t \mid x_t, d_{<t}, H_1, S, B) = P(y_t \mid x_t, d_{<t}, H_2, S, B).$$

Then for every finite fixed or adaptive record $D = (y_1, \ldots, y_n)$ generated in $\mathcal{D}$,

$$BF_{12}(D) = \frac{P(D \mid H_1, S, B)}{P(D \mid H_2, S, B)} = 1,$$

and the posterior odds equal the prior odds.

*Proof.* For an adaptive protocol, the joint likelihood factorizes as

$$P\big(D \mid H_j, S, B\big) = \prod_{t=1}^{n} P\left(y_t \mid x_t, d_{<t}, H_j, S, B\right).$$

Equality of every conditional factor makes the joint likelihoods equal. Bayes' theorem then gives

$$\frac{P(H_1 \mid D, S, B)}{P(H_2 \mid D, S, B)} = BF_{12}(D) \frac{P(H_1 \mid S, B)}{P(H_2 \mid S, B)} = \frac{P(H_1 \mid S, B)}{P(H_2 \mid S, B)}. \quad \square$$

The proposition covers adaptive experimentation: choosing tomorrow's setting in light of today's data does not break an equivalence that holds at every conditional step. It also explains why adding repetitions cannot turn an exactly interpretation-neutral experiment into an interpretation selector. If standard equilibrium Bohmian mechanics and an Everettian package provide the same state transformations and Born-weighted statistics for a circuit, that circuit's experimental Bayes factor between them is one.

The result is domain-relative, not a declaration of permanent global equivalence. Bohmian nonequilibrium theories, modified dynamics, and future extensions can differ. Wallace (2023, 2026) further argues that the apparent equivalence is overstated because Everettian quantum theory inherits the successful practice of interacting quantum field theory whereas Bohmian and collapse programs lack comparably successful general formulations. That challenge is considered below. Proposition 1 applies wherever two complete packages actually assign equal predictive kernels; it does not assume that all theories called "interpretations" do so in every domain.

An approximate form is also useful. If a record satisfies

$$e^{-\varepsilon} \leq \frac{P(D \mid H_1)}{P(D \mid H_2)} \leq e^{\varepsilon},$$

then the evidence can change the odds by no more than those factors. Current experimental indistinguishability is weaker than exact equivalence, but it still bounds what the existing record can accomplish.

### 3.3 Families and marginal likelihoods

Let the hypothesis space be partitioned into mutually exclusive families $F_1, \ldots, F_k$. A family might collect complete packages that preserve ordinary unitary predictions in a specified domain, while other families contain parameterized objective-collapse models or an explicit catch-all of unformulated alternatives. With family prior $\Pi_f = P(F_f)$, within-family prior $w_{i|f} = P(H_i \mid F_f)$, and member likelihood $L_i(e)$, the family marginal likelihood is

$$m_f(e) = \sum_{H_i \in F_f} w_{i|f}\, L_i(e),$$

or the corresponding integral over continuous parameters. The posterior family probability is

$$P\big(F_f \mid e\big) = \frac{\Pi_f m_f(e)}{\sum_g \Pi_g\, m_g(e)}.$$

This standard model-averaging structure prevents several errors. A null collapse search does not compare “unitarity” with an unparameterized word. It compares a likelihood under ordinary dynamics with a prior-weighted range of collapse rates, correlation lengths, spectra, couplings, and auxiliaries. Likewise, listing ten names for predictively identical unitary interpretations should not manufacture ten times the prior probability. Family priors should be assigned before they are distributed among members (Hoeting et al., 1999; Kass & Raftery, 1995).

### 3.4 Family Redistribution Proposition

**Proposition 2 (Member-neutral family redistribution).** Let $F$ be one family in an exhaustive partition, and let

$$m_{\neg F}(e) = \sum_{g \neq f} \frac{\Pi_g}{1 - \Pi_f} m_g(e)$$

be the prior-weighted likelihood of its full complement. Suppose (a) $m_F(e) > m_{\neg F}(e)$ and (b) the evidence is member-neutral within $F$, so $L_i(e) = m_F(e)$ for every $H_i \in F$. Then $P(F \mid e) > P(F)$; every positive-prior member of $F$ rises by the same multiplicative factor; and all within-family odds remain unchanged:

$$\frac{P(H_i \mid F, e)}{P\big(H_j \mid F, e\big)} = \frac{P(H_i \mid F)}{P\big(H_j \mid F\big)}$$

and

$$\frac{P(H_i \mid e)}{P(H_i)} = \frac{P(F \mid e)}{P(F)}.$$

*Proof.* Family odds obey

$$\frac{P(F \mid e)}{P(\neg F \mid e)} = \frac{P(F)}{P(\neg F)} \frac{m_F(e)}{m_{\neg F}(e)}.$$

