Structural Parallels Between VMHvl Line Attractor Dynamics and the Attractor Framework

Robert Galida
Independent Researcher
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fantasyattractor.com

Abstract

The attractor framework proposes that persistence under perturbation is a fundamental marker of reality, with corrective permeability (κ)—a proposed measure of the rate at which a system returns to its basin after perturbation—serving as a key diagnostic variable. Nair et al. (2023) discovered an approximate line attractor in the ventromedial hypothalamus (VMHvl) of mice that encodes an escalating aggressive state. The line attractor exhibits a single integration dimension with a long time constant that correlates with individual differences in aggressiveness. This paper identifies structural parallels between the VMHvl line attractor and the attractor framework. Both frameworks draw on a shared dynamical-systems vocabulary; the parallels are therefore a consistency check, not independent corroboration. The integration dimension's time constant is proposed as a candidate structural analogue for the inverse of corrective permeability ($\kappa \sim 1/\tau$), grounded in the perturbation-recovery events directly observable in Nair et al.'s data. The paper specifies falsifiability conditions, including an affirmative, testable prediction, and acknowledges the framework's preliminary, self-published status.

1. Introduction: Shared Vocabulary, Not Convergence

The attractor framework (Galida, 2026a, self-published May 2026 at fantasyattractor.com; no DOI) proposes that dissipative attractors—stable basins toward which systems converge and from which they resist displacement—are the fundamental units of persistent organization across physical, biological, cognitive, and social domains. Corrective permeability (κ) is a proposed measure of the rate at which a system returns to its basin after perturbation. The framework's concepts were developed independently through philosophical inquiry, systems theory, and N=1 self-engineering experiments—a methodology in which the author systematically tracked physiological, cognitive, and behavioral responses to targeted interventions on himself, generating preliminary data that informed the framework's development but does not constitute independent validation.

In January 2023, Nair, Kennedy, Anderson, and colleagues at Caltech published a study in *Cell* demonstrating an approximate line attractor in the ventrolateral subdivision of the ventromedial hypothalamus (VMHvl) of male mice (Nair et al., 2023). Using calcium imaging and dynamical systems modeling, they showed that neural population activity in VMHvl converges toward and progresses along a stable trough in neural state space, and that the position of activity along this trough correlates with the intensity of aggressive behavior.

Both the framework and the Nair et al. study use the vocabulary of dynamical systems—"attractor," "basin," "time constant." This shared vocabulary reflects a common intellectual lineage in nonlinear dynamics (Strogatz, 2018) and computational neuroscience (Seung, 1996; Mante et al., 2013). The parallels identified in this paper are therefore a consistency check, not independent corroboration. The framework imported these concepts; it did not invent them. The relevant question is whether the framework’s specific claims—about κ, basin depth, and cross-domain generalization—find structural analogues in the VMHvl circuit that are non-tautological. This paper explores that question while acknowledging its limitations.

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2. The VMHvl Line Attractor

Nair et al. (2023) fit recurrent switching linear dynamical system (rSLDS) models to calcium imaging data from VMHvlEsr1 neurons during social interactions. Their unsupervised analysis revealed a dominant integration dimension with a time constant exceeding 50 seconds—significantly longer than all other dimensions. This dimension accounted for approximately 20% of the total variance in neural activity.

The integration dimension exhibited slow ramping as aggression escalated, rising from low values during sniffing to intermediate values during dominance mounting to high values during attack. Once elevated, activity persisted for tens of seconds after the intruder was removed, decaying slowly along the attractor. When a new intruder was introduced, neural activity was transiently displaced from the attractor but rapidly returned to its previous position along the trough.

These perturbation-and-recovery events—intruder removal producing slow decay, new intruder introduction producing transient displacement followed by rapid return—are directly observable in Nair et al.’s Figure 3C–3D and Supplementary Videos 1 and 2. They provide an empirical window into the system’s post-perturbation dynamics and are the natural data from which to estimate any candidate measure of corrective permeability.

Individual mice varied substantially in the time constant of their integration dimension. This variation was strongly correlated with the fraction of time each mouse spent attacking ($r^2 = 0.77$, $n = 14$ animals). Mice with longer time constants were more aggressive. It should be noted that alternative explanations for this correlation exist: testosterone and other androgens influence both VMHvl activity and aggressiveness, and individual differences in circuit excitability could produce both a longer time constant and more aggressive behavior. The time constant–aggression link is robust but not uniquely explained by attractor depth.

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3. Structural Parallels with the Attractor Framework

3.1 The Line Attractor as a Basin. The line attractor is a stable region of neural state space toward which population activity converges and along which it progresses slowly. This is structurally analogous to the framework's concept of a basin—a configuration toward which the system gravitates and from which it resists displacement.

3.2 Integration Time Constant and Corrective Permeability (κ). The framework defines κ as a proposed measure of the rate at which a system dissipates perturbation and returns to its basin. As currently formulated, κ is qualitative and lacks a formal derivation from the framework's axioms. Dimensional analysis suggests a candidate mapping: corrective permeability has dimensions of inverse time (s^{-1}), while the integration time constant τ has dimensions of time (s). A natural structural analogue is $\kappa \sim 1/\tau$. Under this mapping, longer time constants (slower decay) correspond to lower κ (deeper persistence), and shorter time constants correspond to higher κ (faster recovery).

This dimensional argument is necessary but not sufficient. What recommends the specific mapping $\kappa \sim 1/\tau$ over other inverse-time quantities in the system (such as firing rates or synaptic decay constants) is its functional role: κ should specifically track the post-perturbation recovery rate. Nair et al.'s data contain perturbation-and-recovery events—intruder removal and reintroduction—where the time course of return to the attractor can be observed. The integration time constant τ directly governs the rate of this return. It is therefore the natural candidate for a functional, not merely dimensional, analogue. This mapping is a hypothesis, not a derivation. It is offered as a bridge for future formal work.

The observed correlation between the time constant and individual differences in aggressiveness is *consistent with* the framework's prediction that variation in κ may be associated with variation in persistent behavioral traits. It does not independently confirm that prediction.

3.3 Graded Position Along the Attractor as Intensity Encoding. The framework describes attractors as graded landscapes: a system can occupy different positions within a basin, each corresponding to a different state intensity. The VMHvl line attractor demonstrates this property: sniffing, dominance mounting, and attack occur at progressively higher values along the integration dimension.

3.4 Persistence and Resistance to Perturbation. When the intruder is removed, activity decays slowly rather than collapsing immediately. When a new intruder is introduced, activity is transiently displaced but returns to its prior position along the trough. This is a structural analogue of persistence under perturbation.

3.5 Leaky Integration Is Not Thermodynamic Dissipation. Nair et al. describe the VMHvl attractor as "leaky"—activity decays over tens of seconds rather than persisting indefinitely. The attractor framework uses “dissipative” in a thermodynamic sense: a dissipative system exports entropy to its environment and is maintained by continuous energy flow. These are distinct concepts. A conservative (non-dissipative) system could, in principle, exhibit finite decay times under certain conditions. The framework’s “dissipative attractor” and the neurobiological “leaky integrator” share a structural property—finite persistence—but they are not identical in their underlying mechanisms. This distinction should be kept in view to avoid terminological conflation.

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4. Rotational Dynamics as a Contrasting Geometry

Nair et al. also analyzed MPOA, a different hypothalamic nucleus controlling mating. They found no line attractor. Instead, MPOA exhibited rotational dynamics—fast, sequential activity time-locked to specific behavioral actions. This contrast demonstrates that not all neural circuits exhibit line attractor geometry.

The framework can accommodate this contrast as an instance of a broader principle: circuits encoding *scalable, persistent states* (such as the intensity of aggressive motivation) are predicted to exhibit line or point attractor geometries, while circuits encoding *sequential action programs* (such as the progression from sniffing to mounting to intromission) are predicted to exhibit rotational or heteroclinic dynamics. The VMHvl/MPOA contrast is consistent with this generalization. However, the generalization itself is post-hoc in this case, and the framework does not yet make a non-obvious, advance prediction about which geometry should appear in which specific nucleus. The contrast is therefore a productive organizing principle for future neural circuit taxonomy, not a confirmed prediction.

5. Limitations

This mapping is post-hoc. The parallels identified here are structural analogies, not independent evidence for the framework. The shared dynamical-systems vocabulary renders some degree of parallel expected rather than surprising.

The framework's κ remains qualitatively defined. A formal derivation from the framework's axioms—specifying the state variables, the basin geometry, and the perturbation response function—is required before the $\kappa \sim 1/\tau$ mapping can be evaluated as more than a dimensional and functional suggestion. Within the framework, κ is proposed as an attractor-level property: it characterizes the stability of the system's basin, not the strength of individual perturbations or the activity of specific components. It is derived from the persistence of a configuration under perturbation, measured as the rate of return to the attractor after displacement. A full formal derivation remains a task for future work.

