

Consciousness, Closure, and the Cosmos

A consciousness-first research posture via nested closure regimes

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Abstract

We propose a framework that begins from the datum of subjective presence and treats it as a primitive for the purposes of analysis, while keeping metaphysical interpretations explicit and optional. We introduce a lexicon: C as irreducible presence (“I am”), c as localized consciousness-with-content, M as global openness beyond any closure, and m as the local horizon of unspecifiability.

The central modeling idea is Closure (Cl): the stabilization of openness into a coherent regime of distinctions, identity criteria, and admissible transformations. In practice, closure under constraint leaves residual mismatch between any finite model family and the empirical structure being modeled. We call this residual mismatch *remainder* and treat it as operationally unavoidable, while leaving open the question of its ultimate ontological status.

To move beyond metaphor without overclaiming, we introduce a modest proxy in which candidate closures are represented by a partition of degrees of freedom and a sparse interaction graph. Remainder is defined as best-achievable model error within a closure-constrained model family, expressed as a minimum Kullback–Leibler divergence. We provide a short formal definitions subsection and one worked calibration demonstration showing that the proxy recovers planted modules when the data support them, and becomes ambiguous when the data do not.

We distinguish physical time t , closure time τ , and phenomenological time. We outline correspondence-style bridging candidates connecting closure invariants to the structural organization of reportable experience, and we propose an EEG oddball pilot with explicit failure modes. The result is a disciplined research program for studying how stable worlds, and stable experiences within them, can arise from stabilization under constraint without claiming a final metaphysical account.

Introduction

Scientific practice produces increasingly powerful descriptions of the world. Yet those descriptions presuppose something that is not itself a third-person measurement: experience occurs. Whatever else we doubt, there is a point of view. There is a simple “I am.” This datum is not a conclusion of theory. It is the condition under which theory is even encountered.

Many approaches treat consciousness as a late-arriving phenomenon to be explained in terms of prior physical structure (Baars, 1988; Dehaene & Changeux, 2011; Dennett, 2018; Frankish, 2016). This paper explores a different ordering that remains compatible with scientific method. Rather than treating experience as something that must be squeezed into an already fixed ontology, we ask whether the apparent stability of objects, causes, and laws, categories whose foundational status has been questioned since at least Russell (1913), can be described as the outcome of stabilization under constraint.

Following Lawson (2001), we use the term *closure* for the stabilization of distinctions and identities against an open background. Closure makes a world inhabitable, describable, and actionable. Closure is never complete. Any workable description excludes possibilities. What is excluded remains as openness relative to that closure.

The present project has two layers. The minimal core is an operational research program: define closure and remainder in a way that can be computed, calibrated, and tested on neural and behavioral data. The maximal extension is a cosmological hypothesis that treats cosmogenesis as the onset of a stable closure grammar. Readers may endorse the minimal core while remaining agnostic about the maximal extension.

This paper does not attempt to explain why experience exists (cf. Chalmers, 1995; Nagel, 1974). Instead, it asks a more basic question: why does any stable, describable world obtain at all, rather than remaining an indeterminate openness with no durable distinctions?

1. Philosophical Foundations

This section clarifies the philosophical posture of the framework. The aim is not to resolve long-standing metaphysical debates by stipulation, but to separate claims that are often conflated and to fix the conceptual roles played by presence, closure, and remainder. Throughout, we distinguish what is asserted as a datum, what is proposed as a modeling principle, and what is advanced as a hypothesis open to revision.

Presence and content

We begin with a minimal distinction. There is a difference between *presence*, the fact that experience occurs, and *content*, what experience is about. The existence of presence is a first-person datum. It is not inferred from observation or theory, and it is not derived from functional role. The organization of content, by contrast, is structured and can be studied, modeled, and explained.

Many naturalistic programs focus on explaining the functions and contents associated with consciousness, including attention, report, global availability, self-modeling, and control (Baars, 1988; Dehaene & Changeux, 2011; Graziano & Webb, 2015; Lamme, 2006). These approaches differ in emphasis but share a commitment to explaining *c*-level phenomena, meaning localized consciousness-with-content. The present framework does not dispute the value or necessity of such explanations. Instead, it insists on a conceptual separation between the existence of presence and the mechanisms that organize content.

We use *C* to denote irreducible presence, the bare fact that experience is occurring. We use *c* to denote localized consciousness-with-content: perception, memory, attention, affect, agency, narrative self, and reportable cognition. The *C* versus *c* distinction is not a claim about two substances. It is a distinction between a datum and its structured organization.