The likelihood inequality raises the family odds. Member-neutrality makes the common likelihood cancel in every conditional member ratio, fixing the within-family shares. Multiplying each fixed share by the increased family posterior yields the final identity. ▫

The complement condition is essential. Showing $P(e \mid U) > P(e \mid C)$ for a unitary family $U$ and one collapse family $C$ does not guarantee that $P(U \mid e) > P(U)$ if a third, high-likelihood family has substantial prior mass. The correct comparison is $m_U(e) > m_{\neg U}(e)$, or an explicitly restricted two-family analysis. A family can also rise while one of its members falls if the evidence is not member-neutral and instead favors other members.

Consider a simple illustration. Let the prior probability of a unitary family be .40 and that of its full complement .60. Within the unitary family, assign .375 to Everett, .375 to equilibrium Bohm, and .250 to other unitary packages, so Everett's unconditional prior is .15. If the evidence has a family Bayes factor of 9 and is neutral among those members, the unitary posterior becomes .857 and Everett's posterior becomes about .321. Everett has been confirmed in the weak, unconditional probability-raising sense. Yet its 1:1 odds against Bohm are untouched. The experiment has redistributed probability between families, not within the unitary family.

### 3.5 Evidential Inheritance Constraint

The same point can be expressed as an exact decomposition. If a specific interpretation $M$ belongs to family $F$, then

$$\frac{P(M \mid e)}{P(M)} = \frac{P(F \mid e)}{P(F)} \times \frac{P(M \mid F, e)}{P(M \mid F)}.$$

The first factor is family redistribution. The second is member-level discrimination. Calling a result "evidence for Everett" without reporting which factor did the work invites an equivocation.

For a layered claim, let $U$ be a relevant unitary-dynamics hypothesis, $R$ a hypothesis of robust record-bearing branch structure, and $M$ an Everettian ontology, with $M \Rightarrow R \Rightarrow U$ for the packages under comparison. Then

$$\frac{P(M \mid e)}{P(M)} = \frac{P(U \mid e)}{P(U)} \times \frac{P(R \mid U, e)}{P(R \mid U)} \times \frac{P(M \mid R, e)}{P(M \mid R)}.$$

**Proposition 3 (Evidential inheritance constraint).** If $e$ is conditionally independent of the structural bridge once $U$ is fixed, and independent of the ontological bridge once $R$ is fixed, then the last two factors equal one. The evidence may still raise $P(M)$ by raising $P(U)$, but it does not alter confidence in robust branching conditional on $U$, or in Everettian ontology conditional on robust branching.

*Proof.* Conditional independence gives $P(R \mid U, e) = P(R \mid U)$ and $P(M \mid R, e) = P(M \mid R)$. Substitution into the decomposition yields the result. ▫

This constraint does not say that support can never transmit to a conjunction. Bayesian confirmation permits evidence for $U$ to raise $P(U \wedge O)$ even when it is irrelevant to $O$ conditional on $U$. That is a version of the familiar problem of tacking by conjunction (Fitelson, 2002; Schippers & Schurz, 2020). The constraint instead requires evidential claims to disclose their target and bridge factors. Coherence can indirectly confirm an Everettian package against a collapse alternative while providing no new reason, among unitary accounts, to believe that every branch is real.

### 3.6 Inheritance attenuation

The size of the inherited update depends on the composition of the contrast class. Let $M$ imply unitary dynamics $U$ in the relevant domain, and suppose the evidence depends on whether $U$ holds but is neutral about Everettian ontology conditional on that dynamical status. Define

$$r = \frac{P(e \mid U)}{P(e \mid \neg U)}$$

and let

$$q = P(U \mid \neg M)$$

be the share of the non-Everett complement that is also unitary.

**Proposition 4 (Inheritance attenuation).** Under those assumptions,

$$BF_{M,\neg M}(e) = \frac{r}{qr + (1-q)}.$$

For $r \geq 1$,

$$1 \leq BF_{M,\neg M}(e) \leq r.$$

If $q > 0$, then $BF_{M,\neg M}(e) < 1/q$, even in the limit as $r \to \infty$.

