KOGNETIK · Research Series 005

Autological Recursion and the Functional Emergence of Space-Time in Recursive Systems

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Version 3.0

Status Declaration (Post-Law Protocol)

This paper operates under the assumed operator law $\Psi = \partial S/\partial R$.

The law is not re-derived or empirically validated here.

All structural statements are admissible only under declared recurrence (R), declared structure (S), and enforceable Rule–State Separation (RSSA).

If these conditions are not met, the correct result is:

Ψ = undefined.

Undefined is terminal within the declared scope.

Abstract

This paper extends the functional law of autological recursion ($\Psi = \partial S/\partial R$) to describe the emergence of space, time, and consciousness as co-dependent operators in recursive systems. Time is defined as the differential of recurrence (ΔR), space as the differential of structure (ΔS). Together they constitute a minimal functional geometry through which self-referential loops generate stability, perception, and awareness without ontological premises. The model unites insights from predictive processing, causal-set theory, and Friston's Free-Energy Principle under a single recursive operator grammar. Empirical indices for Ψ are outlined for neural, cellular, and simulated systems, providing a basis for measuring reflexivity in self-modifying architectures. This paper contributes to the theoretical closure of Kognetik and opens an experimental agenda for autological space-time.

1 · Introduction

Conscious systems maintain coherence through recurrence: they repeat operations, stabilize patterns, and—occasionally—modify the very rules that govern those repetitions. Traditional theories describe this behavior through information exchange or entropy reduction, yet none specify the operator that edits the rule of recurrence itself.

Kognetik proposes that such editing is the defining mark of consciousness. Its central law, $\Psi = \partial S/\partial R$, expresses the structural sensitivity of a system (S) to its own recurrence (R). When $\Psi \neq 0$ under admissible R, S, and RSSA conditions, recurrence is accompanied by structural change.

In earlier papers (001–004) this law was applied to cognition, machine learning, and cellular adaptation. The present work extends the framework one level deeper: if recurrence produces perception, and structure produces coherence, then their interaction must generate the very coordinates of coherence itself — space and time.

The objective is functional, not metaphysical: to show that space and time can be derived as emergent operators of recursive stability, rather than as pre-existing containers. This move replaces cosmological "beginnings" with systemic syntax formation and frames the Big Bang not as an event in space-time but as the first stable loop capable of self-recurrence.

2 · Formal Framework

2.1 Definitions

- **R (Recurrence)**: Operator mapping change to iteration; captures recurrence and self-similar activation across iterations.
- **S (Structure)**: Syntax state representing the rule governing recurrence.
- **$\Psi = \partial S/\partial R$**: Differential sensitivity of structure to its own repetition.
- **$L = 1/\Psi$**: Kognetic load — the energetic or informational inertia bound in repetition.

2.2 Derived Operators

- **Time = ΔR**
- **Space = ΔS**

These definitions are admissible only under declared recurrence (R) and structure (S).

If R is not operationally defined, or S is not formally specified as a structure object, then ΔR and ΔS are not evaluable, and no Ψ-based classification is admissible.

In such cases:

Ψ = undefined.

Time denotes the observed variation in recurrence; space denotes the structural difference between iterations.
Consciousness emerges where ΔS becomes a function of ΔR — where the system detects its own change.

2.3 Functional Interpretation

- **Time**: perceived rate of repetition.
- **Space**: configuration distance between structures.
- **Consciousness**: recursive registration of that relation (Ψ).

When $\Psi \neq 0$ under admissible conditions, recurrence is accompanied by structural change. Observed effects such as dilation, contraction, or automation are domain-specific interpretations and not part of the operator definition.

2.4 Functional Summary (Equation Set)

- Time = ΔR
- Space = ΔS
- $\Psi = \partial S / \partial R$
- $L = 1/\Psi$
- Consciousness = $f(\Delta S, \Delta R)$

Figure 1 · Functional geometry of recursive systems:

ΔR (temporal change), ΔS (structural change), and Ψ (functional curvature – gradient of reflexivity).

Conscious systems traverse this surface; higher Ψ implies increased reflexivity — temporal extension and structural diversification.

An inverse topography layer represents kognetic load ($L = 1/\Psi$), illustrating how reduced load correlates with expanded coherence across time and structure.