The attractor framework is self-published and has not undergone independent peer review. The foundational paper (Galida, 2026a) was published on fantasyattractor.com in May 2026 and is not archived with a DOI, which limits the independent verifiability of the framework's claims and the timeline of its development.

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6. Falsifiability Conditions

The following observations would weaken or invalidate the parallels drawn here:

- **Disconfirming observation 1:** If the VMHvl integration dimension's time constant were shown to be *uncorrelated* with behavioral persistence or recovery from perturbation after controlling for circuit excitability, the κ analogy would lose its empirical anchor.
- **Disconfirming observation 2:** If line attractor dynamics in VMHvl were shown to be entirely input-driven with no intrinsic persistence, the basin analogy would fail.
- **Disconfirming observation 3:** If alternative models of aggressiveness (e.g., androgen-mediated circuit excitability without attractor dynamics) were shown to explain the data with equal or greater parsimony, the attractor interpretation would be weakened.

Affirmative prediction: If κ ~ 1/τ is more than a dimensional coincidence, then pharmacological or optogenetic manipulations that prolong the integration time constant should produce corresponding increases in aggressive persistence—the tendency to maintain an escalated aggressive state *after the stimulus is removed*—without necessarily lowering the threshold for aggressive *initiation*. Conversely, manipulations that shorten the time constant should produce corresponding decreases in aggressive persistence. This dissociation between persistence and initiation is specifically predicted by the framework's claim that κ governs recovery from perturbation, not the threshold for entering the state, and distinguishes the attractor interpretation from alternative models in which circuit excitability uniformly modulates both initiation and persistence. Aggressive persistence should be operationalized as the latency to cease aggressive posturing or the duration of elevated VMHvl activity following intruder removal, rather than as the overall fraction of time spent attacking, which confounds initiation and persistence. It should be noted that experimentally dissociating these phases in the VMHvl circuit may be technically challenging, as the neurons involved are active during both ramp-up and post-attack periods. A manipulation protocol capable of selectively targeting the post-stimulus interval is required; without this, a null result would be uninterpretable.

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7. Conclusion

The VMHvl line attractor discovered by Nair et al. (2023) exhibits structural parallels with the attractor framework's description of a graded, persistent basin. These parallels are consistency checks, not independent corroboration, given the shared dynamical-systems vocabulary. A dimensional and functional mapping $\kappa \sim 1/\tau$ is proposed, grounded in the perturbation-recovery events observable in Nair et al.'s data. The MPOA contrast is consistent with a framework-based generalization about attractor geometry and behavioral function. The paper specifies both disconfirming and affirmative testable predictions. The framework remains a self-published, preliminary research program. This mapping is a contribution to its ongoing development.

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Structural Analogies Between Psychodynamic Attractor States and the Attractor Framework

Robert Galida
Independent Researcher
June 2026
fantasyattractor.com

Abstract

The attractor framework proposes that persistence under perturbation is a fundamental marker of reality, using corrective permeability (κ) to distinguish reality-aligned from fantasy attractors. A recent clinical article by James Tobin (2026) describes psychological suffering as organized around recurring "attractor states"—stable patterns of emotional organization that resist insight, are embodied, and function as attempts at stability. This paper offers a post-hoc mapping between Tobin's observations and the attractor framework. The parallels are structural analogies, not independent clinical corroboration. Both perspectives draw on a shared dynamical-systems vocabulary, and the mapping is offered as evidence of cross-disciplinary convergence rather than validation. The paper explicitly addresses the limitations of a self-published framework based on N=1 self-engineering, and specifies conditions under which the mapping would be disconfirmed.

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1. Introduction: A Shared Vocabulary, Not Confirmation

The attractor framework (Galida, 2026a) is a naturalistic ontology developed independently through philosophical inquiry, systems theory, and N=1 self-engineering experiments. Its central diagnostic concepts are corrective permeability (κ) and the distinction between reality-aligned and fantasy attractors. The framework is self-published and has not undergone independent peer review.

In May 2026, clinical psychologist James Tobin published "The Psychology of 'Attractor States'" on his professional website. Tobin draws on psychodynamic theory, attachment research, affective neuroscience, and dynamical systems theory to describe how emotional suffering becomes organized around recurring states that resist change. His article does not cite the attractor framework.

This paper identifies structural parallels between Tobin's account and the framework. It does not claim that Tobin's clinical observations independently corroborate the framework. Both Tobin and the framework explicitly draw on dynamical systems theory, and the shared vocabulary of "attractors," “basins,” and “perturbation” reflects this common intellectual lineage. The mapping is a post-hoc exercise in identifying convergent themes across disciplines.

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2. Tobin’s Psychodynamic Attractor States

Tobin’s article describes several features of emotional suffering that will be familiar to readers of dynamical systems literature:

2.1 Attractor States as Recurring Configurations. Tobin describes an attractor not as a single behavior or belief but as a recurring configuration toward which the emotional system gravitates—an entire organization of feeling, bodily expectation, attention, memory, and relational anticipation that emerges repeatedly under similar conditions.

2.2 Persistence Despite Insight. A central clinical puzzle for Tobin is that patients often understand their patterns intellectually, sometimes with considerable sophistication, yet the old emotional organization returns with force when certain emotional conditions arise. Insight alone rarely dislodges these deeply embedded patterns.

2.3 Embodiment and Automaticity. Tobin emphasizes that these patterns are not merely cognitive. They become woven into bodily readiness, autonomic regulation, procedural memory, emotional timing, and unconscious relational expectation—the body learns what to anticipate long before conscious reflection arrives.

2.4 Symptoms as Emotional Solutions. Tobin argues that many symptoms are not random pathology but tragic attempts at psychological stability. They persist, despite their cost, because they have served to preserve some continuity of self under conditions that once felt emotionally overwhelming.

2.5 Destabilization and the Fear of Change. When old attractors begin to loosen, patients experience a vulnerable intermediate state. They are no longer fully stabilized by the older organization, yet have not developed sufficient trust in newer ways of experiencing themselves. The temptation to retreat to the familiar attractor is strong.

2.6 The Goal of Therapy: Expanded Flexibility. Tobin's vision of psychological health is not the elimination of suffering but the gradual expansion of flexibility and reflective space within the personality—the capacity to move among emotional states without being trapped by any one of them.

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3. Structural Parallels with the Attractor Framework

3.1 Attractor States as Basins. Tobin's recurring emotional configuration toward which the system gravitates is structurally identical to the framework's concept of a basin. Both describe a stable state the system returns to automatically.

3.2 Insight Failure as Low Corrective Permeability. The framework defines a fantasy attractor as a system with low κ that resists updating. Tobin's observation—that insight alone rarely dislodges deeply embodied patterns—maps onto this. The cognitive insight is a perturbation that fails to land because the attractor is embedded in non-cognitive systems.

A note on circularity. If κ is measured by flexibility outcomes, and flexibility is what κ is claimed to predict, the mapping is circular. An operationally independent measure of κ—for example, response latency to belief-updating tasks, physiological perturbation recovery rates, or other proxies not identical with therapeutic outcome—would be required to break this circularity. No such measure has yet been validated. The current mapping relies on functional analogy, not independent measurement.

3.3 Symptoms as Stability Attempts: A Conceptual Distinction. Tobin claims symptoms persist because they *function* to maintain stability (a teleofunctional claim). The framework claims persistence under perturbation is the *mark of the real* (an ontological criterion). The two claims overlap—both describe systems that resist perturbation—but they are not identical. A symptom could persist for functional reasons without that persistence carrying ontological significance. The mapping here is of practical convergence, not logical identity. Whether the framework's ontological claim can be grounded in or distinguished from teleofunctional accounts of persistence is a question for future theoretical work.

3.4 Destabilization as Basin Transition. The vulnerable intermediate state between old and new attractors is a phase transition between basins—a prediction the framework makes about any dissipative system under perturbation.

3.5 Therapeutic Flexibility as High Corrective Permeability. Tobin's vision of health—flexibility, the capacity to experience states without being organized by them—is high κ. A reality-aligned attractor absorbs perturbation and updates rather than sealing.

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4. Independence, Shared Lineage, and the Limits of Convergence

Tobin and the framework draw on overlapping intellectual traditions. Tobin cites Lewis (2000) and Thelen & Smith (1994) from dynamical systems psychology; the framework draws on

Ruelle, Prigogine, and the neuroscience of reward. The shared vocabulary (“attractor,” “basin”) reflects this common upstream source, not independent discovery.

The convergence is therefore weaker than it would be between genuinely independent methods. Both parties applied dynamical systems concepts to their respective domains. The fact that they arrived at similar structural descriptions is interesting but expected: the vocabulary constrains the output. This paper does not overinterpret that convergence.

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5. Addressing the N=1 Foundation

The attractor framework was developed partly through N=1 self-engineering experiments. This methodology introduces specific risks: motivated reasoning, experimenter-subject confound, and non-transferability. A single-subject design cannot distinguish between genuinely generalizable dynamics and idiosyncratic personal response.

