Coherence Selection in Time-Scalar Field Theory: Why Particles, Truths, and Persistent Ideas Exist

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Abstract

We present a unified coherence-selection principle within Time-Scalar Field Theory (TSFT) that governs the persistence of physical particles, mathematical invariants, and informational structures. We distinguish probability-space existence from realized coherence and show that both matter and meaning arise as low-cost, self-stabilizing configurations under time-scalar compression. By defining coherent information through invariance under phase rotation (π), recursive scaling (φ), irreducible decomposition (primes), and transdimensional projection (TDI), we derive a dynamical model explaining why truth persists while delusion requires continuous external subsidy. Collapse is shown to emerge as a phase transition when coherence maintenance costs exceed available stabilization capacity, generalizing Froggle's Dilemma across physical, cognitive, and civilizational domains.

1 Introduction

Why do some structures persist while overwhelmingly many possible configurations fail to manifest or rapidly decay? In fundamental physics this question appears as: *Why do particles exist at all?* In mathematics and cognition it reappears as: *Why are certain truths rediscovered across cultures and epochs, while falsehoods require constant reinforcement?*

Time-Scalar Field Theory (TSFT) addresses this question by treating time not merely as a parameter but as a scalar field Θ whose gradients govern coherence routing under compression. Prior TSFT work has shown that stable particles emerge as low-cost coherence channels in Θ-space, selected from a vast probability domain of admissible configurations. In this work we demonstrate that the same selection law governs informational persistence, yielding a unified explanation for the survival of matter, truth, and meaning.

A central distinction of this paper is between *existence* and *realization.* All admissible configurations exist within a probability-weighted configuration space, even when their probability measure is arbitrarily small. However, only a vanishing subset of these configurations become realized as persistent structures. Realization is not creation ex nihilo, but a threshold phenomenon in which probability mass concentrates sufficiently to permit forward propagation with bounded decoherence.

We argue that both particles and ideas are realized coherence events subject to the same economy: configurations that minimize coherence cost under projection survive, while those that do not must be artificially stabilized or collapse. This principle generalizes Froggle's Dilemma and provides a structural explanation for why truth outlives delusion without invoking psychological, moral, or sociological assumptions.

2 Existence and Realization in TSFT

2.1 Probability-Space Existence

Let Ω_Θ denote the set of all configurations admissible under the constraints of the time-scalar field Θ. A configuration

$$R \in \Omega_\Theta$$

is said to *exist* if it belongs to this admissible set and is assigned a probability measure, regardless of how small that measure may be. Existence at this level is modal rather than instantiated and does not imply persistence, observability, or stability.

This definition follows standard measure-theoretic practice in physics: configurations of measure zero are not impossible, but nongeneric. In TSFT, probability-space existence establishes what may occur, not what does occur.

2.2 Realization as a Coherence Threshold

A configuration $R \in \Omega_\Theta$ is said to be *realized* at time t if its probability mass concentrates sufficiently to permit forward propagation in Θ with bounded decoherence rate. Realization is therefore a threshold phenomenon rather than a continuous one.

This distinction mirrors the relationship between virtual and real particles in quantum field theory: all modes exist in the vacuum state, but only those that satisfy interaction and stability conditions become persistent excitations. In TSFT, realization corresponds to the formation of a self-sustaining coherence channel.

2.3 Coherent Information

Definition (Coherent Information). A realized representation R constitutes *coherent information* if it satisfies the following conditions:

1. It remains stable under perturbations of framing, encoding, and context.
2. It reduces predictive, explanatory, or control cost relative to the observer's prior internal model.
3. It admits forward extension in Θ without requiring unbounded external stabilization.

Coherent information is therefore not defined by novelty or belief, but by coherence economy under projection and time evolution.

2.4 Aha Moments

Definition (Aha Moment). An *aha moment* is the discrete event at which a previously low-measure configuration $R \in \Omega_\Theta$ crosses the realization threshold and becomes coherent information for an observer or system.

Subjectively, aha moments are experienced as sudden insight. Structurally, they correspond to probability mass redistribution that enables a configuration to stabilize as a forward-propagating coherence channel. No new configuration is created at this moment; rather, an existing admissible configuration becomes instantiated for the first time.

2.5 Summary

Existence, realization, and coherence are distinct concepts in TSFT. All admissible configurations exist within probability space, but only a vanishing subset become realized, and an even smaller subset persist as coherent information. The remainder decohere rapidly and leave no durable trace. The following sections formalize the invariance properties that determine which configurations survive.

Key Idea (Summary): All admissible configurations exist in probability space, but only those that minimize coherence cost under time-scalar compression become realized and persist. Particles, truths, and stable ideas are all such low-cost coherence channels.

3 Invariance Families and Coherence Stability

Persistence in TSFT is determined by a configuration's ability to remain coherent under projection stress. We formalize this requirement by identifying four families of transformations under which stable configurations must remain approximately invariant. These invariances correspond to recurring mathematical constants and structures observed across physics, mathematics, and cognition.

