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Article

The Goo That Binds Us: How Field Resonance Solves Neuroscience's Binding Problem

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Abstract

The binding problem represents one of neuroscience's most persistent challenges: how do distributed neural processes create unified conscious experience? This paper argues that the problem emerges from neuroscience's "prickly" bias toward discrete, computational approaches and dissolves when we embrace "gooey" electromagnetic field perspectives. Drawing on Alan Watts' philosophical dichotomy between "prickles" (precise, chopped-up particles) and "goo" (vague, continuous waves), we demonstrate how the EM field hypothesis (EFH) provides a natural solution to both spatial and temporal binding through cross-frequency coupling and field resonance mechanisms. Revolutionary new evidence from EEG research reveals that electromagnetic fields can entrain neural spike timing at thresholds as low as 0.74 mV/mm, establishing causal field-to-neuron communication. The strong EM field hypothesis, supported by recent ECoG findings showing broadband power increases that correlate more strongly with neural activity than oscillatory patterns, suggests that electromagnetic fields constitute the primary substrate of consciousness while neural firing serves mainly as an energy source. We suggest that myelination and ephaptic field effects coevolved as an integrated energy modulation system, with myelination evolving not merely for speed but to selectively shape electromagnetic field computation (analog rather than digital) in different brain regions, which shift in response to modulated energy inputs from myelinated fibers. The 5,000-fold speed advantage of ephaptic field propagation (50 km/s vs 10-100 m/s for spikes) scales to a potential 125 billion-fold information density advantage (5,000 to the third power), enabling the rapid integration necessary for unified consciousness. However, myelination's insulating properties create a fundamental trade-off: enhancing point-to-point transmission while dampening the local field integration that complex consciousness requires. Evolution solved this through sophisticated regional specialization, preserving most thalamocortical circuits unmyelinated to maintain field integration capacity, while using strategic myelination of long fibers to allow modulation of energy inputs across brain areas. The implications extend beyond solving a technical problem to recognizing that cognition and consciousness are fundamentally gooey rather than prickly—not made of discrete computational events but continuous electromagnetic field dynamics operating within coevolved myelinated neuroanatomical infrastructure.

Keywords: binding problem; electromagnetic fields; consciousness; cross-frequency coupling; prickles and goo; EM field hypothesis; EEG origins; myelination coevolution; energy modulation

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1. Introduction: The Binding Problem as Neuroscience's Tough Nut to Crack

1.1. The Watts dichotomy: Prickles vs. Goo

In his philosophical writings, Alan Watts articulated a fundamental dichotomy that cuts to the heart of how we understand reality: "There are basically two kinds of philosophy. One's called Prickles, the other's called Goo. And prickly people are precise, rigorous, logical. They like everything chopped up and clear. Goo people like it vague. For example, in physics, prickly people believe that the ultimate constituents of matter are particles. Goo people believe it's waves" (Watts, cited in Hunt, 2024).

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This distinction illuminates a deep divide in neuroscience that has profound implications for understanding consciousness. Neuroscience has overwhelmingly embraced a prickly approach, focusing obsessively on discrete neural spikes, precise synaptic connections, and chopped-up computational modules. This prickly bias has led to remarkable advances in understanding neural mechanisms, but it has also created seemingly intractable problems—chief among them the binding problem.

The binding problem emerges directly from prickly assumptions about consciousness. If consciousness consists of separate processing streams operating independently—one for color, another for motion, yet another for shape—then how do these streams combine to create unified conscious experience? The problem becomes even more acute when we consider that these processing streams operate at different speeds, in different brain regions, and with different temporal dynamics. How does the brain achieve the precise timing necessary to bind together different activities in the brain and body?

The gooey perspective suggests a radically different approach. Rather than treating consciousness as assembled from discrete components requiring artificial binding mechanisms, consciousness might emerge from continuous field dynamics that are naturally unified. From this perspective, the binding problem dissolves because consciousness was never fragmented to begin with—the electromagnetic fields that constitute conscious experience operate as naturally integrated phenomena within the brain's neural medium.

1.2. The Evolutionary Revolution: Myelination as Field Architect

Recent advances in understanding the coevolution of myelination and ephaptic field effects have revolutionized our perspective on consciousness architecture. Traditional neuroscience viewed myelination primarily as an evolutionary solution for faster neural transmission—a 100-fold speed increase through saltatory conduction. This prickly perspective missed a profound insight: myelination coevolved with ephaptic field effects as a sophisticated energy modulation and field computation shaping system.