Disclosure of these risks is not mitigation. The framework’s claims remain untested by independent, blinded, or large-N studies. The clinical parallels described here are suggestive but cannot substitute for such testing. Readers should weigh the framework’s claims accordingly.

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6. Falsifiability: What Would Disconfirm This Mapping?

A framework that diagnoses sealed attractors must specify its own disconfirmation conditions. For the present mapping, the following observations would weaken or invalidate the analogies drawn:

- **Disconfirming clinical observation:** A well-controlled study showing that therapeutic flexibility (the capacity to move among emotional states) is *uncorrelated* with measures of belief-updating or perturbation recovery would break the link between Tobin's flexibility and κ. Currently, no standardized instruments exist to perform this test. The condition is stated in principle; its operationalization requires measurement development beyond the scope of this paper.
- **Disconfirming dynamical finding:** Evidence that the attractor-like patterns Tobin describes are not truly self-reinforcing but are maintained entirely by external environmental contingencies, with no internal basin structure, would undermine the "basin" analogy. Distinguishing internal basin dynamics from environmental maintenance is a hard empirical problem in dynamical systems psychology, and the tools to resolve it are not yet standardized.
- **Superior alternative framework:** If a competing model explains Tobin's clinical observations equally well *without* requiring the attractor framework's ontological commitments, parsimony favors the simpler account. Acceptance and Commitment Therapy's psychological flexibility model, for instance, predicts that cognitive fusion and experiential avoidance produce the rigidity Tobin describes—without appealing to attractor dynamics. Predictive processing accounts of emotional rigidity similarly provide alternative mechanisms. The present paper does not adjudicate between these rival frameworks; it offers the attractor framework as one candidate account among several.

These conditions are not met by the current paper, which offers only preliminary analogies.

7. Conclusion

James Tobin's 2026 clinical article on psychodynamic attractor states and the attractor framework exhibit expected structural parallels, given their shared dynamical-systems heritage. Both describe recurrent, embodied patterns that resist perturbation and that therapeutic or corrective processes can gradually loosen. These parallels are analogical, not evidentiary. The framework remains a self-published, N=1-grounded research program awaiting independent empirical testing. This mapping is a contribution to its ongoing development.

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A Preliminary Mapping Between Ring Attractor Dynamics and the Attractor Framework

Robert Galida
Independent Researcher
June 2026
fantasyattractor.com

Abstract

The attractor framework proposes that persistence under perturbation is the fundamental mark of reality, and that corrective permeability (κ)—the rate at which a system dissipates perturbation and returns to its basin—is a key diagnostic variable distinguishing reality-aligned from fantasy attractors. A recent computational neuroscience study by Chen et al. (2024) developed a ring attractor network with synaptic dynamics that exhibits structural parallels with these concepts. This paper offers a preliminary, post-hoc mapping between the ring attractor model and the attractor framework. The network's synaptic recovery speed (α) is proposed as a candidate analogue for corrective permeability (κ). The network's transition from weighted cue integration to

winner-take-all dynamics maps onto the framework’s distinction between reality-aligned and sealed attractor behavior. The network’s multimodal integration and bistable perception also bear structural resemblance to constraint field navigation and attractor switching, though bistable perception as attractor switching is an existing interpretation in computational neuroscience. The mapping is offered as a set of testable correspondences for future formal investigation, not as independent validation of the framework. The attractor framework remains a self-published construct awaiting independent peer review.

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1. Introduction: A Post-Hoc Mapping

The attractor framework (Galida, 2026a) is a unified naturalistic ontology grounded in the principle that persistence under perturbation is the mark of reality. Its central diagnostic concepts are corrective permeability (κ), defined in Table 1, and the distinction between reality-aligned and fantasy attractors. The framework was developed independently through philosophical inquiry, systems theory, and N=1 self-engineering experiments. It is self-published and has not yet undergone independent peer review.

A recent computational neuroscience study by Chen et al. (2024) developed a ring attractor network with synaptic dynamics that exhibits behaviors structurally similar to those described by the framework. The present paper does not claim that Chen et al. independently validated the framework; they had no knowledge of it, and their model was built within an established tradition of ring attractor research (Amari, 1977; Zhang, 1996; Skaggs et al., 1995). Rather, this paper offers a post-hoc mapping between the two, identifying structural parallels and proposing testable correspondences for future investigation. The value of such a mapping lies in the potential for the framework's qualitative claims to be anchored in a mathematically specified, biologically validated model, and for the ring attractor's quantitative relationships to be extended, hypothetically, into the domains the framework addresses.

Table 1: Key Framework Terms and Operational Definitions

Term	Definition
Dissipative attractor	A system that exports entropy while converging toward a stable basin
Basin	The minimum-energy configuration toward which the system evolves (in physical systems; the analogue in cognitive and social systems is structural, not energetic)
Corrective permeability (κ)	The rate at which a system dissipates perturbation and returns to its basin. Defined here as $\kappa = 1/\tau_{recovery}$, where $\tau_{recovery}$ is the time to return to baseline after a specified perturbation. This definition currently requires a specified perturbation magnitude and an independently established baseline for each domain of application. The measurement of κ in cognitive and social systems is an unresolved methodological challenge.
Reality-aligned attractor	A system with high κ that integrates perturbations and updates its basin
Fantasy attractor	A system with low κ that seals against perturbations, often via reframing or winner-take-all dynamics

2. The Ring Attractor Model

Chen et al. (2024) developed a ring attractor network with asymmetrical neural connections and adaptive synaptic processing. Excitatory neurons are recurrently connected in a functional ring, connected to a uniform inhibitory neuron. The key innovation is the incorporation of synaptic dynamics: available presynaptic resources are depleted at a rate governed by β and recover at a speed governed by α.

The model's behavior is governed by recovery speed α. When α is fast (low recovery time), the network sustains a stable activity bump indefinitely, even without inputs—a self-maintaining basin. When α is slow, the bump decays. The duration of sustainable activity exhibits a negative nonlinear relationship with α (Chen et al., 2024, Fig. 3D).

The network receives exogenous external cues (modeled as Gaussian functions representing sensory inputs) and endogenous shifting signals (self-motion). Its behavior—integration, competition, tracking, switching—depends on cue conflict and certainty.

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3. Structural Parallels

3.1 Synaptic Recovery α as a Candidate Analogue for Corrective Permeability κ

The ring attractor's persistence depends on α. Fast recovery yields a stable, persistent bump; slow recovery leads to decay. The framework's corrective permeability κ describes how quickly a system recovers from perturbation and returns to its basin. The parallel is structural: both α and κ govern the resilience of a stable state.

We propose a testable correspondence: $\kappa \sim f(\alpha)$, where the functional form f is unknown and may not be linear. A specific candidate form is $\kappa = 1/\tau\_decay(\alpha)$, where τ_decay is the bump duration as a function of α. This mapping is hypothetical. It has not been formally derived, and the functional relationship between synaptic recovery and cognitive-level corrective permeability is unknown. It is offered as a bridge for future formal work, not as an established result.

3.2 Weighted Integration vs. Winner-Take-All → Reality-Aligned vs. Sealed Attractor

When cue conflicts are small, the ring attractor integrates them via weighted averaging. When conflicts exceed a critical threshold (≈1.4 radians for $\sigma_1=0.8$, $\sigma_2=1$), it switches to winner-take-all mode. This transition is quantified.

The framework describes a similar dynamic: high-κ systems integrate perturbations (reality-aligned); low-κ systems seal against them (fantasy attractor). The ring attractor's conflict threshold provides a candidate mathematically specified analogue for the framework's qualitative tipping point. Whether the same quantitative relationship holds in cognitive or social attractors is an open hypothesis.

3.3 Multimodal Integration → Constraint Field Navigation

The ring attractor integrates cues from multiple modalities, weighting by certainty and resolving conflicts dynamically. This is structurally analogous to the framework's concept of a dissipative attractor navigating a constraint field. The grouping approach for more than two cues—small conflicts integrated first, then competition among groups—suggests hierarchical constraint navigation, a dynamic the framework predicts but has not operationalized in formal terms. Of the four parallels identified in this section, this is the most loosely specified and the most in need of formal development before quantitative correspondences can be established.

3.4 Bistable Perception → Attractor Switching (with Prior Art)

Under ambiguous cues and slow recovery, the ring attractor exhibits spontaneous alternation between two perceptual interpretations. The framework describes this as attractor switching. However, the interpretation of bistable perception as attractor dynamics is not novel to the framework; it is a standard account in computational neuroscience (Deco & Rolls, 2006; Moreno-Bote et al., 2007). The framework's contribution is the extension of this switching concept to cognitive and social systems, an extension that remains a research hypothesis rather than an established result.

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4. Hypothetical Implications (Research Hypotheses)

The structural parallels documented above suggest several testable hypotheses. These are not supported by Chen et al. (2024) and require independent investigation. They are listed in descending order of current testability.