*Proof.* Write $a = P(e \mid U)$ and $b = P(e \mid \neg U)$. Since $M \Rightarrow U$, $P(e \mid M) = a$. The non-Everett alternative is a mixture: $P(e \mid \neg M) = qa + (1-q)b$. Division by $b$ gives the formula, and the bounds follow algebraically. ▫

Suppose an experiment yields $r = 100$ for unitary over nonunitary dynamics. The inherited Bayes factor changes as follows.

**Table 2**
*Inheritance Attenuation for a Unitarity Bayes Factor of 100*

| $q = P(U \mid \neg M)$ | $BF_{M,\neg M}$ **when** $r = 100$ |
|---:|---:|
| 0 | 100.00 |
| .10 | 9.17 |

| $q = P(U \mid \neg M)$ | $BF_{M,\neg M}$ **when** $r = 100$ |
|---|---|
| .50 | 1.98 |
| .90 | 1.11 |
| 1.00 | 1.00 |

The log difference

$$\delta(e; M, U) = \log r - \log BF_{M,\neg M}(e) = \log(qr + 1 - q)$$

measures *inheritance attenuation*. It is prior- and partition-relative, not an intrinsic distance between propositions. Its value is conceptual: it prevents a strong result against collapse from being advertised unchanged as a strong result for Everett over every alternative.

### 3.7 Safeguards against manufactured confirmation

The framework requires several disciplines. Families must form a disjoint partition; otherwise posterior mass can be counted twice. A catch-all alternative should retain probability for unformulated theories rather than forcing every loss by one collapse model into Everett. Composite likelihoods must marginalize over proper parameter priors. Correlated results must be evaluated jointly or sequentially:

$$BF(e_1, e_2) = BF(e_1)\frac{P(e_2 \mid e_1, H_1)}{P(e_2 \mid e_1, H_2)},$$

not by multiplying headline marginal Bayes factors unless conditional independence holds under both hypotheses. Evidence used to motivate a prior cannot be reused as if it were new likelihood evidence. Finally, duplicating a theory under several names must not increase its aggregate probability: if identical aliases divide the original prior mass and share its likelihood, their posterior masses sum to the original posterior.

These points are especially important in interpretation debates because “Everett,” “Bohm,” “relational,” and “collapse” often identify research programs rather than single fully specified statistical models. The framework is a discipline for making comparisons explicit.

### 3.8 Relation to prior confirmation debates

None of the preceding identities enters an empty literature. Empirical equivalence and underdetermination in quantum theory have been analyzed directly, including the question whether interpretations should count as rival theories or alternative representations (Acuña, 2021; Egg & Saatsi, 2021). Bayesian model averaging already distinguishes a composite family’s marginal likelihood from the likelihood of any selected member. Greaves and Myrvold (2010) explicitly develop a confirmation procedure for Everett, while Wallace (2006) argues that circumstances could rationally lead an observer to believe the interpretation. The problem of irrelevant conjunction shows that evidence for one conjunct can confirm a larger conjunction in an ordinary probability-raising sense even when the added content is evidentially idle (Crupi & Tentori, 2010; Fitelson, 2002; Schippers & Schurz, 2020).

The present architecture does not replace those results. It makes their joint consequence explicit for contemporary claims about many worlds. “Evidence for Everett” has at least three non-equivalent readings: an increase in the probability of the complete Everettian conjunction, an improvement relative to a named rival, and an update that resolves the distinctively Everettian component conditional on shared physics. The first is permissive and allows evidential inheritance. The second is contrast-relative. The third is demanding and blocks the rhetorical transfer of a dynamical Bayes factor to an ontological claim without a bridge.

The inheritance-attenuation result adds a quantitative expression of that distinction. Standard discussions note that common-core evidence cannot discriminate empirically equivalent theories. Proposition 4 asks a different global question: how much does a unitary result favor Everett over *everything that is not Everett*? Its answer depends continuously on how much of that complement already predicts unitarity. The result is elementary, but it turns an often qualitative warning into a bounded, prior-sensitive calculation and provides a direct reporting tool for future claims.

The framework also differs from treating interpretations as cost-free semantic glosses. Complete packages can diverge in probability rules, scope, ontology-dependent auxiliary assumptions, or future dynamics. Those divergences can generate evidence. The disciplined position lies between two extremes: no blanket empirical equivalence is assumed, but no interpretation-specific confirmation is inferred from a common likelihood either.