Metaphysical neutrality note

This framework treats *C* as primitive within its modeling posture. This does not force a metaphysical conclusion. A physicalist may regard *C* as a placeholder for whatever physical processes realize experience, while a consciousness-first metaphysician may regard *C* as ontologically basic. The operational content of the paper does not require settling that dispute.

Openness and closure

Openness names what is not contained in any particular description, model, or distinction. Closure is the operation by which a workable world is stabilized from this open background. Closure consists in the stabilization of distinctions, identity criteria, and admissible transformations sufficient to support description, inference, and coordinated action.

At the same time, closure under constraint leaves residual mismatch between any finite closure family and the empirical structure it aims to represent. We call this mismatch *remainder*. We use M to denote openness at the most global level, beyond any closure grammar. We use m to denote the local horizon of unspecifiability encountered by a situated observer. In the operational proxy introduced later, remainder is defined as best-achievable model error. Whether remainder is ontologically irreducible is left open, but its operational nonzero character under finite constraints is unavoidable.

Epistemic closure and ontic hypothesis

A common concern with closure-based approaches is that they move too quickly from epistemology to ontology. We address this by explicitly distinguishing two steps. First, epistemic closure: closure is an operation by which agents stabilize a describable world from an open background. This claim concerns conditions of intelligibility in experience and inquiry. Second, an ontic hypothesis: we hypothesize that a stable world grammar obtains and that cosmogenesis can be treated as the onset of such a grammar. The epistemic claim does not entail the ontic hypothesis. Readers may endorse the former while remaining agnostic about the latter.

Philosophy of science posture

The closure framework is compatible with constructive empiricism (van Fraassen, 1980; Monton, 2008). It aims to provide models that are empirically adequate and operationally constrained, while keeping metaphysical interpretations explicit and optional. The proxy is evaluated by its behavior under calibration, its predictive constraints, and its vulnerability to failure.

2. Core Claims and Lexicon

This section states the minimal commitments of the framework and fixes terminology. The definitions introduced here remain fixed throughout the paper.

C and c

C denotes irreducible presence, the bare fact that experience is occurring. It is treated as primitive within the framework's posture. No claim is made that C is derivable from physical structure, information processing, or functional organization. Equally, no claim is made that C is incompatible with physical realization. The framework is neutral on that metaphysical question.

c denotes localized consciousness-with-content. It includes perception, memory, attention, affect, agency, narrative self, and reportable cognition. c is presence under constraint, shaped by biological, cognitive, and environmental factors.

Symmetry thesis. C and c are identical in the sense that both refer to presence, but at different descriptive resolutions. Differences between C and c arise from stabilization, access, and organization.

M and m

M denotes global openness beyond any closure grammar. It names what is not exhausted by any stabilized description. M is not introduced as a substance. It is a relational designation for what remains open relative to closure.

m denotes the local horizon of unspecifiability encountered by a situated observer. m depends on access, resolution, modeling capacity, and context.

Closure (Cl)

Closure is the stabilization of openness into a coherent regime of distinctions, identity criteria, and admissible transformations. Closure is an operation, not a substance. It renders a world describable and actionable by fixing what counts as the same, what counts as different, and what transformations are allowed.

Remainder

Remainder is the residual mismatch that persists when a closure-constrained model family is fit to an empirical structure. In the proxy introduced later, remainder is defined explicitly as best-achievable Kullback–Leibler divergence.

Minimal commitments

The framework commits to the following minimal claims: (1) Experience occurs, as a first-person datum. (2) Presence and content are conceptually distinct. (3) Stabilized distinctions support intelligibility and coordination. (4) Under finite constraints, model-based closure leaves residual mismatch. (5) Brains and other agents implement local closure dynamics that organize content. (6) Closure dynamics can be modeled and tested without settling metaphysical questions about presence.

Maximal extension

Beyond these minimal commitments, the framework advances a further hypothesis: a stable world grammar obtains and cosmogenesis can be treated as the onset of such a grammar. This hypothesis is introduced to speak about the emergence of a describable world without presupposing an external temporal background. It is not required for evaluating the minimal core.

3. Closure as a Triad

Closure can be characterized from three complementary standpoints that address different explanatory needs. These standpoints are not competing definitions. Together they form a triad

that clarifies how closure operates across phenomenological, dynamical, and intersubjective domains.