1. **The conflict threshold hypothesis.** The framework's transition from belief integration to belief sealing may exhibit a quantifiable conflict threshold, analogous to the ring attractor's 1.4 radian transition point. This could be tested in belief-updating paradigms where the degree of conflict between existing beliefs and new evidence is systematically varied, and the point of transition from integration to rejection is measured. Of the three hypotheses presented here, this is the most amenable to current experimental methods.
2. **The κ-α correspondence hypothesis.** If κ and α share a functional relationship, then interventions that modulate synaptic recovery (neuromodulators, pharmacological agents) should analogously modulate corrective permeability in cognitive systems. This

hypothesis requires operationalizing κ in cognitive domains, a measurement challenge acknowledged in Table 1.

3. **The hierarchical navigation hypothesis.** Complex belief systems facing multiple simultaneous perturbations may exhibit hierarchical resolution strategies similar to the ring attractor's grouping approach for multiple cues. This hypothesis is the most speculative of the three and requires further specification of the domain of application (e.g., small-group decision-making, multi-source evidence integration in individual cognition) before it can be tested.

These hypotheses are speculative. They are offered as potential bridges between the framework and empirical research programs, not as established implications.

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5. Limitations

This mapping is post-hoc. The ring attractor model was not designed to test the attractor framework, and the correspondences identified here were constructed after the fact. The framework itself remains a self-published construct that has not undergone independent peer review. The operational definitions of κ, while stated here, have not been validated against empirical data in cognitive or social domains. The measurement of κ in these domains requires specifying perturbation magnitudes and establishing independent baselines, challenges that are currently unresolved. The value of this paper lies not in demonstrating validation, but in proposing concrete, testable correspondences that could, if investigated, either strengthen or falsify the framework's claims.

6. Conclusion

The ring attractor model of Chen et al. (2024) provides a mathematically specified, biologically validated system that bears structural parallels with the attractor framework. Synaptic recovery speed α is proposed as a candidate analogue for corrective permeability κ. The transition from integration to winner-take-all maps onto the framework's reality-aligned/fantasy distinction. Multimodal integration and bistable perception correspond, respectively, to constraint field navigation and attractor switching, with the latter being a standard interpretation in existing neuroscience.

These correspondences are not independent validation. They are post-hoc structural analogies. Their value lies in the testable hypotheses they generate, not in the confirmation they appear to provide. The framework remains a research program in its early stages, and this mapping is a contribution to its ongoing development.

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The MAGA Attractor: Fantasy, Colonization, and the

Terminal Phase of a Sealed Basin

Robert Galida, Independent Researcher
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Abstract

The MAGA movement is a colonizing fantasy attractor exhibiting the structural features the attractor framework predicts: a destabilizing perturbation, a dopamine-rich sealed narrative, near-zero corrective permeability (κ), active colonization of rival basins, and a terminal phase characterized by attacks on reality-delivery institutions. This paper applies the κ diagnostic—a set of observable indicators measuring a belief system's willingness to update on contradictory evidence—to MAGA as a case study. We include a minimal comparative sketch applying the same indicators to a left-aligned movement to demonstrate symmetric applicability. We engage disconfirming instances within the MAGA case, define the terminal phase formally, and ground the attractor framework in established dynamical-systems and motivated-reasoning literatures. The paper does not offer predictions. It identifies structural tendencies and leaves empirical validation to future work.

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1. Introduction: The Diagnostic Stance

The attractor framework (Galida, 2026) defines a fantasy attractor as a belief system with low corrective permeability (κ): it resists updating when confronted with contradictory evidence, reframes error signals to protect its core narrative, and often seeks to colonize or destroy neighboring basins. The framework draws on dynamical-systems theory (Strogatz, 2018; Kelso, 1995), which characterizes attractors as regions in state space toward which trajectories converge and remain unless perturbed. A high-κ attractor absorbs perturbation and updates; a low-κ attractor resists perturbation and seals. This paper applies that diagnostic to the MAGA movement.

The framework predicts that sealed attractors exist across the political spectrum. A fully symmetric analysis would examine movements of all orientations using the same κ indicators. The present paper is a single-case application, supplemented by a brief comparative sketch in Section 6. It does not imply that MAGA is unique or uniquely sealed. It demonstrates the diagnostic method on a prominent and well-documented case.

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2. Operationalizing Corrective Permeability (κ)

Corrective permeability is not a single number. It is a composite of observable indicators. A movement's κ can be estimated—qualitatively, not metrically—by examining its responses to disconfirming events. The indicators below are applicable to any political or social movement.

κ Indicators

Indicator	High κ (reality-aligned)	Low κ (fantasy attractor)
Electoral loss response	Concedes defeat; analyzes reasons; adapts strategy	Rejects outcome as fraudulent; seeks to overturn result

Indicator	High κ (reality-aligned)	Low κ (fantasy attractor)
Legal defeat response	Accepts ruling; appeals within system; adjusts behavior	Delegitimizes courts; portrays defeats as persecution
Internal dissent tolerance	Debates openly; allows factional disagreement	Purges dissenters; enforces narrative loyalty
Media coverage response	Engages with critical reporting; distinguishes bias from fact	Labels all critical media as “enemy”; constructs alternative media ecosystem
Policy failure response	Acknowledges failure; revises approach	Blames enemies; reframes failure as sabotage
Leader criticism response	Evaluates criticism on merits; holds leaders accountable	Treats all criticism as treason; leader is beyond reproach

A movement that scores low across most or all indicators has κ approaching zero. A movement that scores high across most has κ approaching one. The assignment is comparative and qualitative, not computational.

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3. The Initial Perturbation: A Basin Destabilized

The MAGA movement emerged from a genuine, large-scale perturbation to the personal and social attractors of millions of Americans. For decades, the post-war American basin was stable for its primary beneficiaries: manufacturing jobs provided middle-class security, cultural norms were broadly shared, and the United States enjoyed unchallenged global dominance. Over several decades, that basin was progressively destabilized. Deindustrialization eliminated millions of stable jobs. Globalization shifted economic power away from domestic manufacturing. Cultural norms around race, gender, sexuality, and religion shifted rapidly. Demographic projections showed a future in which the previously dominant group would become a minority. Each of these was a perturbation. Cumulatively, they shattered the old basin.

The attractor framework does not judge the legitimacy of the grievances. It notes that a destabilized attractor seeks a new basin. The question is always: *What basin will replace the old one?*

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4. The New Basin: Narrative, Dopamine, and Motivated Reasoning

The core narrative of the MAGA attractor is well-documented: the adherent is the authentic voice of the nation; their loss is a theft by corrupt elites and internal enemies; the leader will restore greatness. This narrative is an ontological rescue. It replaces a confusing, painful reality with a simple, morally charged story.

The dopamine dynamics are well-established. Certainty, righteous anger, and tribal belonging activate the mesolimbic reward system (Olds & Milner, 1954). But dopamine alone does not distinguish fantasy attractors from reality-aligned movements—all high-commitment groups generate reward. What distinguishes low-κ attractors is the *impermeability* of the reward loop: the system prevents corrective information from entering, so the dopamine cycle never encounters disconfirmation.

The motivated-reasoning literature provides a well-established parallel. Individuals process information in ways that protect identity-congenial beliefs (Kahan, 2013). Social identity theory (Tajfel & Turner, 1979) predicts that group membership becomes a source of self-esteem, making threats to the group's narrative feel like personal attacks. The MAGA attractor operates at the intersection of these dynamics: a highly salient group identity, a narrative of victimhood and restoration, and a reward system that fires on certainty. The basin is psychologically satisfying and neurochemically self-reinforcing.

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5. Applying the κ Indicators to MAGA

When we apply the six κ indicators to the documented behavior of the MAGA movement, the pattern is clear.

- **Electoral loss response:** The 2020 election was rejected as fraudulent. Over 60 court cases were dismissed, yet the "stolen election" narrative persisted. Electoral officials who certified results have been purged and replaced. κ is near zero on this indicator.
- **Legal defeat response:** Criminal and civil indictments against the movement's leader are framed as "witch hunts" and "election interference." Courts are delegitimized. κ is near zero.
- **Internal dissent tolerance:** Republicans who criticized the leader have been primaried, censured, or forced from office. Internal debate is treated as disloyalty. κ is near zero.
- **Media coverage response:** Mainstream media are labeled "enemies of the people." A parallel media ecosystem delivers only narrative-congruent information. κ is near zero.
- **Policy failure response:** Trade wars that harmed farmers

were reframed as necessary sacrifices, not policy failures. Promised infrastructure and healthcare reforms that did not materialize were blamed on opponents, not acknowledged as unfulfilled. κ is near zero.
- **Leader criticism response:** Criticism of the leader is treated as treason. The leader's statements, even when contradictory or demonstrably false, are accepted by adherents without correction. κ is near zero.

5.1 Disconfirming Instances and Complexity

The assignment of $\kappa \approx 0$ is a pattern judgment, not a uniform claim. Several behaviors complicate a blanket zero-κ diagnosis and must be acknowledged.