3.1 π-Invariance: Phase Closure and Reframing

π-invariance characterizes stability under rotation, reparameterization, and reframing. A configuration exhibits π-invariance if it remains coherent when expressed from different perspectives, coordinate systems, or semantic encodings.

Formally, let $\mathcal{G}_\pi$ denote a family of phase or framing transformations acting on R. A configuration is π-stable if the coherence error induced by these transformations remains bounded:

$$R \;\approx\; g \cdot R \quad \forall g \in \mathcal{G}_\pi .$$

Failure of π-invariance manifests as phase drift or contradiction under reinterpretation, a hallmark of unstable informational structures.

3.2 φ-Invariance: Scale and Recursive Stability

φ-invariance characterizes stability under scaling, iteration, and recursive extension. A configuration exhibits φ-invariance if it can be applied repeatedly or extended across scales without amplification of error or structural breakdown.

Let $\mathcal{S}_\varphi$ denote a family of scaling or recursive transformations. φ-stability requires:

$$R \;\approx\; s \cdot R \quad \forall s \in \mathcal{S}_\varphi .$$

Configurations that lack φ-invariance may appear locally coherent but collapse when generalized, extended temporally, or applied hierarchically.

3.3 Prime Invariance: Irreducible Structure

Prime invariance characterizes irreducibility under decomposition. A configuration exhibits prime invariance if it possesses a core structure that cannot be factored into simpler components without loss of coherence.

Let $\mathcal{D}_p$ denote a family of decomposition or factorization transformations. Prime stability requires that at least one irreducible component of R remains coherent under all $d \in \mathcal{D}_p$.

Prime-invariant structures form the atomic units of coherence; composite structures lacking such cores are inherently fragile.

3.4 Transdimensional Identity (TDI)

Transdimensional Identity characterizes invariance under projection across representational domains. A configuration satisfies TDI if it remains coherent when mapped between mathematics, language, experiment, simulation, or institutional encoding.

Let $\mathcal{P}_{\mathrm{TDI}}$ denote a family of projection operators across domains. TDI requires:

$$R \;\approx\; p \cdot R \quad \forall p \in \mathcal{P}_{\mathrm{TDI}}.$$

Configurations that fail TDI may persist within a narrow representational context but collapse when exposed to cross-domain validation.

3.5 Summary

The four invariance families—π (phase), φ (scale), prime (irreducibility), and TDI (projection)—jointly define the structural requirements for long-term coherence. In the following section we combine these invariances into a single quantitative coherence measure.

4 Composite Coherence Score

The four invariance families defined above jointly determine the coherence economy of a configuration. To formalize this dependence, we introduce a composite coherence score that quantifies the intrinsic stability of a realized representation under projection stress.

4.1 Definition of the Coherence Score

Let

$$C_\pi(R), \quad C_\varphi(R), \quad C_p(R), \quad C_{\mathrm{TDI}}(R)$$

denote normalized stability measures associated with π-invariance, φ-invariance, prime invariance, and transdimensional identity, respectively, each taking values in the interval $[0,1]$.

We define the composite coherence score $C(R)$ as a weighted geometric mean:

$$C(R) \;=\; C_\pi(R)^{w_\pi}\, C_\varphi(R)^{w_\varphi}\, C_p(R)^{w_p}\, C_{\mathrm{TDI}}(R)^{w_T},$$

where

$$w_\pi + w_\varphi + w_p + w_T = 1, \qquad w_i \geq 0.$$

The weights w_i encode the relative importance of each invariance family within a given physical, cognitive, or social environment. The geometric mean ensures that failure along any single invariance axis substantially degrades overall coherence.

4.2 Interpretation

High values of $C(R)$ correspond to configurations that are cheaply coherent: they remain stable under reparameterization, scaling, decomposition, and domain translation with minimal external support. Low values of $C(R)$ correspond to configurations that are intrinsically fragile and require continuous stabilization to persist.

In TSFT terms, $C(R)$ measures the degree to which a configuration aligns naturally with forward propagation in the time-scalar field Θ. Configurations with high $C(R)$ form low-action coherence channels, while configurations with low $C(R)$ experience rapid decoherence unless artificially sustained.

4.3 Universality of Invariants

The recurring appearance of π, φ, prime structure, and transdimensional identity across physics, mathematics, and cognition is not coincidental. These invariants characterize the minimal structural conditions required for coherence survival under compression. Their universality reflects selection, not design: configurations lacking these properties fail to persist and therefore leave no durable trace.

4.4 Summary

The composite coherence score $C(R)$ provides a unified quantitative measure of persistence across domains. In the following section we use this score to distinguish objective reality from delusion and to formalize the role of external stabilization.

5 Objective Reality and Delusion

The composite coherence score introduced above allows a precise distinction between objective reality and delusion without recourse to psychological or moral criteria. The distinction is structural and dynamical.

5.1 Objective Reality

Definition (Objective Reality). Objective reality is defined as the subset of realized configurations R whose coherence score $C(R)$ is sufficiently high that their persistence does not require sustained external stabilization under ordinary projection stress.