Capacity

From the standpoint of capacity, closure names practical requirements for contentful experience: distinctions must be drawn, salience must be stabilized, and identities must persist long enough to be tracked. This describes conditions under which experience can have determinate content, not an explanation of why presence exists.

Variational stability

From the standpoint of variational stability, closure is selection under constraints. Among many possible parsings of an open background, some are more stable or simpler than others. Closure corresponds to settling into minima or metastable basins of an objective that trades off fit against complexity.

Consistency

From the standpoint of consistency, closure concerns the coordination of multiple perspectives. A shared world requires that different agents stabilize sufficiently aligned distinctions and identity criteria. Perfect alignment is not required. Partial alignment is sufficient for communication and joint action. The intuition that meaningful coordination can arise without pre-established harmony has a long history (cf. Jung, 1973, on acausal connecting principles); the closure framework gives this intuition a structural rather than metaphysical reading.

Unity of the triad

Keeping the triad explicit helps avoid reductionism. Capacity alone risks phenomenological vagueness. Variational stability alone risks treating closure as a purely technical optimization problem. Consistency alone risks sociological relativism. Together, the triad situates closure as stabilization that supports experience, modeling, and coordination.

4. The Nested Closure Ladder

Once a stable closure grammar obtains, nested closures can unfold. The nested closure ladder is a conceptual map that organizes how increasingly specific regimes of stabilization become possible within a broader, already stabilized world. The ladder is not a derivation of one science from another, nor a claim that higher levels are reducible to lower ones.

Cosmic closure

At the most general level, we posit the onset of a stable closure grammar. We refer to this onset as Closure at the Bang. The Big Bang is interpreted as the structural horizon or asymptotic limit of this onset when modeled from within the stabilized regime. This framing avoids invoking time before time by treating temporal relations as internal features of a stabilized grammar.

Physical and chemical closures

Within a stabilized cosmic grammar, more specific closures become possible: physical closures stabilize objects, fields, and lawful transformations (Lieb, 1976; Lieb & Seiringer, 2010); chemical closures stabilize molecular identities and reaction patterns.

Biological and cognitive closures

Biological closures stabilize self-maintaining systems capable of metabolism, replication, and adaptation. Cognitive closures further stabilize perception, memory, attention, and action selection within an organism's niche. Brains, on this view, implement local closure dynamics that stabilize a workable world-model under changing conditions.

Phenomenal closure

At the level of localized experience, phenomenal closure stabilizes a coherent empirical or narrative self. It binds perceptual, affective, and cognitive elements into an integrated representational perspective that persists across time. Remainder persists as ambiguity and novelty, and as the sense that experience could unfold otherwise.

Conceptual role of the ladder

The ladder clarifies three points. Higher-level closures depend on lower-level ones without being reducible to them. Each level introduces new identity criteria and admissible transformations. Breakdown at one level constrains or disrupts closures at higher levels.

5. Grammar, Closure States, and Hierarchy

This section distinguishes closure as an operation, closure states as selected stabilizations, and closure grammars as rule-families that constrain what kinds of stabilizations are admissible.

Closure operation, closure state, closure grammar

Closure is the act of stabilizing distinctions, identity criteria, and admissible transformations against an open background. A closure state is a particular stabilized configuration at a given closure time τ . A closure grammar is a rule-family that constrains what closure states are admissible.

Formally, let Ω denote a closure grammar, and let $K(\Omega)$ denote the space of admissible closure states under that grammar. Given an empirical structure $p(\tau)$, the preferred closure state $K^*(\tau, \Omega)$ is selected by approximate minimization of a closure objective within $K(\Omega)$.

Persistence and regime change

Closure-state persistence occurs when a particular closure remains a stable minimum under small perturbations. Grammar persistence operates at a higher level: a grammar persists when it continues to support productive closure states across conditions. High remainder across all admissible states can signal grammar inadequacy rather than local misfit.

Hierarchy and sub-grammars

Stable grammars typically support hierarchies of sub-grammars through contextual restriction and coarse-graining. Hierarchy reflects the need to manage complexity while maintaining stability.

Cosmological relevance

The cosmological hypothesis concerns the onset of a first stable closure grammar, not the selection of a particular closure state within an already stabilized world. Maintaining this distinction prevents the cosmological extension from being misread as a scaled-up mental process.

6. Time as Closure Rhythm

This section clarifies the role of time in the closure framework. Rather than assuming time as a primitive background within which closure occurs, we treat temporal notions as internal features of stabilized regimes.