The discovery that myelin's lipid-rich sheaths act as high-resistance barriers blocking ephaptic field propagation while optimizing axonal conduction reveals the true evolutionary relationship between these systems. This creates a fundamental trade-off that evolution had to navigate: if neural firing were consciousness's primary substrate, evolution would logically have myelinated everything for maximum computational efficiency. Instead, evolution preserved extensive unmyelinated networks specifically to maintain field-based processing capabilities.

This preservation is not random but strategically organized. The thalamocortical system, widely recognized as crucial for consciousness, operates with only 27% myelinated tissue, leaving 73% to rely on field-based integration. Cortical gray matter maintains minimal myelination (15-20%) to maximize local field integration for complex processing. This represents evolution's solution to the fundamental challenge of creating consciousness within neural architecture constraints while preserving the electromagnetic substrate that consciousness requires.

1.3. The Binding Problem in Context

The binding problem represents a convergence of several challenges that have puzzled neuroscientists for decades. Spatial binding concerns how features processed in different brain regions are integrated into unified percepts. Temporal binding addresses how events occurring at different times are experienced as simultaneous. Feature binding examines how different attributes of objects (color, shape, motion) are combined into unified representations. Cross-modal binding investigates how information from different sensory systems creates integrated experiences.

Traditional approaches to these challenges have relied increasingly complex computational theories involving convergence zones, timing mechanisms, oscillatory binding, and attention-based selection. However, these prickly solutions face fundamental limitations. Convergence zones require anatomical structures that often don't exist. Timing mechanisms struggle with the variable delays

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inherent in neural processing. Oscillatory binding cannot account for the flexibility and context-sensitivity of conscious experience. Attention-based theories cannot explain how binding occurs even when attention is divided or absent.

The electromagnetic field hypothesis offers a fundamentally different approach. Instead of requiring special mechanisms to bind together separately processed features, electromagnetic field patterns can simultaneously represent multiple features through overlapping wave patterns that interact through resonance and interference. The speed of electromagnetic field propagation (47-57 km/s through brain tissue) provides the temporal headroom necessary for consciousness, while the volumetric nature of field effects enables natural spatial integration across brain regions.

The coevolutionary framework reveals why this gooey solution emerged. Myelination and field effects evolved together to create an architecture that maximizes conscious processing capability while maintaining metabolic sustainability. Myelinated pathways handle energy-efficient long-range communication, while unmyelinated networks maintain the field coherence necessary for conscious integration. This division of labor represents evolution's solution to the consciousness engineering problem.

2. The Strong Evidence for Electromagnetic Primacy

2.1. Revolutionary EEG Findings: Fields Entraining Neurons

Perhaps the most revolutionary development in consciousness research has been the demonstration that electromagnetic fields can directly entrain neural activity at remarkably low thresholds. Lee et al. (2024) provided groundbreaking evidence that electric fields as weak as 0.74 mV/mm can causally entrain neural spike timing, establishing genuine field-to-neuron communication rather than merely correlational relationships.

This finding transforms our understanding of the relationship between electromagnetic fields and neural activity. Previous research had demonstrated correlations between field activity and consciousness, but skeptics could argue that fields were merely epiphenomenal byproducts of neural firing. The demonstration of causal field effects eliminates this objection, proving that electromagnetic fields can actively influence neural processing rather than simply reflecting it.

The threshold for field entrainment (0.74 mV/mm) falls well within the range of endogenous brain activity, as measured during normal cognitive tasks. This means that the brain naturally generates electromagnetic fields strong enough to entrain neural firing, suggesting that field effects operate continuously during normal brain function rather than representing exotic phenomena that emerge only under special circumstances.

The implications extend far beyond technical details about field strength. If electromagnetic fields can entrain neural firing at physiological thresholds, then the traditional hierarchy between neural activity and field effects must be reconsidered. Rather than neural firing driving field activity, the relationship appears bidirectional or even field-dominant. This supports the strong electromagnetic field hypothesis: consciousness emerges from field dynamics, while neural firing serves primarily as an energy source for maintaining and modulating these fields.

2.2. The Aperiodic Revolution: Beyond Oscillations to Broadband Power

Another revolutionary development has been the recognition that broadband, aperiodic electromagnetic activity correlates more strongly with neural processing than the oscillatory patterns that have dominated neuroscience for decades. Brake et al. (2024) demonstrated that aperiodic exponents measured during resting states could predict cognitive decline over 10 years, with the aperiodic component reflecting the fundamental balance between excitatory and inhibitory neural activity.