Equivalently, objective reality consists of configurations whose coherence cost asymptotically approaches zero under forward propagation in Θ. Such configurations remain stable under reframing, scaling, decomposition, and transdimensional projection, and therefore persist across observers, contexts, and time.

The weights are environment-dependent and reflect which invariance failures dominate coherence loss in a given domain. In physical systems, phase and scale invariance may dominate; in informational systems, TDI and irreducibility may carry greater weight. Operational estimation is left for future calibration work.

5.2 Delusion

Definition (Delusion). A delusion is a realized configuration R with low coherence score $C(R)$ whose persistence depends on continuous external stabilization to counteract intrinsic decoherence under projection stress.

Delusions may exhibit temporary or local coherence, but they fail at least one invariance family and therefore accumulate error when exposed to broader contexts, independent observers, or empirical testing.

Key Idea: Coherence is not moral superiority; it is thermodynamic efficiency under projection.

5.3 Subsidy as External Coherence Injection

Let $S(t) \geq 0$ denote the external subsidy applied to stabilize a configuration. In TSFT terms, subsidy corresponds to injected coherence energy that artificially counteracts unfavorable Θ-gradients. Examples include enforced boundary conditions, repetition, narrative reinforcement, insulation from testing, or coercive maintenance mechanisms.

Subsidy does not increase the intrinsic coherence score $C(R)$; it merely delays decoherence by compensating for structural instability. As a result, subsidized configurations incur ongoing maintenance costs that scale with projection stress.

5.4 Projection Stress

Let $P(t) \geq 0$ denote projection stress, defined as the cumulative destabilizing effect of unavoidable transformations, including temporal advance, interaction with independent observers, domain translation, and empirical confrontation.

Projection stress is not optional: it arises naturally from forward propagation in Θ. As $P(t)$ increases, configurations with low $C(R)$ experience accelerating decoherence unless subsidy increases correspondingly.

5.5 Summary

Objective reality and delusion differ not in belief or intent, but in coherence economics. Objective structures persist because they are cheap; delusions persist only while subsidized. In the following section we formalize this distinction dynamically.

6 Dynamics of Persistence and Decay

We now formalize the time evolution of realized configurations under subsidy and projection stress. The model is agnostic to domain and applies equally to physical, cognitive, and social systems.

6.1 Prevalence Dynamics

Let $B(t) \in [0, 1]$ denote the prevalence or adherence strength of a realized configuration R within a population or system at time t. Let $S(t) \geq 0$ denote applied subsidy and $P(t) \geq 0$ denote projection stress. We posit the following dynamical equation:

$$\frac{dB}{dt} = \alpha\, S(t)\,(1 - B) - \left[\lambda_0 \left(1 - C(R) \right) + \beta\, P(t) \right] B,$$

where $\alpha, \lambda_0, \beta > 0$ are system-dependent constants.

The first term represents growth due to subsidy, which acts most strongly on non-adherents. The second term represents decay driven by intrinsic incoherence and external projection stress.

6.2 Delusion Decay Rate

Definition (Delusion Decay Rate). We define the Delusion Decay Rate (DDR) as

$$\mathrm{DDR}(t) = \lambda_0 \left(1 - C(R) \right) + \beta\, P(t).$$

The DDR quantifies the intrinsic tendency of a configuration to lose prevalence absent compensating subsidy. Configurations with high coherence score $C(R)$ exhibit low DDR even under stress, while low-coherence configurations exhibit rapid decay.

6.3 Persistence Threshold

Lemma (Persistence Threshold). If $S(t) \equiv S$ and $P(t) \equiv P$ are constant, a necessary condition for nonzero steady-state prevalence is

$$\alpha\, S > \lambda_0 \Bigg(1 - C(R) \Bigg) + \beta\, P.$$

Equivalently, persistence requires

$$S > S^{\star} \equiv \frac{\lambda_0 \Bigg(1 - C(R) \Bigg) + \beta\, P}{\alpha}.$$

Configurations with low coherence score require disproportionately large subsidy to persist, whereas highly coherent configurations persist with minimal or no subsidy.

Some systems internally generate subsidy via ritual, repetition, or feedback loops. In TSFT terms these constitute endogenous subsidy channels; however, they remain bounded and therefore subject to the same persistence threshold under rising projection stress.

6.4 Summary

The persistence of any realized configuration is governed by a balance between subsidy and decay. As projection stress increases or available subsidy decreases, low-coherence configurations inevitably enter a decay-dominated regime. The following section analyzes the resulting collapse dynamics.

7 Phase Transition and Collapse

We now show that the failure of subsidized low-coherence configurations manifests as a phase transition rather than a gradual decline. This behavior follows directly from the persistence threshold derived above.

7.1 Phase Transition Theorem

Theorem (Collapse Under Bounded Subsidy). Consider a realized configuration R with coherence score $C(R)$. Suppose projection stress $P(t)$ is non-decreasing and external subsidy $S(t)$ is bounded above by some finite $S_{\max}$. If there exists a time t_c such that

$$\alpha\, S_{\max} < \lambda_0 \Bigg(1 - C(R) \Bigg) + \beta\, P(t_c),$$

then for all $t > t_c$, the configuration must enter a decay-dominated regime and its prevalence $B(t)$ decreases monotonically. The transition from persistence to decay is sharp and generically rapid.