Physical time t

Physical time t denotes the internal temporal coordinate used in physical theories within a stabilized closure grammar. It orders events, supports dynamical laws, and enables prediction.

Closure time τ

Closure time τ indexes updates of closure states. It is an ordering parameter for successive stabilizations and need not coincide with physical time.

Phenomenological time

Phenomenological time involves the reportable succession of experience. In this framework, the structural dynamics of this succession are modeled as the rhythm of closure updates (indexed by τ) occurring against continuity-providing persistence (trace, memory), while remainder prevents any closure from becoming terminal. Accordingly, if remainder were driven to zero and remained stably zero under perturbation within the operative grammar and access limits, closure updating would terminate and phenomenological succession would collapse into a fixed regime (even though physical dynamics in t may continue).

Cosmogenesis as a phase transition in closure space

Cosmogenesis is framed as the emergence of a first stable closure grammar. This emergence is treated as a phase transition in closure space rather than as an event occurring within a pre-existing temporal background. Crucially, this hypothesis concerns the onset of a structural grammar (the conditions for physical constraints and eventual c -level organization). It makes no claim that C (irreducible presence) is generated by, or identical to, this cosmic phase transition, preserving the framework's metaphysical neutrality.

Grammar selection without deliberation

When we say that a particular closure grammar obtains, we do not imply deliberative choice. Grammar selection is understood in the stability sense: grammars that are not robust do not persist.

7. A Modest Mathematical Proxy for Closure

This section introduces a deliberately modest formal proxy for closure. The purpose is to provide a concrete, computable handle on stabilization and remainder within a universe like ours. The proxy is intended to be stress-tested, revised, or rejected on empirical grounds.

Representation: partition plus interaction graph

Let a system be described by degrees of freedom whose joint state is represented by an empirical probability distribution p or a quantum state ρ . A candidate closure K is represented by a pair (Π, E) , where Π is a partition of degrees of freedom into blocks and E is a sparse interaction graph between those blocks.

Remainder as best-achievable model error

Remainder is the residual mismatch that persists when a closure-constrained model family is fit to an empirical structure. Remainder is always relative to (i) a closure grammar Ω (which closures are admissible), (ii) a closure candidate K (which distinctions and relations are enforced), (iii) a representation of the target structure p , and (iv) the access and resources available to the modeling agent. It is therefore not introduced as an absolute property of reality-in-itself, but as the principled openness left over once a finite closure has drawn its distinctions.

In empirical applications it is useful to separate three contributors to observed remainder: (R_e) estimation remainder from finite data and measurement noise; (R_a) approximation remainder from limitations of the chosen model family even with abundant data; and (R_c) closure remainder from the structural constraints enforced by closure under limited access and resources. The present program is primarily concerned with R_c , and treats the separation of R_c from R_e and R_a as an empirical responsibility (with controls and failure modes), not a philosophical assumption.

Within a chosen representation, minimized remainder under globally informed modeling serves as a proxy for M , while minimized remainder under restricted access and restricted model classes serves as a proxy for m . A key constraint follows: increasing access (more observability, resolution, or revealed mediators) should tend to reduce remainder without requiring arbitrary retuning of tradeoff parameters; systematic violations count against the interpretation of remainder as structured openness rather than artifact.

A variational closure objective

We introduce a closure objective $S(K | p)$ that trades off remainder against structural complexity. Closure selection is modeled as settling into minima or metastable basins of this objective under constraints. Interpreting remainder as best achievable under constraint depends on tradeoff

weights being independently grounded; if λ and γ behave like free knobs tuned per dataset, the proxy loses explanatory force.

Interpretive limits

The proxy does not claim that closure is literally a partition plus a graph, nor that remainder is literally KL divergence at the cosmic level. These constructs are tools appropriate to regimes where empirical data and modeling are available. Their value lies in behavior under calibration and in clearly stated failure modes. In particular, remainder must be interpreted alongside basic data-quality controls (window length, effective sample size, and SNR proxies); if remainder primarily tracks such quality measures rather than structure-dependent changes under matched conditions, the intended interpretation is weakened.

7.1 Formal Definitions (Proxy Notation and Selection Rule)

We state the proxy definitions explicitly.

Degrees of freedom and empirical structure

Let X denote a set of degrees of freedom. Let p denote an empirical structure over X . In applications, p may be a probability distribution estimated from data, a covariance structure, or a short-window description $p(\tau)$ indexed by closure time τ .