## 4. Four Evidential Roles

The evidence categories relevant to many worlds are best called roles rather than mutually exclusive types. One result can play different roles under different contrasts.

**Table 3**
*Evidential Roles in Everettian Confirmation*

| Evidential role | Formal or methodological criterion | Licensed conclusion |
| --- | --- | --- |
| **Member-discriminating** | $BF_{H_i,H_j}(e) \neq 1$ for complete theory packages | Changes posterior odds between specified interpretations |
| **Family-discriminating** | $m_F(e)/m_G(e) \neq 1$ for disjoint, prior-specified families | Redistributes probability between families; may leave member odds fixed |
| **Structural or bridge support** | Evidence or derivation bears on a required mechanism such as robust records | Supports internal adequacy; reaches ontology only through stated bridge premises |
| **Compatibility-only** | The result is allowed by a theory, without a rival assigning lower likelihood | Establishes non-refutation, not positive confirmation by itself |

Compatibility is the weakest role. The observation that an experiment “is what many worlds predicts” is not enough: almost any successful interpretation of ordinary quantum mechanics predicts the observed quantum statistics. Positive Bayesian confirmation requires the evidence to be more likely under the target than under a specified alternative or complement. Conversely, family-discriminating evidence is not illusory merely because it fails to choose a member. A medical test can favor a disease family without identifying the subtype; likewise, a coherence result can favor ordinary unitary dynamics over a specified collapse model without deciding how unitary dynamics should be interpreted.

## 5. Contemporary Case Studies

### 5.1 Massive matter-wave interference

Interference is the clearest evidence that spatially separated amplitudes have remained coherent enough to recombine. Pedalino et al. (2026) recently used three optical gratings with 133-nm period to distinguish quantum interference from a classical trajectory model for sodium clusters centered near 172 kDa. The representative mass range was approximately 143-197 kDa, corresponding to particles about 8 nm in diameter and containing more than 7,000 atoms. The inferred delocalization was 133 nm, more than an order of magnitude larger than the particle diameter, and the reported macroscopicity was $\mu = 15.5$. The observed visibility as a function of grating power tracked the quantum rather than the classical prediction.

This is substantial evidence for regime-level coherence. It extends the tested combination of mass, internal complexity, and spatial separation; it also constrains modifications that would have destroyed the observed visibility. Precision matters, however. The apparatus transmitted clusters approaching 1 MDa, but in that range the accessible quantum and classical visibility predictions converged. The operational quantum-classical discrimination occurred below roughly 200 kDa, not at 1 MDa.

“Macroscopic” is not a single ordering. Bild et al. (2023) prepared cat states of a mechanical oscillator with an effective mass of 16 micrograms, enormously greater than the nanoparticle mass, but with opposite-phase vibrational states separated by only about $10^{-18}$ m. One experiment is more macroscopic by effective mass, the other by spatial separation and center-of-mass interference. Such metrics illuminate physical regimes; they do not measure the number or reality of worlds. Under a contrast with a collapse model that predicts appreciable loss of visibility, the result is directly discriminating and can favor a broader ordinary-dynamics family. Under a contrast between Everett and quantum-equilibrium Bohmian mechanics, both of which retain the coherent wave and reproduce the same visibility, Proposition 1 assigns a Bayes factor of one. Nor is this experiment structural evidence for mature branches in the strong record-bearing sense. Observable interference is possible precisely because which-path alternatives have not been irreversibly copied into a large environment. The experiment displays coherent alternatives, not communication between autonomous quasi-classical worlds.

**5.2 XENONnT and the logic of collapse constraints**

Objective-collapse theories are unusually important for this debate because they can convert a philosophical contrast into quantitative dynamics. GRW and CSL introduce stochastic localization characterized by parameters such as a collapse rate and correlation length; particular versions predict spontaneous radiation, heating, or diffusion (Bassi et al., 2013; Ghirardi et al., 1986). Evidence can therefore discriminate ordinary quantum dynamics from those versions without observing a collapse event directly.

The XENON Collaboration (2026) searched the XENONnT detector’s 1-140 keV electron-recoil data for spontaneous X-rays predicted by mass-proportional, Markovian white-noise CSL and by a regularized Diósi-Penrose model. The analysis used a 1.16 tonne-year exposure and incorporated electron-proton charge cancellation in the atomic radiation calculation. No significant excess was found. The resulting CSL bound improved the prior Majorana limit by about a factor of 135, while the Diósi-Penrose bound improved by about a factor of five. Within the tested white-noise formulation, a commonly used GRW-inspired point, $r_C = 10^{-7}$ m and $\lambda = 10^{-16}\ \mathrm{s}^{-1}$, was strongly excluded.