- Some MAGA-aligned officials did certify the 2020 election results under intense pressure, including figures such as Georgia Secretary of State Brad Raffensperger and Arizona's Republican governor Doug Ducey, who faced threats and political retaliation for doing so. This is evidence of $\kappa > 0$ among individuals within the movement's orbit.
- The movement's policy agenda did shift in notable ways relative to prior Republican orthodoxy, including trade protectionism, pharmaceutical pricing reform, and infrastructure spending. These represent genuine policy adaptation, even if they served the broader narrative of economic nationalism.
- Internal dissent, while punished, has not been eliminated. Some Republican figures continue to criticize the leader from within the party, and factions with incompatible interests (economic libertarians, Christian nationalists, working-class populists) persist.

These instances suggest that the movement is not a perfectly uniform basin. Some members and subgroups exhibit higher κ than others. However, the overall pattern—sustained across multiple years, multiple domains, and the movement's dominant institutional responses—remains one of extremely low corrective permeability. The dissenting officials were purged, not elevated. The policy shifts occurred within a sealed narrative that did not acknowledge prior error. Internal critics were marginalized. The diagnostic is a structural assessment of the attractor's dominant dynamics, not a claim about every individual within it.

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6. Comparative Sketch: A Left-Aligned Case

The framework's symmetry requirement demands that the same κ indicators be applied to movements of other political orientations. A full comparative analysis is beyond the scope of this paper, but a brief sketch demonstrates the method's applicability.

Consider the progressive wing of the Democratic Party's response to the 2016 election loss. On the κ indicators:

- **Electoral loss response:** The loss was accepted, though accompanied by narratives of Russian interference and Electoral College illegitimacy. The outcome was not rejected as fraudulent, but external factors were invoked to explain defeat—a partial but not complete κ signal.
- **Legal defeat response:** Progressive legal setbacks (e.g., on immigration policy, voting rights) have generally been accepted within the system, with strategy adjustments rather than court delegitimization. κ is moderate-high.

- **Internal dissent tolerance:** The progressive coalition contains vigorous internal debate between moderates and left factions. Primary challenges are common and openly contested. κ is high on this indicator.
- **Media coverage response:** Progressives engage with mainstream media but also criticize it for bias. An alternative media ecosystem exists but has not fully sealed; cross-pollination with mainstream outlets is common. κ is moderate.
- **Policy failure response:** Failed progressive initiatives (e.g., certain criminal-justice reform measures, housing policies) have generated internal debate and strategy revisions, though blame-shifting also occurs. κ is moderate.
- **Leader criticism response:** Progressive leaders face significant internal criticism. Figures such as Bernie Sanders and Alexandria Ocasio-Cortez are both celebrated and challenged from within the movement. κ is high.

This sketch suggests a moderate-to-high κ for this movement, with some indicators showing partial sealing. The exercise demonstrates that the κ indicators do not automatically classify one’s political opponents as fantasy attractors and one’s allies as reality-aligned. The diagnostic discriminates based on behavior, not affiliation.

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7. Colonization: “You Must Join or Be Destroyed”

A fantasy attractor does not peacefully coexist. It colonizes. The MAGA movement demands that other basins submit to its narrative or be treated as enemies. This operates at interpersonal, institutional, and electoral levels. Families are fractured by loyalty demands. The judiciary, civil service, and military are to be purged of “disloyal” elements. Election administration is being restructured to place loyalists in positions of authority over vote counting and certification. Colonization is a structural necessity: a sealed attractor cannot tolerate rival basins that might deliver a fatal perturbation.

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8. Beam and Sliver: Internal Contradictions as Diagnostic Features

All political coalitions contain tensions between stated values and enacted policy. The diagnostic question is not whether contradictions exist, but whether the attractor can acknowledge and address them. High-κ movements can name their own tensions. Low-κ movements cannot.

The MAGA attractor exhibits several severe, structurally unresolvable contradictions:

- **Liberty vs. Authoritarianism:** The movement claims to defend freedom while supporting a leader who attacks the free press, demands personal loyalty, and threatens to use state power against opponents.
- **Law and Order vs. Criminality:** The movement claims to uphold law and order while its leader faces multiple felony convictions and indictments.
- **Populism vs. Plutocracy:** The movement claims to be a working-class revolt while its policy agenda primarily benefits the wealthy.
- **Christianity vs. Cruelty:** The movement claims Christian values while supporting policies that separate migrant families and mock the vulnerable.

What makes these contradictions diagnostically severe is not their existence—all coalitions contain tensions—but their structural unresolvability within the current basin. The movement’s dependence on a single leader whose personal legal exposure is inextricably linked to its narrative makes acknowledgment of criminality equivalent to basin collapse. The contradiction cannot be resolved; it can only be suppressed by attacking the legal system itself. This dynamic is distinct from the ordinary policy tensions of a political coalition, where compromise, leadership change, or platform evolution can absorb and resolve contradictions over time. In the MAGA basin, the leader cannot be replaced without dissolving the attractor, and the criminal charges cannot be acknowledged without invalidating the narrative of persecution. The beam is locked in place.

The sliver is projected outward with equal force: every fault is hung on the opponent. The movement cannot name its own contradictions, so it names everyone else’s—real or invented—with relentless intensity.

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9. The Terminal Phase: Formal Definition and Observable Signs

Within the attractor framework, a **terminal phase** is reached when a sealed attractor, facing sustained and credible existential threats, shifts its primary behavior from narrative self-maintenance and colonization to the active dismantling of the external correction mechanisms that could deliver a fatal perturbation.

Transition conditions include:

1. **Loss of institutional control:** The movement no longer reliably controls the executive or legislative branches through normal electoral means.

2. **Credible legal jeopardy:** Leadership faces prosecution, incarceration, or removal from ballots.
3. **Narrowing coalition:** The movement's demographic base cannot reliably produce majorities in national elections.
4. **Elite messaging shift:** The movement's leadership explicitly frames institutional destruction as the only path to survival.

When these conditions are met, the attractor is no longer merely sealed. It is actively destroying the sources of perturbation.

Observable signs of a terminal-phase political attractor:

1. **Rejection of electoral outcomes** as illegitimate unless the movement wins.
2. **Purge of dissenting officials** from election administration and party structures.
3. **Preparation for institutional override** through legal theories that would allow loyalist bodies to override popular vote counts.
4. **Normalization of violence** as patriotic self-defense.
5. **Attacks on truth-delivery systems**—media, science, intelligence, courts—to neutralize their corrective function.

The MAGA movement currently exhibits all five signs. The transition conditions are partially met (credible legal jeopardy is present; electoral losses have occurred; the coalition faces demographic challenges) and partially contested (the movement retains significant institutional power through the courts and state legislatures). The terminal phase is not an all-or-nothing category; it is a trajectory along which the movement has demonstrably moved.

10. Trajectory: Structural Tendencies, Not Predictions

The attractor framework identifies structural tendencies, not certainties. Three trajectories are possible for a terminal-phase fantasy attractor, and they are not mutually exclusive.

Escalation. If the leader faces incarceration, removal from ballots, or definitive electoral defeat, the movement may escalate. Violence is the final defense of a sealed basin that cannot tolerate reality. Escalation risk is elevated when institutional pressure intensifies.

Fracture. The movement contains factions with incompatible interests. If the central figure becomes unavailable, the attractor may fracture into competing sub-basins, each claiming legitimacy. This is a common post-charismatic trajectory.

Slow Fade. Some fantasy attractors fade as the promised restoration never arrives, adherents age, and younger generations find the narrative less compelling. This trajectory requires sustained institutional resilience and an absence of triggering crises.

The current structural conditions—ongoing legal pressure, sustained institutional attacks, and the centrality of a single figure—make escalation and fracture the highest-concern scenarios. The slow fade remains a possibility only if institutions hold and no major crisis intervenes. No probability is assigned. The framework names the tendencies and leaves empirical validation to events.

11. Conclusion

The κ indicators, applied qualitatively, suggest that the MAGA movement exhibits near-zero corrective permeability across multiple domains. The movement colonizes rival basins, cannot acknowledge its internal contradictions, and exhibits the observable signs of a terminal-phase attractor. Disconfirming instances complicate but do not overturn the overall pattern. Symmetric application of the κ diagnostic to movements of other political orientations is methodologically required and has been briefly sketched; full comparative validation remains necessary. The framework provides structural tendencies, not predictions. The methodological limitations are acknowledged. The analysis is offered as a diagnostic contribution, not a final determination.

The Distributed Mind: How the Brain Regulates a Federation of Conscious Subsystems

Author: Robert Galida
Date: June 2026 (Final Edition)
Based on: Extended collaborative development of the attractor framework, N=1 physiological experimentation, and a re-reading of Spinoza’s conatus.