Closure candidates

A closure candidate is $K = (\Pi, E)$, where Π is a partition of X into blocks and E is a sparse interaction graph over those blocks.

Model family consistent with closure

Let $Q(K)$ denote a family of models q that respect the constraints implied by Π and E . The specific form of $Q(K)$ depends on the application. In Gaussian demonstrations, $Q(K)$ may be the set of block-structured Gaussian models.

Remainder (state-level)

Define remainder as the best achievable fit within $Q(K)$:

$$R(K | p) = \min_{q \in Q(K)} D_{\text{KL}}(p \parallel q)$$

Remainder is always remainder relative to the closure grammar Ω , the closure candidate K , the representation used for p , and finite access/resources. Observed remainder can reflect estimation limits (R_e), model-class limits (R_a), and closure-imposed limits (R_c). The empirical program treats these as separable targets: R_e should shrink with more data and better estimation; R_a can be probed by testing robustness across reasonable model families; and R_c is the structured openness that remains once a nontrivial closure is imposed under finite constraints.

State-level versus grammar-level remainder

State-level remainder concerns misfit for a particular closure state K : $R(K | p)$. Grammar-level remainder concerns the best achievable misfit within a fixed grammar Ω :

$$R_\Omega(p) = \min_{K \in \mathcal{K}(\Omega)} R(K | p)$$

Persistently high $R_\Omega(p)$ suggests grammar inadequacy rather than local misfit, motivating expansion or replacement of Ω rather than further within-grammar tuning.

Zero-remainder edge case (and why it is not a refutation)

Remainder can be identically zero for maximally permissive closures (for example, a one-block closure paired with a flexible within-block model). This does not mean closure has eliminated openness; it means the proposed closure did not enforce distinctions that exclude possibilities. Nontrivial closure is not mere fit. It is fit under structural and resource constraints, and the closure objective’s complexity terms are what can favor simpler, more structured closures even when an unconstrained model could fit perfectly.

Closure objective and selected closure

Define a closure score that trades off fit against simplicity:

$$\mathcal{S}(K | p) = R(K | p) + \lambda C_E(E) + \gamma C_\Pi(\Pi)$$

Here C_E and C_Π are complexity penalties for the interaction structure and the partition. The parameters λ and γ are tradeoff weights. To preserve interpretability, λ and γ should be grounded by measurable factors (e.g., effective sample size, noise level, resource costs, or MDL/Bayesian priors) and results should be robust across preregistered sensitivity ranges; if they must be tuned ad hoc per dataset, the proxy loses explanatory force. The preferred closure is defined as:

$$K^*(p) = \operatorname{argmin}_K \mathcal{S}(K | p)$$

Time-indexed forms (selected remainder)

In time-resolved settings, compute $p(\tau)$ in short windows and define $K^*(\tau) = K^*(p(\tau))$. The empirically relevant remainder dynamics are those of the selected remainder:

$$R^*(\tau) = R(K^*(\tau) | p(\tau))$$

rather than $R(K | p(\tau))$ for an arbitrary K . Local remainder m is the same construct under additional access constraints: restricted observation typically increases best-achievable mismatch, and added access should reduce it without retuning the tradeoff scheme.

Bridge-ready derived quantities

We define several quantities that can be compared across datasets and implementations.

$\Delta S(\tau)$ is the score gap between the best and second-best closure at τ .

$\Phi_c(\tau)$ is an integration proxy defined as the increase in remainder incurred when a forced factorization is imposed.

$\kappa(\tau)$ is a stabilization rate defined by the slope of remainder reduction following perturbation, computed over a specified post-event interval.

Practical interpretation constraint (data-quality control)

Remainder should be reported with basic quality covariates (window length, effective sample size, variance/SNR proxies, and stability under standard preprocessing). A disconfirming pattern is that remainder primarily tracks these covariates (or disappears under straightforward denoising/rescaling) rather than tracking structure-dependent changes under matched conditions.

8. Calibration Studies

This section evaluates the behavior of the proxy before it is applied to neural, behavioral, or cosmological data. The purpose is to verify that the objective recovers structure when it exists, refuses to invent privileged structure when it does not, and responds predictably to changes in access and constraint.