The evidential conclusion is real but conditional. XENONnT directly disfavors the tested models and parameter regions relative to their no-extra-radiation alternatives. It thereby supplies family-level support for ordinary dynamics when the family comparison and parameter prior are specified. It does not rule out collapse in general. Colored, dissipative, non-Markovian, differently coupled, or otherwise modified models can have different signatures; current work continues to construct such alternatives (Gundhi et al., 2026). The experiment also did not prepare a macroscopic superposition. It used a sensitive detector as a probe of predicted excess radiation.

Bayesian phrasing exposes another subtlety. Exact no-collapse is a point hypothesis, whereas a collapse family may be continuous in $\lambda$. A continuous prior with no point mass at $\lambda = 0$ cannot acquire posterior point probability at exactly zero. A null result shifts density toward smaller effects and removes mass from excluded regions; whether it favors a distinct exact-unitarity model depends on the prior structure. The lesson is not that the limit is subjective, but that "collapse is ruled out" is not a prior-free translation of a confidence contour.

For Everett, the update has the architecture of Proposition 2. The result can increase Everett's unconditional posterior by reducing probability assigned to specified collapse dynamics. It does not change Everett's odds against Bohmian, relational, or other packages that predict the same XENONnT spectrum. It supports neither redundant branches nor ontological multiplicity directly.

### 5.3 Quantum Darwinism and record-bearing structure

Decoherence explains why interference between certain alternatives becomes locally inaccessible, but Everett also needs positive structure: stable records that multiple observers can consult without substantially disturbing the system. Quantum Darwinism describes the environment as a communication channel that redundantly proliferates information about pointer observables (Zurek, 2009). If many disjoint fragments each reveal nearly the same classical information while global quantum correlations remain delocalized, the model explains how apparently objective facts become accessible.

Zhu et al. (2025) produced an engineered demonstration with superconducting circuits. In one implementation, two central system qubits and ten environmental qubits were coupled so that information about the designated pointer states $|00\rangle$ and $|11\rangle$ spread into environmental fragments. Tomographic reconstructions increasingly clustered around the pointer states as the environment grew. A related nine-qubit experiment measured mutual information, Holevo information, and discord. In the Darwinistic regime, small fragments reached the expected classical-information plateau while discord was suppressed; the more global quantum information remained accessible only through sufficiently inclusive measurements.

This is structural evidence in a meaningful experimental sense. It validates, in a controlled finite system, central information-theoretic and geometric predictions of the Darwinism mechanism. It shows that unitary interactions plus restricted access can create multiple locally accessible records that behave classically. Earlier photonic demonstrations and results on spectrum broadcast structure support the same research program (Chen et al., 2019; Horodecki et al., 2015).

The bridge to worlds is nevertheless incomplete. The system-environment split, pointer states, and conditional gates in the superconducting experiment were designed. Ten qubits are not an uncontrolled macroscopic environment; the records are not observers; and global coherence remains deliberately manipulable. The main preparation also used equal amplitudes, so it does not derive or discriminate probability rules. Decoherence converts a pure global state into an improper reduced mixture, but it does not select one term as the unique outcome (Adler, 2003).

For Everett, the result strengthens the structural-adequacy factor $P(R \mid U, e)/P(R \mid U)$ if the experiment was not already entailed with certainty by the accepted model. It does not force the ontological factor $P(M \mid R, e)/P(M \mid R)$ to change. Contemporary demands for a precise account of branches reinforce that distinction. Approximate, emergent worlds need not have sharp microscopic boundaries, but an adequate theory must still say what physical features make a branch robust enough to carry records and why alternative decompositions are dynamically inferior (Franklin, 2024; Riedel, 2025; Taylor & McCulloch, 2025).

## 5.4 Wigner's friend and Local Friendliness

Extended Wigner's-friend arguments ask whether an observer and laboratory can be treated coherently by a super-observer while the internal observer has registered a definite result. Bong et al. (2020) proved a strong no-go theorem: given sufficiently scalable quantum control, the conjunction of Absoluteness of Observed Events, locality, and an appropriate freedom or no-superdeterminism assumption conflicts with quantum predictions. Their photonic proof of principle used a path degree of freedom as the “friend.” It tested the correlation structure, not the reversible quantum control of a conscious observer or ordinary laboratory.