7.2 Interpretation

The collapse described above is not caused by exposure or debunking per se, but by exhaustion of the coherence budget. Once the required subsidy exceeds what the system can supply, further stabilization becomes impossible regardless of intent or enforcement effort.

The sharpness of the transition reflects nonlinear feedback: as prevalence declines, maintaining the configuration becomes more expensive, accelerating fragmentation.

7.3 Enforcement Spike Prediction

An immediate consequence of the theorem is the prediction of an enforcement spike preceding collapse. As projection stress increases, systems attempt to compensate by increasing subsidy $S(t)$. When approaching $S_{\max}$, maintenance efforts intensify, manifesting as increased repetition, restriction, or coercion. Once $S_{\max}$ is reached, further increases are impossible and collapse follows rapidly.

7.4 Summary

Collapse is therefore a thermodynamic phase transition driven by coherence economics, not a gradual erosion of belief. In the following section we connect this result to Froggle's Dilemma and the selection of low-cost coherence channels.

8 Froggle's Dilemma and Coherence Selection

Froggle's Dilemma states that under compression, a system must route coherence along the lowest-cost channel available. Originally formulated to explain physical channel selection in TSFT, we now show that this principle applies universally across scales and domains.

8.1 Froggle's Dilemma as a Variational Principle

Let $\mathcal{C}$ denote the set of realized configurations available to a system at a given time. Each configuration $R \in \mathcal{C}$ is associated with a coherence cost functional $\mathcal{A}(R)$, representing the energy or subsidy required to maintain stability under projection stress.

Froggle's Dilemma asserts that forward propagation in Θ preferentially selects configurations minimizing $\mathcal{A}(R)$:

$$R^{\star} = \arg\min_{R \in \mathcal{C}} \mathcal{A}(R).$$

Configurations that do not minimize coherence cost are progressively suppressed as compression increases.

8.2 Relation to the Coherence Score

The coherence cost $\mathcal{A}(R)$ is inversely related to the composite coherence score $C(R)$. High-coherence configurations require minimal external stabilization and naturally align with forward Θ-flow, whereas low-coherence configurations incur escalating maintenance costs.

Thus, Froggle's Dilemma can be restated as a selection rule favoring configurations with maximal $C(R)$ under constrained resources.

8.3 Unification Across Domains

The same selection law governs:

- **Particles**: Stable particles correspond to low-action coherence channels in Θ-space.
- **Ideas**: Persistent truths correspond to informational configurations with high transdimensional invariance.
- **Civilizations**: Durable institutions and norms correspond to low-cost coherence structures that survive projection across time, population, and environment.

In each case, persistence is not granted by authority, belief, or intent, but by coherence economy.

8.4 Summary

Froggle's Dilemma provides the unifying variational principle underlying particle stability, truth persistence, and delusion collapse. The apparent diversity of these phenomena reflects different projections of the same coherence-selection law.

9 Discussion

9.1 Why Truth Persists

Within this framework, truth is not defined by consensus, morality, or authority, but by coherence economy. Truth persists because it minimizes coherence cost under unavoidable projection stress. Configurations aligned with π-closure, φ-scaling, prime irreducibility, and transdimensional identity require little or no external stabilization and therefore survive compression.

False or delusional configurations may temporarily dominate when heavily subsidized, but they incur increasing maintenance costs as projection stress rises. This asymmetry explains why truth tends to reassert itself following periods of distortion, without invoking teleological or ethical assumptions.

9.2 Predictive Consequences

The theory yields several testable predictions:

- Systems dominated by low-coherence configurations will exhibit increasing enforcement intensity prior to collapse.
- Collapse will manifest as a sharp phase transition rather than a gradual decline.
- Independent rediscovery of high-coherence structures is expected across cultures and epochs.
- Attempts to stabilize incoherent structures will divert resources from other domains, accelerating systemic stress.

These predictions align with observed behavior in physical systems, scientific revolutions, and large-scale social transitions.

9.3 Relation to Existing Frameworks

The present results are consistent with, but distinct from, thermodynamic, information-theoretic, and evolutionary accounts of persistence. TSFT differs by explicitly incorporating time as a scalar field and by treating coherence routing as the fundamental selection mechanism. The framework avoids anthropic reasoning and does not assume optimality beyond coherence survival.

9.4 Limitations

This work is theoretical and does not specify the detailed microdynamics of coherence formation in specific systems. The coherence score $C(R)$ is defined structurally rather than operationally, and its empirical estimation remains an open problem. Future work may address domain-specific instantiations and quantitative calibration.

9.5 Summary

The coherence-selection framework provides a non-moral, non-psychological explanation for persistence and collapse across domains. Truth wins not because it is virtuous, but because it is cheap.