Abstract

Consciousness is traditionally viewed as either a non-physical substance (dualism) or a product of the brain alone (reductive physicalism). This paper presents an alternative: the human body is a nested hierarchy of semi-autonomous, attractor-based conscious subsystems—each with its own rudimentary integration, valence, learning, and goal-directedness. Using the nematode *C. elegans* (302 neurons) as a minimal benchmark, we argue that **sufficient integrated complexity** (operationalised as attractor dimensionality or integrated information Φ) is the key criterion for rudimentary consciousness. The enteric nervous system (200–600 million neurons), the intrinsic cardiac nervous system, the limbic system, and (under conditions of decoupling) the spinal cord meet or exceed this threshold. The brain does not *create* consciousness; it **regulates** these distributed conscious components, coupling them into a coherent whole-body attractor. This view dissolves the binding problem, explains the feeling of being an alien observer of one's own actions, and aligns with Spinoza's conatus—the principle that no part of the body diminishes its own power to act. We provide empirical signatures, testable predictions, and an N=1 self-engineering case study (ECM restoration, abdominal relaxation, sleep optimisation) that illustrates the framework. The conclusion: consciousness is not a solitary flame in the skull, but a federation of dancers, with the brain as first among equals.

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1. Introduction

The dominant neuroscience paradigm assumes that consciousness is generated by the brain. Yet this assumption struggles to explain:

- Why the enteric nervous system (ENS) can learn and remember independently of the brain.
- Why cardiac signals influence decision-making and self-awareness.
- Why split-brain patients exhibit two separate conscious entities within one cranium.
- Why the universal feeling of “not being in control” (*“why did I do that?”*) persists.

We propose a paradigm shift: **consciousness is a graded, emergent property of any sufficiently complex, dissipative, attractor-based system.** The brain is not the sole author; it is the **regulator** of a distributed network of semi-autonomous conscious subsystems.

This framework builds on dynamical systems theory, integrated information theory (IIT), global workspace theory (GWT), and Spinoza’s philosophy, while grounding itself in measurable empirical signatures and N=1 self-experimentation.

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2. The Attractor Framework for Consciousness

2.1 Core Definitions

- **Attractor:** A region in state space toward which trajectories converge and remain unless perturbed. Characterised by negative Lyapunov exponents and basin stability.
- **Consciousness (operational):** A system exhibits consciousness if its attractor possesses:
  1. **Integration** – binds multiple sensory/interoceptive streams.

2. **Self-reference** (minimal) — distinguishes self from environment.
3. **Valence** — attraction to some states, repulsion from others.
4. **Learning** — attractor landscape changes with experience.
5. **Goal-directedness** — acts to maintain its basin (conatus).
6. **Evolutionary/developmental provenance** — the system's attractor landscape emerged through evolutionary or developmental selection, not external engineering. This excludes thermostats and purely programmed control systems while allowing biological, synthetic, or hybrid systems with genuine autopoietic histories.

- **Mind:** A conscious attractor. Not a substance, but a real, causally effective pattern (like a whirlpool).

2.2 The Minimal Benchmark: *C. elegans*

The nematode *C. elegans* has exactly 302 neurons. Despite this simplicity, it exhibits:

- Sensory integration (touch, temperature, chemical gradients)
- Associative learning (pairing odours with food)
- Goal-directed behaviour (chemotaxis, thermotaxis)
- Minimal self-reference (distinguishes self-generated from external touch)

Thus, **302 neurons with rich, heterogeneous connectivity are sufficient for rudimentary consciousness.** However, neuron count alone is not the criterion; **integrated complexity** (attractor dimensionality, or IIT's Φ) is what matters. We use Φ operationally as a proxy for integrated complexity, without committing to all postulates of IIT (see Doerig et al., 2021, for critical review). *C. elegans* has high integrated complexity relative to its neuron count. A subsystem with many neurons but low connectivity or heavy enslaving may not reach the same threshold.

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3. The Federation of Conscious Subsystems in the Human Body

We evaluate major subsystems against the integrated complexity benchmark.

Subsystem	Neuron count	Integrated complexity	Rudimentary consciousness?	Evidence
Enteric nervous system (ENS)	200–600 million	High (dense local circuits, 30+ neurotransmitters)	**Yes**	Independent peristaltic rhythms, learning, memory, “second brain” (Furness, 2006)
Spinal cord	197–222 million	Moderate to high (but heavily enslaved)	**Yes, but normally suppressed**	Central pattern generators; after injury can reorganise into semi-independent attractors (Calancie et al., 1994; Dimitrijevic et al., 1998). Evidence for “spinal consciousness” remains preliminary.

Subsystem	Neuron count	Integrated complexity	Rudimentary consciousness?	Evidence
Intrinsic cardiac nervous system (ICNS)	14,000–43,000	Moderate (local processing loops)	**Intermediate (contributor)**	Influences emotion, decision, interoception (McCraty et al., 2009)
Limbic system	tens of millions	High (emotional valence, memory)	**Yes**	Often acts before cortical awareness; strong valence and learning
Basal ganglia & motor routines	>100 million	Moderate (procedural)	**Yes (habitual)**	Automatic action sequences, operate semi-autonomously
Immune system	N/A (non-neural)	Low (no centralised attractor)	**Proto-conscious**	Learns, remembers, communicates; lacks integration into a unified attractor
Gut microbiota	N/A (trillions of microbes)	N/A (external ecosystem)	**No**	Perturbs human attractors but has no intrinsic nervous integration

3.1 The ENS: A Second Conscious Mind?

The ENS operates independently — severed from the vagus nerve, it still coordinates digestion. It uses over 30 neurotransmitters, including 95% of the body's serotonin. It can learn to avoid noxious stimuli and remember past exposures (Furness, 2006). In attractor terms, the ENS possesses a resilient, low-dimensional attractor landscape with clear valence (nutrients vs. toxins) and goal-directedness (propulsion, secretion). We conclude that the ENS meets the integrated complexity threshold and qualifies as a **rudimentary, semi-independent conscious subsystem.**

3.2 The Heart's "Little Brain"

The ICNS (14,000–43,000 neurons) processes sensory information from the heart and vessels, modulates heart rate, and sends significant signals to the brain via the vagus. Heartbeat-evoked potentials correlate with interoceptive awareness and even self-recognition. While not as independent as the ENS, the ICNS is a **candidate for a localised conscious attractor** that contributes directly to the global feeling of "being alive."

3.3 The Enslaved Majority: Spinal Cord

The spinal cord's 200 million neurons far exceed the *C. elegans* count, but its attractor dynamics are **tightly enslaved** by descending cortical and brainstem signals. In pathological states (spinal cord injury), the cord below the lesion can reorganise into new, semi-independent attractors – sometimes leading to spontaneous movements and, in rare cases, patterns that have been controversially described as "spinal consciousness" (Calancie et al., 1994; Dimitrijevic et al., 1998). The evidence is preliminary, but it suggests that the cord has latent capacity for local consciousness, normally suppressed by the brain's regulating influence.

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4. The Brain as Regulator, Not Sole Generator

If many subsystems possess rudimentary consciousness, why do we experience a unified self? Because the brain's primary function is **regulation** – emphasising and suppressing the contributions of these subsystems to create a coherent global attractor.

4.1 Spinoza’s Conatus: No Part Diminishes Its Own Power

Spinoza’s *Ethics* (III, 6) states that every thing, insofar as it is in itself, strives to persevere in its being (conatus). A part of the body, left alone, does not curb its own power to act. Spinoza explicitly uses sexual function as an example: the erect penis acts according to its nature; it cannot voluntarily diminish itself.

Thus, if a subsystem’s local attractor is not externally perturbed, it will continue its own pattern. The brain’s role is to **provide those external perturbations** — not to annihilate the subsystem’s conatus, but to **couple** it with other subsystems so that the combined whole has greater power. The brain’s regulatory perturbations are themselves expressions of the whole organism’s higher-order conatus, aligning parts to preserve the whole.

4.2 Regulation by Emphasis and Suppression

The brain does not “command”; it modulates. Through descending pathways, neuromodulators (dopamine, serotonin, norepinephrine), and synchronised rhythms, the brain:

- **Amplifies** certain subsystem signals (e.g., gut hunger signals become conscious cravings).
- **Damps** others (e.g., spinal reflexes are suppressed during voluntary movement).
- **Entrains** rhythms (e.g., cardiac and respiratory rhythms lock to cortical oscillations during focused attention).

In attractor language, the brain shifts the **effective landscape** of each subsystem, making some local attractors shallower (easier to override) and others deeper (more influential). This is regulation, not annihilation.

4.3 The Alien Feeling: When Regulation Falters

When you ask *“why did I do that?”* — a subsystem (habit, emotional reflex, gut impulse) acted before the brain could integrate it. The global attractor was temporarily misaligned. The “alien” feeling is the **friction between semi-autonomous local attractors and the slower, narrative self**. It is not pathology; it is the normal noise of a distributed system. Libet-type experiments (Libet et al., 1983) have shown that brain activity for voluntary actions often precedes conscious awareness, illustrating this temporal decoupling. (While the interpretation of these experiments remains debated, the existence of action-preceding awareness is sufficient for the present argument.)