Zeng et al. (2025) subsequently implemented larger, loophole-bearing circuits on quantum processors. They introduced a “branch factor,” based on the difference between the complexity of initializing and distinguishing a record, as a proxy for friend-like scale. Reversible GHZ-type registers reached a reported branch factor of 16. This is impressive coherent control of increasingly large record-like systems. It is not a calibrated measure of consciousness, observation, or the number of real worlds, and same-device circuits do not close the locality and agency gaps of an ideal Local Friendliness test.

The no-go structure is disjunctive. Everett can reject a unique absolute outcome. Relational approaches can reject observer-independent facts. Bohmian mechanics is explicitly nonlocal. Collapse theories can deny scalable reversible unitarity for sufficiently macroscopic friends. Superdeterministic and retrocausal programs alter other assumptions. Thus a violation can place pressure on a conjunction without selecting one interpretation. The evidence becomes Everett-favoring only conditional on bridge judgments that independently privilege locality, measurement independence, universal control, and non-uniqueness of outcomes over the competing resolutions.

This point also calibrates the recent suggestion that Bell inequality violations are powerful evidence for many worlds. Saunders (2026) develops a locality condition for single-case Everettian probabilities under which non-unique remote outcomes provide an escape from a Bell inequality. That is a substantive comparative argument, not mere compatibility. Its evidential force, however, depends on the comparison: Bohmian theories accept nonlocality; retrocausal approaches revise causal assumptions; and disputes remain over the appropriate locality condition. Bell data can become conditional ontological evidence when those bridge premises are defended. The raw correlations alone do not assign an Everett-specific likelihood.

### 5.5 "Interbranch communication" as a diagnostic case

Violaris (2026) proposes a Wigner's-friend protocol in which a friend writes a message, the friend's memory is uncomputed, and a global unitary changes correlations among qubit, room, friend, memory, and paper registers. A later friend-copy encounters the written content without retaining the history of writing it. The proposal describes this as communication across multiverse branches and suggests that a sufficiently distinctive message might bear on Everett versus Bohm. The paper is a preprint and thought experiment, not a reported experimental test.

Altman (2026) implemented a five-qubit circuit inspired by the proposal on IBM hardware. With 20,000 shots, the experiment obtained substantial visibility and coherence-witness values. Altman carefully characterizes the result as inter-register transfer within one circuit, not physical signaling, and explicitly states that it does not discriminate interpretations. The implementation is useful as a coherent-reversibility and device-noise benchmark.

The case reveals why operational analysis must precede ontological language. A global unitary can erase a record, permute labels and correlations, and later make a stored bit accessible in a different record context. Whether the components before and after that operation should be identified as the same branches is not fixed by a privileged "room" qubit. Everettian branches are emergent patterns of the full state. In a small, deliberately recohered circuit, the components have not become permanently autonomous macroscopic worlds in the robust sense at issue.

More decisively, a claim of interbranch communication does not itself produce $P(e \mid M) \neq P(e \mid B)$. In quantum equilibrium, Bohmian mechanics retains an evolving wave function whose "empty" packets can participate in later interference and reproduces ordinary circuit statistics (Dürr et al., 1992). Relabeling a coherent correlation as the origin of a message supplies no Bayes factor unless a complete rival predicts a different final distribution. The distinctive narrative may prompt useful questions about identity, records, and information flow; it is not yet member-discriminating evidence. A genuine interpretation-dependent communication result would need at least five elements: a physically motivated branch criterion; two complete rival packages; a protocol yielding different outcome probabilities after nuisance parameters are marginalized; a demonstration that ordinary coherent evolution under the rival cannot reproduce the effect; and a record that operationally preserves the alleged sender-receiver relation. Without those elements, “communication” is a description of amplitude manipulation shared by the interpretations.

### 5.6 What the cases jointly show

Across the cases, evidential role changes with the contrast. Matter-wave interference extends the domain of coherent superposition. XENONnT constrains specified stochastic-collapse dynamics. Quantum Darwinism demonstrates mechanisms for redundant branch-like records. Local Friendliness circuits probe a conditional no-go structure. The interbranch circuit implements ordinary coherent correlations. None presently supplies an outcome distribution that favors Everett over every operationally equivalent unitary rival, and none directly establishes that every decohered component is a real world.