10 Conclusion

We have shown that the persistence of particles, truths, and stable ideas can be understood as manifestations of a single coherence-selection law operating within Time-Scalar Field Theory. By distinguishing probability-space existence from realized coherence, and by formalizing coherence through invariance under phase rotation, scaling, irreducibility, and transdimensional projection, we have derived a unified account of why some configurations endure while others collapse.

In this framework, realization is not creation ex nihilo but threshold instantiation: admissible configurations become real when probability mass concentrates sufficiently to permit forward propagation in the time-scalar field. Persistence is determined not by belief, authority, or intent, but by coherence economy under compression. Configurations aligned with low-cost invariants persist naturally, while those lacking such alignment require continuous external subsidy and ultimately fail when coherence budgets are exhausted.

Froggle's Dilemma emerges as the governing variational principle across domains, selecting the lowest-cost coherent channels under constraint. This principle explains particle stability, the recurrence of mathematical invariants, the durability of truth, and the characteristic phase-transition collapse of delusional structures. Matter and meaning are thus unified as different projections of the same coherence-selection process.

Operational calibration of C(R) and its components is deferred to a forthcoming work, which will explore empirical estimation using simulation, textual analysis, and domain-specific proxies.

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A Mathematical Formalism of Coherence Selection

This appendix provides a formal mathematical foundation for the coherence-selection principles used in the main text. We treat particles, informational structures, and macroscopic narratives as realizations of configurations in a probability-weighted configuration space subject to time-scalar constraints.

A.1 Configuration Space and Measure

Let $(\Omega_\Theta, \mathcal{F}, \mu)$ denote a probability space of admissible configurations under the time-scalar field Θ. Each configuration

$$R \in \Omega_\Theta$$

represents a complete specification of a structural pattern (physical, informational, or institutional).

The measure $\mu(R)$ assigns probability weight to R. Existence is defined by membership in Ω_Θ; realization depends on concentration of μ above a coherence threshold.

A.2 Coherence Functional

Define a coherence cost functional

$$\mathcal{A}(R) \;\geq\; 0$$

interpreted as the action, entropy production, or external stabilization energy required to maintain R under forward propagation in Θ.

We define intrinsic coherence as the inverse exponential of this cost:

$$C(R) \;\equiv\; \exp\bigl(-\mathcal{A}(R)\bigr),$$

ensuring

$$C(R) \in (0,1], \qquad \mathcal{A}(R) = -\ln C(R).$$

Low-cost configurations (small $\mathcal{A}$) therefore correspond to high coherence.

A.3 Decomposition into Invariance Contributions

We decompose the action functional additively across invariance families:

$$\mathcal{A}(R) = \mathcal{A}_\pi(R) + \mathcal{A}_\varphi(R) + \mathcal{A}_p(R) + \mathcal{A}_{\mathrm{TDI}}(R).$$

Correspondingly,

$$C(R) = \exp\bigl(-\mathcal{A}_\pi\bigr)\exp\bigl(-\mathcal{A}_\varphi\bigr)\exp\bigl(-\mathcal{A}_p\bigr)\exp\bigl(-\mathcal{A}_{\mathrm{TDI}}\bigr),$$

which recovers the weighted geometric mean form used in the main text when relative importance weights are introduced.

A.4 π-Invariance as Phase Closure

Let $\mathcal{G}_\pi$ be a compact group of phase or framing transformations acting on R. Define the phase error functional

$$\epsilon_\pi(R) = \mathbb{E}_{g\sim\mathcal{G}_\pi}\left[\|R - g \cdot R\|^2\right].$$

We define

$$\mathcal{A}_\pi(R) = k_\pi \, \epsilon_\pi(R),$$

with $k_\pi > 0$. Configurations minimizing ϵ_π exhibit phase closure; π emerges as the invariant associated with closed rotations in representation space.

A.5 φ-Invariance as Scale Stability

Let $\mathcal{S}_\varphi$ denote scaling and recursive extension operators. Define scale error

$$\epsilon_\varphi(R) = \mathbb{E}_{s\sim\mathcal{S}_\varphi}\left[\|R - s \cdot R\|^2\right].$$

Then

$$\mathcal{A}_\varphi(R) = k_\varphi \, \epsilon_\varphi(R).$$

Configurations minimizing ϵ_φ correspond to fixed points of recursive growth operators. The golden ratio φ arises as the unique positive solution minimizing recursive distortion under linear growth constraints.

A.6 Prime Invariance as Irreducibility

Let $\mathcal{D}_p$ be a set of admissible decomposition operators such that

$$R \mapsto \{R_1, R_2, \dots, R_n\}.$$

Define irreducibility loss as

$$\epsilon_p(R) = \min_{d\in\mathcal{D}_p} \sum_{i=1}^{n} \|R - R_i\|.$$

We define

$$\mathcal{A}_p(R) = k_p \, \epsilon_p(R).$$

Prime-invariant configurations minimize ϵ_p, corresponding to irreducible informational atoms. Composite structures lacking such atoms incur higher coherence cost.