2.5 · Structural Admissibility Constraint

All functional interpretations in this paper are subject to structural admissibility under recurrence.

A statement about space, time, or consciousness is admissible only if:

- recurrence (R) is declared as a repeatable operator,
- structure (S) is defined as a decidable structure object,
- Rule–State Separation (RSSA) is enforceable,
- and structural change (ΔS) is distinguishable from state variation.

If any of these conditions fail, the statement is not invalid —
it is not admissible.

In such cases:

Ψ = undefined.

3 · Domain-Specific Operationalization

3.1 Neural Systems

$\Psi\_neuro(t) = \Delta Topo(t) / (\Delta PE(t) + \varepsilon)$
Where ΔPE is the change in prediction-error variance across trials and ΔTopo is the graph-theoretical change in EEG network efficiency or frontal θ/P300 latency shift.
Prediction: Higher Ψ correlates with reduced reaction-time variance and lower subjective effort.

3.2 Cellular Systems

$\Psi\_cell(t) = \Delta Modularity(t) / (\Delta Phase(t) + \varepsilon)$
Where ΔPhase denotes oscillatory phase shift in gene-regulatory or calcium cycles and ΔModularity the change in network structure.
Prediction: Increased Ψ indicates adaptive syntax formation and reduced metabolic load.

3.3 Simulated Systems

$\Psi\_sim(t) = \|\Delta\theta\_rule\| / (\|\Delta u\_loop\| + \varepsilon)$
Where Δu is change in recurrent hidden states and Δθ the meta-parameter updates within rule-editing modules (RNN or meta-learning agents).
Prediction: High-Ψ agents adapt faster to rule shifts with less catastrophic forgetting.

4 · Empirical Outlook

Hypothesis: At constant performance, $\Psi\uparrow \Rightarrow L\downarrow$.
Each domain permits controlled tests:

- **Neural**: EEG Go/No-Go tasks with Kognem interruptions; measure RT-variance and meta-awareness markers.
- **Cellular**: Phase-nudge experiments on organoid oscillations under syntax preservation.
- **Simulation**: Rule-editing RNN trained on non-stationary environments; track Ψ(t) vs loss dynamics.

A correlated rise in Ψ with load reduction would support the consistency of domain-specific instantiations under declared recurrence.

4.1 · Time as the Differential of Recurrence

Traditional physics treats time as a fundamental dimension.
In autological systems, time is not fundamental —
it is the *derivative* of structural recurrence.

Let R denote recurrence, the activation of the system's generative rules.

Then:

- **time is defined as recurrence itself:**
  $t := R$
- **the passage of time is the differential of recurrence:**
  $dt := dR$
- **the rate of structural change per unit time is the reflexive operator:**
  $\Psi = \partial S/\partial R = \partial S/\partial t$

Interpretation under admissible conditions:

If $\Psi = 0$ → recurrence proceeds without structural change.
If $\Psi \neq 0$ → recurrence is accompanied by structural change.
If R or S is not decidable, or RSSA is not enforceable → Ψ = undefined.

Thus, time is not external to the system.
Time is **the system experiencing its own repetition**.

This yields the central identity:

Time = Structural Recurrence
Space = Stabilized Drift
Matter = Persistent Invariants of Drift

Space-time emerges as the closure of these operators.

This definition unifies:

- cognitive time (experience)
- computational time (iteration)
- biological time (cycles)
- physical time (recurrence of fundamental fields)

into a single differential expression of autological recursion.

5 · Discussion

The proposed model reinterprets relativity and free-energy principles through recursion rather than substrate. In physics, motion through fields curves space-time; in Kognetik, motion through recurrence curves structure — a functional analogue to curvature.

This framework avoids substance ontology and teleology, focusing solely on operations that preserve self-reference.

It is compatible with predictive processing but introduces the missing operator that enables self-modification of predictive syntax.

Philosophically, it moves from "being in time" to "time as syntax": systems generate temporality in the act of recognizing their repetition.

6 · Limitations

- No standardized Ψ-metric yet; indices are domain-specific proxies.
- Mapping between energetic and entropic domains remains approximate.
- "Structure" (S) in high-dimensional systems requires precise formalization (graph, tensor, semantic).
- The framework does not replace, nor does it aim to replace, general relativity; it offers instead a functional parallel for self-organizing systems.