**Table 4**

*Evidential Classification of the Contemporary Cases*

| Case | Strongest present evidential role | Everett-specific likelihood? | Principal limit |
|---|---|---:|---|
| Massive interference | Coherence and collapse-family constraint | No | Coherent paths are not yet robust record-bearing branches |
| XENONnT | Direct constraint on specified collapse dynamics | No | Model and parameter dependence |

| Case | Strongest present evidential role | Everett-specific likelihood? | Principal limit |
|---|---|---|---|
| Quantum Darwinism | Structural support for redundant records | No | Engineered finite environment; no outcome selection |
| Local Friendliness | Conditional no-go evidence | Only with disputed bridge premises | Observer, locality, and agency assumptions |
| Interbranch circuit | Compatibility and coherent-control benchmark | No | Same unitary outcome law across compared packages |

This conclusion does not erase differences in theoretical scope. Wallace (2023, 2026) argues that unmodified unitary quantum theory, read Everettianly, covers interacting quantum-field-theoretic practice, whereas Bohmian and collapse programs lack equally successful general formulations. If rival packages truly have different predictive scope, global operational equivalence fails. Completeness, integration with field theory, Lorentz structure, and the capacity to calculate known phenomena are legitimate comparative virtues.

The inference still needs care. An undeveloped rival does not assign probability zero to data; sometimes it supplies no defined likelihood at all. Comparing a mature formalism with a research program changes the question from an experiment between fixed models to the viability and promise of broader programs. Such scope can affect priors, model availability, and abductive assessment, and a completed extension could eventually yield distinct likelihoods. It should not be conflated with a laboratory Bayes factor that directly detects ontology. Operational equivalence is therefore asserted here only over specified domains, never as a timeless global theorem about interpretation labels.

## 6. What Would Count as Evidence for Many Worlds?

The answer depends first on the evidential target. If the target is Everett versus a named collapse model, an interference result or null radiation search can already be direct discriminating evidence because the complete packages assign different probabilities. If the target is Everett versus all non-Everett theories, the same evidence is attenuated by the unitary share of the complement, as Proposition 4 shows. If the target is ontological multiplicity conditional on accepted unitary and branch dynamics, current experiments appear neutral.

Several developments could strengthen the evidential case without requiring a mythical "photograph of another world." First, larger and cleaner interference experiments can increase likelihood ratios against collapse models that predict scale-dependent decoherence. Their significance should be reported model by model, with priors or exclusion regions explicit. Second, complementary searches for radiation, heating, diffusion, time-correlation, and gravitational signatures can cover assumptions that any one collapse search leaves open. Joint evidence must be modeled with its dependencies rather than multiplied rhetorically.

Third, structural research can improve the bridge from unitarity to worlds. Experiments and theorems could establish that redundant records arise generically rather than only in engineered networks; that branch criteria are stable under reasonable coarse grainings; that recoherence complexity grows in the required way; and that observers embedded in the dynamics recover consistent records. This would strengthen Everett's internal adequacy even if it did not distinguish its ontology from every rival.

Fourth, an Everett-specific test requires a probability difference. A proposed protocol must state a complete Everettian likelihood, a complete rival likelihood, and an outcome or sequence for which the ratio differs. The difference cannot arise only from replacing "amplitude," "relative state," or "empty wave" with "world." It must survive translation into preparations, transformations, records, selection rules, and probabilities. If no such difference exists in the domain, Proposition 1 is not pessimism; it is the definition of experimental equivalence.

Fifth, evidence can bear on the probability bridge within Everett. Born-frequency data may discriminate Everett-plus-Born-weight from a sufficiently precise Everett-plus-alternative-weighting account, even though the winning Everett package remains equivalent in outcome probabilities to a non-Everett theory using the same Born rule. Recent defenses of branch-counting alternatives make it especially important not to treat “Everett” as already containing an uncontested empirical measure (Khawaja, 2026). A successful non-circular derivation, combined with frequency evidence, would be a real contribution to Everettian confirmation, although its force would be partly theoretical rather than a novel detector signal.

Finally, interpretation-specific support can be abductive. A theory may integrate quantum field theory more completely, formulate locality more transparently, use fewer dynamical laws, or explain stable records with less added structure. These considerations can rationally alter priors or overall theory choice. They are not valueless because they are not likelihoods, but they are contestable: Everett may be parsimonious in laws while extravagant in ontology; Bohm may be clear in primitive ontology while nonlocal; relational approaches may economize on absolute states while revising facts. A rigorous claim should say which virtue is used and why it tracks truth rather than taste.