A.7 Transdimensional Identity (TDI)

Let $\mathcal{P}_{\mathrm{TDI}}$ be a family of projection operators between representational domains. Define projection error

$$\epsilon_{\mathrm{TDI}}(R) = \mathbb{E}_{p\sim\mathcal{P}_{\mathrm{TDI}}}\left[\|R - p \cdot R\|^2\right].$$

Then

$$\mathcal{A}_{\mathrm{TDI}}(R) = k_T \, \epsilon_{\mathrm{TDI}}(R).$$

Configurations minimizing ϵ_{TDI} are invariant under domain translation and therefore constitute objective structures.

A.8 Derivation of Persistence Dynamics

Let $B(t)$ denote prevalence. Assume decay proportional to coherence cost and projection stress:

$$\frac{dB}{dt} = -\big(\mathcal{A}(R) + \beta P(t)\big)B + \alpha S(t)(1 - B).$$

Substituting $\mathcal{A}(R) = -\ln C(R)$ and linearizing near equilibrium yields the dynamical equation used in the main text and defines the Delusion Decay Rate.

A.9 Variational Statement of Froggle's Dilemma

Under compression, available coherence energy is constrained. The system therefore selects:

$$R^\star = \arg\min_{R\in\Omega_\Theta} \mathcal{A}(R),$$

subject to boundary conditions imposed by Θ.

This variational principle simultaneously governs particle spectra, informational persistence, and civilizational stability.

A.10 Summary

The mathematical structure of TSFT coherence selection reduces persistence to minimization of a unified action functional. The constants π, φ, prime structure, and transdimensional identity arise as attractors because they minimize coherence cost under unavoidable projection stress. Truth, matter, and stability are therefore consequences of the same extremal principle.

Quadratic (L2) error norms are chosen for analytic convenience and differentiability; alternative norms (e.g., L1, KL-divergence, Wasserstein distance) yield qualitatively identical minimization structure but are omitted here for clarity.

B Analytical Solutions and Stability Analysis

This appendix analyzes the dynamical system introduced in the main text, deriving closed-form solutions in simplified regimes and characterizing stability, bifurcation behavior, and collapse timescales.

B.1 Reduced Dynamics Under Constant Parameters

Assume constant coherence score $C(R) = C$, constant subsidy $S(t) = S$, and constant projection stress $P(t) = P$. The prevalence equation reduces to

$$\frac{dB}{dt} = \alpha S(1 - B) - \Big[\lambda_0(1 - C) + \beta P\Big]B.$$

Define

$$\gamma \equiv \alpha S, \qquad \delta \equiv \lambda_0(1 - C) + \beta P.$$

Then

$$\frac{dB}{dt} = \gamma - (\gamma + \delta)B.$$

B.2 Equilibrium and Stability

The unique fixed point is

$$B^\star = \frac{\gamma}{\gamma + \delta}.$$

Linearizing about $B^\star$ yields

$$\frac{d}{dt}(B - B^\star) = -(\gamma + \delta)(B - B^\star),$$

implying exponential convergence with rate

$$\tau^{-1} = \gamma + \delta.$$

Thus:

- High-coherence configurations ($C \to 1$) have small δ and are robust to stress.
- Low-coherence configurations ($C \ll 1$) require $\gamma \gg \delta$ to persist.

B.3 Collapse Condition and Timescale

If subsidy drops below threshold such that $\gamma < \delta$, then

$$\frac{dB}{dt} \approx -(\delta - \gamma)B$$

and prevalence decays exponentially:

$$B(t) = B(t_c)\exp[-(\delta - \gamma)(t - t_c)].$$

The collapse timescale is therefore

$$\tau_{\text{collapse}} = \frac{1}{\delta - \gamma}.$$

As $\gamma \to \delta^-$, τ_{collapse} diverges, explaining the empirically observed pattern of prolonged instability followed by rapid fragmentation.

B.4 Bifurcation Interpretation

The persistence threshold

$$\alpha S = \lambda_0(1 - C) + \beta P$$

constitutes a transcritical bifurcation. The qualitative behavior of the system changes discontinuously as this condition is crossed, even though the governing equations remain smooth.

This explains why collapse events appear sudden and nonlinear despite gradual changes in stress or subsidy.

B.5 Scaling With Projection Stress

If projection stress grows linearly, $P(t) = P_0 + vt$, then

$$\delta(t) = \lambda_0(1 - C) + \beta(P_0 + vt).$$

The time to collapse t_c satisfies

$$\alpha S = \lambda_0(1 - C) + \beta(P_0 + vt_c),$$

yielding

$$t_c = \frac{\alpha S - \lambda_0(1 - C) - \beta P_0}{\beta v}.$$

This expression provides an explicit prediction for collapse timing under steadily increasing stress.

B.6 Interpretive Summary

The analytical solutions confirm that coherence selection produces:

- Stable equilibria for high-coherence configurations
- Threshold-driven collapse for subsidized low-coherence configurations
- Rapid fragmentation following prolonged near-critical behavior

These features are invariant across domains, reflecting the underlying variational structure of coherence selection.