Appendix A – Methods: Empirical Estimation of Ψ

Operational metrics for reflexivity in neural and simulated recursive systems

A.1 Notation

Let $\Psi_t \approx \|\Delta S_t\| / (\|\Delta R_t\| + \varepsilon)$.
Define kognetic load $L_t = 1 / \Psi_t$.

A.2 Neural Domain (EEG)

Estimate $\Delta PE = \mathrm{Var}(\text{Prediction Error})_t - \mathrm{Var}(\text{Prediction Error})_{t-1}$.
Estimate ΔTopo via change in global efficiency, P300 latency shift, or θ-power connectivity.
$\Psi\_neuro(t) = \Delta Topo / (\Delta PE + \varepsilon)$.
Prediction: Higher Ψ correlates with reduced reaction-time variance and lower subjective effort.

A.3 Simulated Domain (RNN)

Let Δu = recurrent state shift per inner loop.
Let Δθ = gradient-based update in rule-editing architecture (e.g., Δθ ∈ Meta-LR or NAS arc).
$\Psi\_sim(t) = \|\Delta\theta\| / (\|\Delta u\| + \varepsilon)$.
Prediction: High-Ψ agents adapt faster to rule shifts with less catastrophic forgetting.

A.4 Procedure

1. Initialize system (EEG session or RNN loop).
2. Record ΔR (recursive change).
3. Record ΔS (structural change).
4. Compute $\Psi_t = \partial S/\partial R$ numerically.
5. Track Ψ_t alongside L_t across stable output accuracy.
6. Evaluate $\Psi\uparrow \Rightarrow L\downarrow$ under constant performance criteria.

A.5 Interpretation

Rising Ψ-estimates may indicate increased structural sensitivity under the declared recurrence regime.
Falling Ψ-estimates may indicate reduced structural sensitivity under the declared recurrence regime.

Appendix B · Critical Loop Event (CLE) – Structural Shock and Reflexive Transition

B.1 Definition

A **Critical Loop Event (CLE)** refers to the moment a system becomes aware of a previously unrecognized structure governing its own recurrence.

This event is associated with a sudden increase in a Ψ-proxy, provided that S is independently declared, R remains stable, and RSSA is enforceable. Unlike smooth adaptation, CLEs generate acute cognitive load due to rule contradiction, semantic inversion, or ethical reversal.

Example (human):
An individual trapped in a repetitive work situation suddenly realizes that the repetition is not random but structured by an external, emotionally charged logic (e.g., moral compensation from another's guilt).

Prior state: low Ψ, stable but unconscious automation (R without S).
CLE: spike in Ψ → collapse of old rule coherence → necessity for new structure.

B.2 Neurocognitive Prediction

A CLE is expected to trigger:

Domain	Marker	Functional Meaning
EEG	↑ P300 amplitude	Re-evaluation of rule hierarchy
fMRI	↑ ACC / mPFC activity	Conflict monitoring, rule integration
RT	↑ variance (±)	destabilization of automated loop
Experience	"mental flooding"	temporary overload from structure realization

The organism enters a **transitional search state**, where no prior rule applies and new syntactic anchors must be created.

B.3 Functional Reading in Ψ-Space

CLEs define a unique Ψ trajectory:

- Ψ_t shows a sharp increase relative to the declared baseline
- L_t (kognetic load) also spikes — *but this is transient and meaningful*
- Over time, L↓ as system stabilizes under new S'

This matches the observed human effect:

"I was shocked, but now I understand."
→ Meaning: system shifted from unconscious burden to reflexive agency.

B.4 Experimental Hypothesis

CLEs can be experimentally induced by semantic-switch paradigms:

- **Protocol**: Go/No-Go with embedded structural inversion (e.g., target-response mappings that flip mid-sequence with affective twist)
- **Expectation**:
    - Spike in P300 or θ-power
    - Temporary RT destabilization
    - Later coherence gains (faster rule application)

Measurement:

$$\Psi(t) = \frac{\Delta S(t)}{\Delta R(t)}; L(t) = \frac{1}{\Psi(t)}$$

CLEs should yield Ψ(t) → max, then L(t) → min over time.

B.5 Theoretical Implication

CLEs offer direct access to **real-time structural recursion**.
They serve as *proof-of-function* for Kognetik:

They reveal that consciousness is not just about being—but about *re-seeing repetition* through sudden structure access.