The most probative imaginable result is therefore not generically “more quantum weirdness.” It is a result that creates evidential asymmetry at the relevant level. Against collapse, that may be a larger superposition or a missing noise signal. For branch structure, it may be robust redundant records under natural dynamics. For Everettian multiplicity itself, it must be an outcome law or independently defended bridge principle that changes the odds among ontology packages sharing the same ordinary quantum core.

## 7. Philosophical Consequences

The framework rejects both triumphalism and insulation. Everett is not experimentally proved by every successful quantum experiment. Yet it is also not evidentially untouched. Scientific theories are confirmed as packages, and evidence for a shared consequence can raise the probability of every package that entails it. Calling that update indirect or inherited is not a denial of confirmation; it is a statement about resolution.

Three senses should therefore be kept apart. *Global confirmation* asks whether $P(M \mid e) > P(M)$. *Contrastive confirmation* asks whether $e$ changes Everett's odds against a specified rival. *Component-resolving confirmation* asks whether $e$ changes confidence in ontological multiplicity once the shared dynamics and branch structure are held fixed. A result can answer yes, yes, and no respectively. Much disagreement about evidence for many worlds is a disagreement about which question was intended.

This separation also locates underdetermination. It is neither a universal verdict that physics cannot inform ontology nor a temporary embarrassment automatically removed by scale. Where complete theories remain operationally equivalent, data cannot redistribute their odds; theoretical virtues and bridge arguments must do the work. Where dynamics, scope, or probability rules diverge, experiments can discriminate. The boundary is revisable because theories and experimental domains develop.

For scientific communication, an evidential target principle follows: every claim that a result is evidence for many worlds should state (a) the target Everettian package, (b) the contrast class, (c) the likelihood-bearing assumptions, and (d) whether the update is family-level, structural, or member-discriminating. This modest reporting rule would eliminate most apparent contradictions without deciding the interpretation in advance.

## 8. Limitations

The analysis is Bayesian but does not pretend that interpretation priors are uniquely measurable. Results involving family marginal likelihoods depend on partitions and parameter priors, while the inheritance-attenuation quantity depends on $q = P(U \mid \neg M)$. Sensitivity analysis is therefore essential. The framework also idealizes theories as sufficiently complete to assign likelihoods, although real research programs are often partial. A missing likelihood is not a failed prediction, and nonempirical virtues may be needed when formal scope differs.

The case studies are selective rather than exhaustive. They do not cover every gravity-related collapse proposal, quantum cosmology, primitive-ontology program, consistent-histories account, QBist theory, or relational variant. Several 2026 items discussed here are preprints and may change. Finally, the paper assumes that Bayesian confirmation is a useful language for the question. Other accounts of explanation, severe testing, or scientific realism may redescribe the same architecture, although the operational-equivalence constraint remains.

## 9. Conclusion

Current experiments provide substantial evidence for coherent quantum evolution across increasingly demanding regimes, impose strong constraints on specified objective-collapse dynamics, and demonstrate mechanisms by which stable, redundant classical records can emerge from controlled unitary interactions. These achievements matter to Everettian quantum mechanics. They do not have identical evidential force for the claim that every branch is ontologically real.

Operational equivalence fixes the limit: when complete theories assign the same predictive distribution throughout a domain, every experimental Bayes factor between them is one. Family redistribution explains the opportunity: evidence can raise Everett's unconditional probability by weakening nonunitary rivals while preserving its odds against equivalent unitary members. The inheritance constraint identifies the missing bridges from dynamics to records to ontology. Inheritance attenuation quantifies how those shared rivals dilute a strong dynamical result when Everett is compared with its full complement.

Accordingly, “macroscopic interference is evidence for many worlds” and “macroscopic interference does not distinguish many worlds from Bohmian mechanics” can both be correct. The first reports inherited or family-relative confirmation; the second reports the absence of member-level discrimination. A rigorous evidential claim must say which one it means.

What would count as stronger evidence for many worlds is therefore clear in form, even if no current experiment supplies it: a well-defined Everettian package and a serious rival must generate different probabilities, or an independently warranted bridge must connect the observed structure to the distinctive ontology. Until then, the scientifically responsible conclusion is neither proof nor irrelevance. Everett remains indirectly confirmable, structurally assessable, and, within domains of genuine operational equivalence, ontologically underdetermined.

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