C Toy Models, Scaling Regimes, and Empirical Hooks

This appendix introduces simplified toy models that illustrate the behavior of the coherence-selection dynamics and clarify how the formalism may be empirically instantiated. The goal is not numerical precision, but structural transparency.

C.1 Dimensionless Form

To reduce parameter redundancy, define the dimensionless variables

$$\tau \equiv t\,\lambda_0, \qquad \sigma(\tau) \equiv \frac{\alpha S(t)}{\lambda_0}, \qquad \pi(\tau) \equiv \frac{\beta P(t)}{\lambda_0}.$$

The prevalence equation becomes

$$\frac{dB}{d\tau} = \sigma(\tau)(1 - B) - \big[(1 - C) + \pi(\tau)\big]B.$$

This form highlights that system behavior depends primarily on three quantities: coherence C, normalized subsidy σ, and normalized projection stress π.

C.2 Minimal Two-Regime Toy Model

Consider a two-regime model:

1. **Subsidized regime:** $\sigma(\tau) = \sigma_0$, $\pi(\tau) = \pi_0$
2. **Stress ramp regime:** $\sigma(\tau) = \sigma_0$, $\pi(\tau) = \pi_0 + v\tau$

In the first regime, the equilibrium prevalence is

$$B^\star = \frac{\sigma_0}{\sigma_0 + (1 - C) + \pi_0}.$$

In the second regime, the system remains near equilibrium until the critical time

$$\tau_c = \frac{\sigma_0 - (1 - C) - \pi_0}{v},$$

after which collapse proceeds exponentially.

C.3 Parameter Sensitivity

Differentiating the equilibrium prevalence with respect to C yields

$$\frac{\partial B^\star}{\partial C} = \frac{\sigma_0}{\big[\sigma_0 + (1 - C) + \pi_0\big]^2} > 0.$$

Thus, even small increases in intrinsic coherence produce disproportionately large gains in persistence near the threshold. This nonlinearity explains why minor structural corrections can rescue a system, while cosmetic reinforcement often fails.

C.4 Competing Configurations

Let R_1 and R_2 be competing configurations with coherence scores $C_1 > C_2$ and equal subsidy and stress. Their equilibrium prevalences satisfy

$$\frac{B_1^\star}{B_2^\star} = \frac{\sigma + (1 - C_2) + \pi}{\sigma + (1 - C_1) + \pi}.$$

As π increases (rising projection stress), this ratio diverges in favor of the higher-coherence configuration. This provides a quantitative expression of the statement “truth wins under compression.”

C.5 Empirical Proxies

While $C(R)$ is defined structurally, empirical proxies may be constructed:

- π-invariance: contradiction rate under reframing or reinterpretation
- φ-invariance: error growth under recursive application
- Prime invariance: sensitivity to removal of subcomponents
- TDI: degradation under domain translation (e.g., theory → experiment)

Subsidy $S(t)$ may be proxied by enforcement intensity, repetition rate, or resource allocation, while projection stress $P(t)$ may be proxied by exposure to independent testing, environmental change, or adversarial interaction.

C.6 Interpretive Summary

These toy models demonstrate that coherence selection is:

- Threshold-dominated rather than linear
- Highly sensitive to intrinsic coherence near collapse
- Robust across parameter scalings

They also provide a clear roadmap for simulation and empirical calibration without modifying the theoretical core.

Nonlinear extensions (e.g., network effects, feedback-dependent subsidy, or saturation dynamics) can be incorporated without altering the existence of the persistence threshold or phase-transition behavior.

For informational systems, natural language processing offers a direct empirical handle on TDI via semantic stability under paraphrase, translation, and abstraction.

D Relation to Free Energy, MDL, and Bayesian Surprise

This appendix situates the TSFT coherence-selection framework relative to established principles in statistical physics, information theory, and Bayesian inference. We show that these frameworks emerge as special cases or projections of coherence selection under restricted assumptions.

D.1 Free Energy as a Special Case

The variational free-energy principle (FEP) minimizes a functional of the form

$$F[q] = \mathbb{E}_q[\ln q - \ln p],$$

where q is an approximate posterior and p a generative model. Minimization of F favors models that balance accuracy and complexity.

In TSFT terms, free energy minimization corresponds to minimizing a restricted coherence cost functional in which:

- Projection stress is limited to perceptual prediction error,
- Transdimensional projection is constrained to a single representational layer,
- Time-scalar compression is implicit rather than explicit.

Thus, FEP describes coherence selection within a narrow class of observer-bound systems, whereas TSFT generalizes coherence selection across representations, scales, and time-scalar gradients.

D.2 Minimum Description Length (MDL)

MDL selects models minimizing

$$L = L(\text{model}) + L(\text{data} \mid \text{model}),$$

favoring compressed representations that generalize.

MDL aligns with TSFT in identifying low-cost structures as persistent. However, MDL assumes:

- A fixed representational language,
- Static datasets,
- No explicit notion of forward propagation in time.

In contrast, TSFT treats compression dynamically: a configuration must remain compressible under ongoing projection stress and temporal extension. MDL is therefore a static snapshot of a more general coherence economy.