Calibration A: modular versus non-modular structure

In the modular case, variables cluster into planted groups with stronger within-group relations than between-group relations. The objective should recover the planted modules, yielding a non-arbitrary parsing into parts. In the non-modular case, dependence is broadly uniform. No uniquely privileged partition exists. In this setting, the objective should become ambiguous rather than impose an artificial ontology.

Calibration B: switching near near-degenerate minima

Near-degeneracy of closure minima yields switching dynamics under small perturbations, providing a principled analogue of perceptual bistability.

Calibration C: limited access and remainder increase

Restricted access increases best-achievable fit error. Remainder increases under local observation, giving operational meaning to local mystery m .

What calibration establishes

Calibration establishes that the proxy behaves sensibly in settings where ground truth structure is known. It does not establish a metaphysical conclusion about the ultimate status of presence or openness.

8.1 Worked Demonstration: Modular versus Non-Modular Dependence

We provide one fully specified demonstration using multivariate Gaussian structure. This demonstration is intended to be reproducible and to illustrate how remainder and a simple complexity penalty can support non-arbitrary closure selection.

Setup

We consider six variables $X_1..X_6$ with two synthetic correlation structures. System A (modular): variables 1 to 3 are strongly correlated with each other, variables 4 to 6 are strongly correlated with each other, and cross-group correlations are weak (Figure 1). System B (uniform): all off-diagonal correlations are equal (Figure 2).

Instantiation of $Q(K)$

For this demonstration, p is a zero-mean Gaussian with covariance Σ . For a candidate partition Π , $Q(K)$ is the set of Gaussians whose covariance is block diagonal under Π . The KL-minimizing block diagonal approximation keeps within-block covariances and sets cross-block covariances to zero.

Remainder values

Table 1 reports $R(K | p)$ computed as $D_{\text{KL}}(N(0, \Sigma) \| N(0, \Sigma_{\text{bd}}))$ for several candidate partitions. We also report the number of free covariance parameters in the block-diagonal model as a simple proxy for structural complexity.

In System A, the planted 3+3 partition yields very low remainder relative to mixed partitions. In System B, partitions with the same block sizes yield identical remainder, indicating that object boundaries are not privileged by the data.

Figure 1. Modular correlation structure (System A).

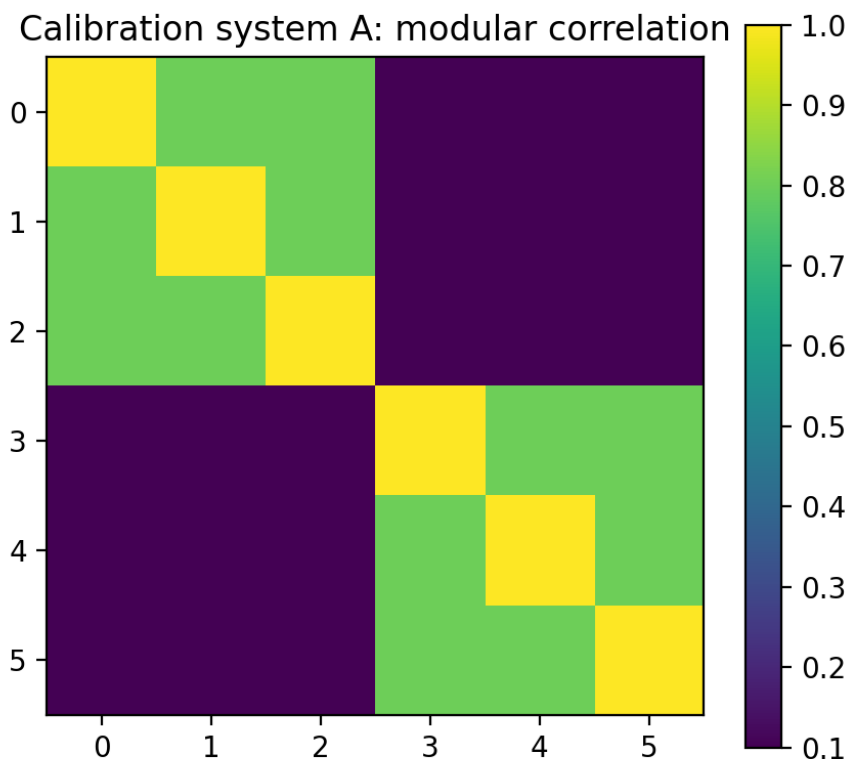


Figure 2. Uniform correlation structure (System B).