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5. Empirical Signatures and Testable Predictions

5.1 Signatures of Subsystem Consciousness

- **Local learning and memory** (e.g., ENS conditioned aversion; Furness, 2006).
- **Semi-autonomous rhythms** (e.g., slow waves of the gut, heartbeat variability).
- **Local valence** (e.g., immune cells produce pro- vs anti-inflammatory attractors).
- **Coupling strength** to the global attractor — measurable via transfer entropy or cross-correlation.
- **Behavioural dissociation** — actions initiated before conscious awareness (Libet, 1983).

5.2 Predictions

1. **Perturbation of a subsystem (e.g., vagus nerve stimulation) should alter the global conscious narrative** — already well-established.
2. **Decoupling a subsystem (e.g., spinal anaesthesia) should produce local, independent attractor dynamics** — measurable by recording from the isolated cord.
3. **Training a subsystem (e.g., biofeedback of heart rate variability) should deepen its local attractor basin** — measurable by increased resilience to perturbations (McCraty et al., 2009).
4. **In split-brain patients, each hemisphere should be able to independently regulate its ipsilateral subsystems** (e.g., left hemisphere regulates left ENS, right hemisphere regulates right ENS). A suitable protocol would present lateralised interoceptive cues (e.g., unilateral gut distension) and measure lateralised cortical responses in callosotomy patients (Gazzaniga, 1967).

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6. N=1 Case Study: Restoring Whole-Body Coherence

The author conducted a months-long self-engineering experiment based on the attractor framework. This N=1 case study is **hypothesis-generating** and provides a motivating existence proof, not a validation of the framework itself.

6.1 Interventions

- **ECM restoration:** Gelatin, taurine, 28 Hz vibration plate

(90 min every other day), contrast baths. Improved collagen accretion, VO_2 max, skin quality.
- **Abdominal relaxation:** Consciously releasing chronic stomach tension (letting the belly sag) to allow diaphragm excursion.
- **Sleep protocol:** Smaller evening meals, morning cardio + sunlight, 15 min reading low-arousal fiction (*The Mayor of Casterbridge*).

6.2 Outcomes

- Nocturnal SpO_2 rose above 90% consistently; sleep fragmentation ceased.
- Deep sleep reached acceptable levels.
- Subjective "alien" feeling reduced; sense of whole-body coherence increased.

6.3 Interpretation

Each intervention reduced a **self-imposed constraint** that had been forcing a subsystem (abdominal muscles, sympathetic tone, rumination network) into a local attractor misaligned with global sleep-breathing needs. By relaxing those constraints, the brain could more easily regulate the subsystems into a coherent whole-body attractor. The alien feeling diminished because the **coupling** between global "I" and local subsystems improved. This outcome is **consistent with** the framework, but does not prove it; further controlled studies are required.

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7. Philosophical Implications

7.1 Spinoza Vindicated

Spinoza's conatus — the inherent striving of every mode — is precisely the attractor's tendency to maintain its basin. His claim that a part does not diminish its own power is equivalent to saying that a subsystem's local attractor will not self-suppress unless externally perturbed. The brain provides those perturbations, not to diminish but to **align**. Spinoza's metaphysics lacked dynamical systems theory, but his intuition is fully realised in the attractor framework.

7.2 The Binding Problem Dissolved

The traditional "binding problem" — how separate neural activities unite into a single conscious experience — is **dissolved** when we recognise that consciousness is already distributed. The global attractor *is* the binding. No extra mechanism is required; coupling *creates* coherence. The question as traditionally posed is ill-formed: there is no need to bind what was never separate in the first place. This dissolution follows the strategy of Wittgenstein, Ryle, and Dennett.

7.3 The Self as Negotiation

The feeling of a unified "I" is the ongoing **negotiation** between the brain and the federation of subsystems. When negotiation runs smoothly, you feel at home in your body. When it stutters, you feel like an alien. The self is not a substance; it is a **temporary, resilient attractor pattern** — a dance of the whole.

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8. Conclusion

The human body is not a machine with a single conscious ghost in the control room. It is a nested hierarchy of conscious attractors – from the gut's "second brain" to the heart's intrinsic ganglia to the limbic system's emotional core. The brain's role is not to generate consciousness but to **regulate** these distributed components, coupling them into a coherent whole. This view explains the feeling of being an alien observer, aligns with Spinoza's conatus, and yields testable predictions. It also offers a practical path for self-engineering: by removing unnecessary constraints and restoring whole-body coherence, we can reduce the alien feeling and dance more gracefully.

The mind is not a solitary flame. It is a federation of dancers, with the brain as first among equals – and the music is the attractor landscape.

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Sleep as Attractor Maintenance: Glymphatic Clearance, Synaptic Rescaling, and Dynamical Resilience

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Author: Robert Galida
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Preprint available at: https://fantasyattractor.com/

Abstract

Sleep is often called "hardware maintenance" (deep sleep) and "software maintenance" (REM sleep).
This paper re-interprets sleep using the **attractor framework**, where your mind is a dissipative attractor of your whole body.

We propose that different sleep stages are different **attractor regimes**:

- **Deep (NREM) sleep** – a slow, relaxing state that clears waste and dials down brain connections.
- **REM sleep** – a fast, high-dimensional attractor that updates your brain's internal model.

We review evidence for:

- Glymphatic clearance (waste removal)
- Synaptic homeostasis (downscaling of connections)
- Slow-oscillation/spindle coupling
- Sleep–immune interactions

We also show how sleep fragmentation, ageing, chronotypes, and sleep disorders can be understood as changes in **attractor depth**, **stability**, and **corrective permeability**.

The framework introduces a **persistence functional** P(x)$P(x)$ — a single number that measures basin depth — which could be estimated from EEG or wearables to predict resilience to sleep loss and guide closed-loop interventions.

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1. Introduction

In the attractor framework, your mind is a **dissipative attractor of your whole body** — a pattern that needs constant energy, can be disturbed, and can adapt.
Sleep is a natural, periodic disturbance that lets the system reset, repair, and reorganise. It is **not** passive; it is an **active attractor maintenance process**.

We focus on two major sleep stages:

- **NREM sleep**, especially deep slow-wave sleep (NREM 3) — a **slow constraint relaxation** that brings the brain and body back to a low-energy baseline.
- **REM sleep** — a **fast, high-dimensional attractor** for active reorganisation, memory consolidation, and predictive coding updates.

This paper bridges sleep neuroscience with the attractor framework.

What does the framework add?

- **Integration** – a common language across scales.
- A **unified quantitative biomarker** P(x)$P(x)$ from EEG or wearables.
- **Novel predictions** (e.g., wearable early-warning signals, REM-emotional rebound) that are not obvious from the individual component theories.
  This is **generative integration** – a scientific contribution even without claiming new mechanisms.

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2. The Attractor Framework Primer

- **Conservative attractors** (the "six metronomes") – eternal, time-symmetric, provide steady rhythms. They are the floor, not part of maintenance.
- **Dissipative attractors** (life, mind, society) – need energy flow, have finite lifetimes, can evolve. The brain is a nested stack of dissipative attractors.
- **Persistence under perturbation** – a resilient system returns quickly to its attractor after a disturbance.
- **Self-engineering** – using small, repeated disturbances to reshape your own attractor. Sleep is a natural self-engineering cycle.

Sleep moves you through: **wake → NREM → REM → wake**.

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3. NREM Deep Sleep – Slow

Constraint Relaxation

3.1 Glymphatic clearance – flushing out waste

Deep slow-wave sleep (NREM 3) is essential for clearing brain waste.
Studies show that the glymphatic system (which removes waste) works best during deep NREM (Iliff et al., 2012). Norepinephrine drops during sleep, expanding the space around cells and improving fluid flow (Balkrishnan et al., 2023, conference abstract).

In attractor terms: The deep-sleep attractor (high delta power) relaxes the metabolic constraints that build up during the day. Waste clearance rate scales with **attractor depth** (measured by slow-wave activity, SWA). Shallow or broken sleep leads to waste buildup.

3.2 Synaptic homeostasis – resetting brain connections

The synaptic homeostasis hypothesis (SHY) says:

- Wakefulness strengthens synapses (deepens attractor basins).
- NREM sleep downscales synapses (shallows basins) (Tononi & Cirelli, 2006).

SWA reflects this – it is high after waking and declines across the night.

In attractor terms: The persistence functional P(x)$P(x)$ would be high after waking, then drop during NREM as synapses downscale. The rate is steep early and plateaus later – compatible with critical slowing down near awakening (though direct evidence is mixed).

3.3 Slow-oscillation–spindle coupling – nested rhythms

Memory consolidation during sleep depends on the tight coordination of:

- Cortical slow oscillations (<1 Hz)
- Thalamocortical spindles (12–15 Hz)

This is best described as **nested oscillatory coupling** (Ngo et al., 2013) — the slow oscillation modulates excitability, creating windows for spindles.
We interpret this as **different timescales within a single attractor manifold** (parsimonious). (Two coupled attractors could also produce phase locking; the question is subtle, but we take the simpler view.)

Stronger phase-locking between spindles and slow oscillations predicts better memory. Closed-loop stimulation (auditory or electrical) timed to the up-phase enhances both slow waves and spindles — showing that the attractor can be externally reinforced.