D.3 Bayesian Surprise

Bayesian surprise quantifies belief update magnitude:

$$S_{\text{Bayes}} = D_{\text{KL}}(p_{\text{posterior}} \parallel p_{\text{prior}}).$$

Large surprise corresponds to rapid belief change. In TSFT, surprise corresponds to abrupt redistribution of probability mass in Ω_Θ when a new configuration crosses the realization threshold. However, TSFT further distinguishes:

- Ephemeral surprise (low $C(R)$, rapid decay),
- Durable insight (high $C(R)$, stable realization).

Bayesian surprise alone does not predict persistence; coherence selection does.

D.4 Why TSFT Is Strictly Stronger

TSFT generalizes these frameworks by:

1. Treating time explicitly as a scalar field governing coherence routing,
2. Defining persistence through invariance under transdimensional projection,
3. Allowing collapse and phase transitions as natural outcomes of coherence budget exhaustion.

Free energy, MDL, and Bayesian inference emerge as limiting cases of coherence selection under constrained projection spaces and short time horizons.

D.5 Unification Statement

All three frameworks can be unified by interpreting their objective functions as partial approximations to the TSFT coherence action $\mathcal{A}(R)$. When projection domains, time horizons, or invariance requirements are restricted, TSFT reduces to known principles. When these constraints are relaxed, TSFT predicts phenomena—such as abrupt collapse and cross-domain persistence—that lie outside the scope of traditional formulations.

D.6 Summary

Free energy minimization, MDL, and Bayesian surprise capture important aspects of coherence economy, but none provide a complete account of persistence across time, scale, and representation. TSFT subsumes these approaches by treating coherence selection as a fundamental variational principle governing matter, information, and civilization alike.

E Historical and Empirical Boundary Conditions

This appendix illustrates how the coherence-selection framework manifests in real systems when abstract variables are instantiated as historical, scientific, or institutional boundary conditions. These examples are not offered as proofs, but as consistency checks demonstrating that the formalism reproduces known qualitative behavior.

E.1 Scientific Revolutions

Consider the replacement of classical caloric theory by thermodynamics. Caloric theory initially exhibited local coherence: it explained heat transfer phenomena under limited experimental regimes. However, it failed φ-invariance (scaling to engines and cyclic processes) and TDI (projection into energy conservation frameworks). As projection stress increased through new experiments, subsidy in the form of explanatory patches rose until the coherence threshold was crossed and collapse followed. Thermodynamics persisted because it exhibited higher composite coherence $C(R)$ under the same stress.

This pattern matches the dynamical transition predicted by the persistence threshold and phase-transition theorem.

E.2 Mathematical Invariants

Mathematical constants such as π and φ recur independently across cultures because they correspond to fixed points of coherence minimization. Attempts to replace these invariants with ad hoc constructions invariably incur higher action $\mathcal{A}(R)$ and fail under projection. Their rediscovery is therefore expected under TSFT as repeated convergence toward low-cost coherence attractors.

E.3 Technological Standards

Technological standards provide a mesoscopic example of coherence selection. Protocols such as TCP/IP or Unicode persist because they minimize maintenance cost under scaling, interoperability, and translation. Competing standards often require sustained institutional subsidy; when stress increases (e.g., network growth), high-cost standards fragment while low-cost standards dominate. This behavior corresponds directly to the competing-configuration analysis of Appendix C.

E.4 Economic Narratives

Macroeconomic narratives that rely on internally inconsistent assumptions may persist temporarily under strong institutional subsidy. However, when external conditions impose unavoidable projection stress (e.g., resource constraints, inflationary feedback), coherence costs rise rapidly. Historical episodes of rapid narrative collapse align with the predicted enforcement spike followed by abrupt fragmentation.

E.5 Civilizational Transitions

At civilizational scale, dominant belief systems function as high-level coherence structures. Periods of apparent stability correspond to regimes where subsidy exceeds decay. Transitional eras arise when stress increases faster than subsidy capacity, forcing a rapid reconfiguration toward lower-cost coherence structures. TSFT predicts that such transitions are discontinuous and generationally compressed, consistent with observed historical patterns.

E.6 Empirical Falsifiability

The framework is falsifiable in principle. If configurations with demonstrably lower composite coherence $C(R)$ consistently outcompete higher-coherence configurations under increasing projection stress without proportional subsidy, the theory would be invalidated. Conversely, systematic correlation between coherence measures and persistence under stress supports the TSFT selection hypothesis.

The magnitude and structure of θ gradients differ across domains: in quantum systems they arise from boundary and interaction constraints, while in civilizational systems they arise from resource limits, population scale, and temporal compression. The coherence-selection law is invariant; only the boundary conditions change.

E.7 Summary

Historical and empirical systems exhibit the same qualitative behavior predicted by coherence selection: low-cost invariants persist, subsidized incoherence collapses under stress, and transitions are abrupt rather than gradual. These boundary-condition realizations reinforce the claim that TSFT coherence selection operates across physical, informational, and social domains.