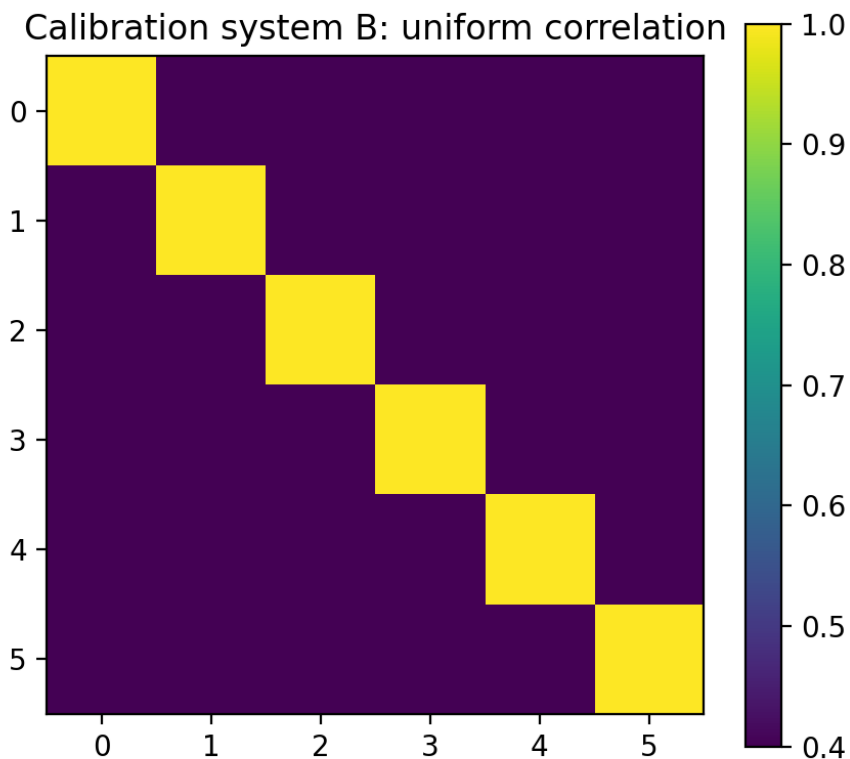


Table 1. Remainder values and structural complexity for candidate closures.

Candidate closure K	Cov params	$R(K p)$ modular	$R(K p)$ uniform
K0: 1 block (6)	21	0.000000	0.000000
K1: 2 blocks (3+3 true)	12	0.006702	0.293893
K2: 2 blocks (3+3 mixed)	12	1.237241	0.293893
K3: 2 blocks (2+4)	13	0.621755	0.268571
K4: 3 blocks (2+2+2)	9	1.243389	0.466228
K5: 6 blocks (1×6)	6	2.270066	0.727758

Note. In this demonstration, the 1-block closure has zero remainder by construction because it allows the full covariance. Whether that closure is preferred depends on the complexity tradeoff weights in $S(K | p)$. The point of the demonstration is that when the data are modular, a low-complexity partition exists with small remainder, while in a uniform system many partitions are equally plausible.

9. Bridging Law Candidates and EEG Pilot

This section proposes correspondence-style bridges between closure invariants and the structural or topological features of reportable experience. The goal is not to reduce presence to neural activity, nor to claim that closure structure exhausts phenomenology. Instead, we propose testable covariations. Because these bridging candidates rely on closure states computed from

empirical data $p(\tau)$, they operate strictly at the level of c (localized consciousness-with-content). They do not attempt to cross the explanatory gap to explain the existence of C .

Closure invariants

Let $p(\tau)$ denote a short-window empirical description of neural activity indexed by closure time τ . Let $K^*(\tau)$ denote the preferred closure state under a fixed grammar. Candidate invariants include remainder level $R^*(\tau)$, ambiguity gap $\Delta S(\tau)$, an integration proxy $\Phi_{cl}(\tau)$, and a stabilization rate $\kappa(\tau)$.

Directional bridging candidates

Reportable clarity is expected to increase as $R^*(\tau)$ decreases and $\Delta S(\tau)$ increases. Reportable unity is expected to increase with $\Phi_{cl}(\tau)$. Novelty is expected to produce a transient increase in remainder followed by restabilization.