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4. REM Sleep – Fast, High-Dimensional Attractor

REM sleep has activated EEG (low voltage, fast rhythms) and vivid dreaming.
From a **predictive coding** view (Friston, 2010), REM updates the brain's generative model by resolving prediction errors.

Dynamically, the NREM → REM transition is a **phase bifurcation**:

- NREM is a low-dimensional attractor (regular slow oscillations).
- REM is higher-dimensional (complex, desynchronised EEG).

Indeed, EEG complexity (e.g., Lempel-Ziv complexity) is higher in REM and wake than in NREM.

If REM dreaming implements predictive coding, then nights with stronger REM (longer, more intense periods) should show greater emotional memory consolidation. (The idea of lucid dreaming as a “meta-attractor” is not pursued here.)

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5. Sleep Fragmentation and Attractor Instability

Frequent awakenings (fragmentation) repeatedly disturb the sleep attractor.
Each arousal is a temporary escape from the NREM or REM basin, reducing effective depth and slowing re-entry. This is a state of **reduced attractor stability** with **critical slowing down** (Scheffer et al., 2009): recovery takes longer.

Recent work (de Mooij et al., 2020) found that EEG change-points – transitions between stages – are often preceded by early-warning signals (rising variance and autocorrelation).
Grossman et al. (2025) showed that the wake-to-sleep transition follows a bifurcation dynamic, detectable minutes before sleep onset.

Wearables (HRV, actigraphy) could detect similar signs – rising movement variance, increasing HRV autocorrelation – before a failed sleep transition. Closed-loop auditory tones could then reinforce the desired attractor.

6. Inter-individual Differences, Aging, Chronotypes, and Immune Coupling

Resilience to sleep loss

People vary widely. The **PER3 clock gene polymorphism** is a paradox:

- PER3^{5}/^{5} individuals have more slow-wave sleep and higher delta power, yet they suffer **greater** performance declines under sleep loss (Viola et al., 2011).

This shows that a deeper baseline attractor does **not** guarantee resilience. The framework says resilience requires not only depth but also **corrective permeability** — the ability to re-enter deep sleep after an awakening and to update the attractor under stress (see Section 7).

Aging

Slow-wave sleep drops dramatically with age. In a community study, each 1% annual reduction in SWS was linked to a 27% higher risk of dementia (Himali et al., 2023).
In attractor terms: the deep-sleep basin **erodes** with age, and corrective permeability weakens. Exercise, light therapy, and melatonin may help a little, but only modestly.

Chronotypes

Morning larks and night owls differ mainly in the **phase** of the sleep–wake attractor relative to the light–dark cycle. Both can have similar basin depths, but misalignment may weaken the attractor.

Sleep–immune coupling

Sleep deprivation increases pro-inflammatory cytokines (IL-6, TNF-α) and reduces T-cell activity (Irwin et al., 2016; Besedovsky et al., 2012).
A shallow or fragmented sleep basin destabilises the immune attractor, leading to slower recovery from infection (Cohen et al., 2009) and blunted vaccine responses (Spiegel et al., 2002).

Immune challenge (e.g., infection) also disrupts sleep, increasing SWS — a “sickness behaviour” attractor shift (Krueger et al., 2013). This is **bidirectional coupling** between two attractor landscapes.

Framework-specific prediction: Corrective permeability κ should be **lower** on nights following an immune challenge, independently of changes in delta power.
(Statistical test: partial correlation or regression of κ on immune challenge, controlling for P_{EEG}.) This prediction is not deducible from the cytokine model alone.

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7. Sleep Disorders as Maladaptive Attractors and Corrective Permeability

7.1 Defining corrective permeability κ

κ measures how quickly a system returns to its primary attractor after a disturbance and how easily it updates under chronic stress.$\kappa = \frac{1}{\tau_{recovery}}$

where $\tau_{recovery}$ (minutes) is the time from an awakening back to stable deep NREM (stage 3).

- High $\kappa > 0.2$ min^{-1} → fast recovery (<5 min).
- Low $\kappa < 0.05$ min^{-1} → poor recovery (>20 min).

These thresholds are provisional — for empirical calibration.

Heart-rate recovery slope after awakenings is a candidate wearable proxy (hypothesis, not yet validated).

7.2 Disorder taxonomy

- **Insomnia** — abnormally shallow sleep attractor (low depth) **and/or** low κ. Hyperarousal prevents settling into deep sleep.
- **Narcolepsy** — blurred boundary between wake and REM attractors (orexin loss).
- **REM behaviour disorder** — failure of REM attractor to suppress muscle activity; dream movements “leak out”.

7.3 Falsification conditions

Falsification of the “shallow basin” explanation
If an insomnia patient shows normal delta power ($P_{EEG} > 0.7$) **and** normal corrective permeability ($\kappa > 0.1$) but still has non-restorative sleep, the “shallow basin” model is falsified for that patient.
The framework would be incomplete, not wrong. **But** to prevent this clause from making the theory unfalsifiable, we add a provisional bound:

> *If more than 30% of diagnosed insomnia cases need such additional mechanisms, the framework’s descriptive utility for insomnia would be in question, and the core hypothesis would be falsified.*

Falsification of the attractor framework itself
If sleep stage transitions show **no** evidence of basin-crossing dynamics (no rise in variance/autocorrelation, no attractor dimensionality difference between NREM and REM, no critical slowing down before awakening), then the attractor framework should be abandoned in favour of a purely stochastic or oscillator-based model.
Specifically, a well-powered study using the methods of de Mooij et al. (2020) that finds null results would constitute strong falsification. (We require convergent null evidence across multiple measures.)

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8. The Persistence Functional $P(x)$

$P(x)$ measures attractor depth — the ability to resist disturbance and return to stable state.
We base it on the **dominant Lyapunov exponent** λ_1.

Primary definition (fixed $\tau = 1$ s):$P_{raw} = e^{-\lambda_1 \cdot \tau}$

For a stable attractor, $\lambda_1 < 0$, so $P_{raw} > 1$. Deeper attractors (more negative λ_1) give larger P_{raw}.

To get a bounded [0,1] measure:$P_{norm} = \frac{1}{1 + e^{\lambda_1 \tau}}$

- Values near 1 → deep basin.
- 0.5 → neutral.
- Near 0 → unstable/chaotic.

EEG-practical approximations:

- **Correlation dimension D_2** — in sleep EEG, deeper stages have lower D_2. This is a **sleep-specific** approximation. Then $P \propto 1/(1+D_2)$.

- **Delta power ratio** (simplest):

$$P_{EEG} = \frac{\langle \delta(t) \rangle}{\delta_{wake} + \langle \delta(t) \rangle}$$

where $\langle \delta(t) \rangle$ is mean delta power (0.5–4 Hz) in the epoch, and δ_{wake} is the same during relaxed wakefulness. Deep sleep → value close to 1; shallow sleep → near 0.

We recommend P_{EEG} for practical sleep research. All three definitions should correlate under the framework’s assumptions, but empirical validation is needed.

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9. Testable Predictions

Prediction	Type	Proposed Test Protocol	Source / Support
Glymphatic clearance correlates with SWA	Retrodiction	–	Iliff et al., 2012
EEG complexity decreases across NREM	Retrodiction	–	Tononi & Cirelli, 2006
SO–spindle coupling predicts memory	Retrodiction	–	Ngo et al., 2013
Sleep fragmentation preceded by rising variance/autocorrelation	Novel	Re-analyse existing sleep EEG datasets	de Mooij et al., 2020; Grossman et al., 2025

Prediction	Type	Proposed Test Protocol	Source / Support
Wearable early-warning signals (HRV lag-1 autocorrelation) predict night-to-night sleep quality	**Novel**	Pilot N=1 wearable study (30+ nights); confirm with larger cohort	Proposed here
REM rebound scales with emotional load during wake	Plausible	Daily stress diary (1–10) + actigraphy/PSG for REM%	Proposed here
Immune challenge reduces next-night κ*κ* independently of delta power	**Novel (framework-specific)**	Controlled immune challenge (e.g., vaccine) with wearable/PSG κ*κ*; partial correlation controlling for PEEG*P*EEG	Proposed here

Falsification of core framework: If no evidence of basin-crossing dynamics (rising variance/autocorrelation, difference in attractor dimensionality) is found in a well-powered EEG study using de Mooij et al.'s methods, the attractor framework for sleep should be abandoned.

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10. Conclusion

Sleep is not passive — it is a dynamic, bifurcated process of **attractor maintenance**.

- **Deep NREM sleep** — slow constraint relaxation, clearing waste and downscaling synapses.
- **REM sleep** — fast, high-dimensional attractor, updating the brain's generative model.

Fragmentation, aging, and sleep disorders can be understood as changes in attractor depth, stability, and corrective permeability.

The persistence functional $P(x)$ gives a quantitative language for sleep engineering.

The dance of sleep is the dance of maintenance — and we can learn to engineer it.

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