EEG pilot: oddball novelty paradigm

Electroencephalography supports event-locked analysis at millisecond resolution (Polich, 2007; Li et al., 2018; OpenNeuro, 2025b), and auditory oddball paradigms provide a mature context for novelty and updating effects. A minimal pilot can estimate multichannel covariance or coherence in short windows and compute remainder under a fixed closure grammar, such as a coarse anterior versus posterior partition. The prediction is an event-locked remainder increase for oddball targets followed by stabilization. Resting-state baselines drawn from default-mode network studies (Raichle et al., 2001; Buckner, Andrews-Hanna, & Schacter, 2008) provide a natural control condition for comparing closure dynamics during task versus rest. All pilot data should be organized in BIDS format (Gorgolewski et al., 2016; Markiewicz et al., 2021) to facilitate replication.

Failure modes

Failure to detect systematic remainder dynamics across reasonable closure grammars, preprocessing choices, and datasets would undermine the claim that this proxy leaves measurable traces in neural data, motivating revision or abandonment of the proxy framework.

10. Predictions and Constraints

This section summarizes falsifiable commitments of the closure research program.

Near-degenerate closure switching

In tasks exhibiting perceptual bistability, fitted closure landscapes should reveal near-degenerate minima and switching dynamics that covary with subject reports of structural or perceptual state changes. Disconfirmation would include persistent absence of near-degeneracy or no relation between switching statistics and reports.

Remainder dynamics and stabilization

When subjects report a transition from perceptual ambiguity to structural coherence, remainder is expected to decrease following the transition, controlling for simple signal-to-noise changes. Disconfirmation would include flat or increasing remainder as reported coherence increases.

Parameter grounding

Tradeoff parameters should be constrained by measurable quantities such as noise level, sample size, or description-length priors. If parameters behave as unconstrained knobs, the proxy loses explanatory force.

Independence from metaphysical commitment

These predictions can be evaluated independently of any metaphysical stance on presence.

11. Relation to Existing Theories and Programs

This section situates the framework relative to established programs in philosophy of science, neuroscience, and contemporary physics.

Philosophy of science

The framework is compatible with constructive empiricism (van Fraassen, 1980; Monton, 2008) and evaluates models by adequacy, constraints, and vulnerability to failure.

Neuroscience and cognitive theories

Mechanistic theories such as global workspace models (Baars, 1988; Dehaene & Changeux, 2011), recurrent processing accounts (Lamme, 2006), integrated information approaches (Tononi, 2004), predictive processing (Friston, 2010), and attention-schema theories (Graziano & Webb, 2015) operate primarily at the level of c . The closure framework does not compete with them as a mechanistic replacement. Rather, it supplies a formal, structural vocabulary for measuring the stabilization and remainder of these processes, agnostic to their specific mechanistic implementations.

Modern physics and emergent spacetime

Work on emergent spacetime (Ryu & Takayanagi, 2006; Swingle, 2012; Freedman & Headrick, 2017; Jacobson, 2016) suggests that geometry and locality may be effective descriptions of deeper relational structure. The closure framework resonates with this possibility without identifying irreducible presence (C) with entanglement, integrated information, or computation.

Closure grammar versus effective theory selection

An effective theory presupposes a fixed space of admissible descriptions and asks which laws best govern them. Closure grammar constrains what counts as admissible description at all. In this sense, it supplies a background condition under which effective theories become meaningful.

12. Discussion: Strengths, Gaps, and Extensions

Strengths

The framework separates presence from content, closure from remainder, and operational modeling from metaphysical interpretation. It treats remainder as a measurable residual under constraint and proposes explicit failure modes.

Gaps

The framework does not derive the existence of presence (*C*) from structure. Bridging laws are structural correspondence hypotheses, mapping mathematical stabilization to the reportable organization of experience (*c*), and they require empirical validation. The cosmological extension is speculative and should be evaluated for coherence and fruitfulness rather than direct testability.

Extensions

Future work can test robustness across datasets and grammars, explore alternative objectives, and develop stronger parameter grounding. In particular, multi-echo fMRI datasets (e.g., OpenNeuro, 2025a) offer a promising modality for extending the calibration studies to whole-brain closure dynamics at slower timescales than EEG affords.

13. What This Framework Enables

This framework enables a disciplined way to talk about stability. It treats closure grammar as a vocabulary for regime-level stability, breakdown, and transition. It also reframes mystery as structural rather than merely epistemic. By formalizing remainder as best-achievable error under constraint, it shows how openness persists even in highly successful models.

If successful, the closure framework does not tell us what reality ultimately is. It clarifies why reality is stable enough to be investigated, shared, and encountered as coherent content within experience, while keeping metaphysical interpretations explicit and optional.

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