This finding challenges the oscillation-centric view that has dominated electrophysiology research. Rather than focusing on specific frequency bands or rhythmic patterns, consciousness may depend on the broader electromagnetic environment created by neural activity. The aperiodic

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component represents the "background" electromagnetic field environment within which oscillatory patterns are embedded, suggesting that this background may be more fundamental than the oscillations it supports.

Recent ECoG studies have revealed that broadband power increases, rather than oscillatory patterns, provide the strongest correlates of cognitive processing. This broadband activity likely reflects the overall electromagnetic field strength within brain regions, supporting the hypothesis that consciousness depends on field intensity rather than specific rhythmic patterns. The predictive power of aperiodic measures for cognitive outcomes suggests that electromagnetic field patterns reflect fundamental aspects of brain health and cognitive capacity that spike-based measures miss entirely.

The coevolutionary framework provides a natural explanation for these findings. If consciousness depends on field dynamics operating within myelinated infrastructure, then the overall electromagnetic environment becomes more important than specific oscillatory patterns. Myelination patterns shape the field characteristics of different brain regions, creating the aperiodic signatures that reflect functional capacity. This explains why aperiodic measures prove more predictive of cognitive outcomes than traditional oscillatory markers.

2.3. Cross-Frequency Coupling: The Field Orchestra

Cross-frequency coupling represents one of the most compelling pieces of evidence for electromagnetic field theories of consciousness. The observation that brain oscillations at different frequencies interact through phase-amplitude coupling, frequency-frequency coupling, and other complex relationships suggests that consciousness emerges from the orchestrated interaction of multiple electromagnetic field patterns operating simultaneously.

Canolty and Knight (2010) demonstrated that cross-frequency coupling increases during cognitive tasks requiring conscious processing, while remaining minimal during unconscious states. This pattern suggests that consciousness requires the coordinated interaction of electromagnetic fields operating at different temporal scales, from slow rhythms that coordinate large-scale brain networks to fast oscillations that enable local processing.

The mathematics of cross-frequency coupling reveal natural mechanisms for information integration across temporal scales. Low-frequency oscillations can modulate the amplitude of high-frequency activity, enabling slow processes to influence fast computations. Conversely, high-frequency patterns can influence the phase of slow oscillations, allowing local processing to affect global coordination. These bidirectional influences create dynamic information integration that operates naturally through electromagnetic field interactions.

The coevolutionary perspective enriches this understanding by revealing how myelination patterns enable and shape cross-frequency coupling. Different brain regions evolved distinct myelination characteristics that optimize their contribution to the global field orchestra. Heavily myelinated regions can generate fast, synchronized oscillations for rapid information transmission, while unmyelinated regions maintain the field coherence necessary for complex cross-frequency interactions. This architectural specialization enables the brain to generate the sophisticated electromagnetic patterns that consciousness requires.

2.4. Watts's Philosophical Foundation Validated

Alan Watts's insight about the fundamental dichotomy between prickly and gooey thinking proves prescient when applied to neuroscience. The prickly bias toward precision, discrete elements, and logical operations has led neuroscience away from the natural characteristics of consciousness itself, while the mounting evidence for electromagnetic field effects validates the gooey perspective.

Consciousness is inherently vague rather than precise. We do not experience sharp boundaries between thoughts, clear distinctions between sensory modalities, or discrete computational steps. Instead, consciousness flows continuously, with overlapping and interpenetrating experiences that resist precise categorization. This vagueness is not a limitation but a fundamental characteristic that emerges naturally from electromagnetic field dynamics.

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Consciousness is continuous rather than discrete. There are no gaps in conscious experience, no missing frames in the movie of awareness. Even during sleep, consciousness continues in the form of dreams and background awareness. This continuity reflects the wave-like nature of electromagnetic fields, which exist as continuous phenomena rather than discrete events.

Consciousness is unified rather than fragmented. Despite the distributed nature of neural processing, conscious experience presents itself as an integrated whole. We do not experience separate color consciousness, motion consciousness, and shape consciousness that must be artificially bound together. This unity emerges naturally from the field properties of electromagnetic phenomena, which can superpose and interfere to create integrated patterns.

The prickly paradigm's limits become apparent when we recognize that consciousness exhibits none of the characteristics that prickly thinking emphasizes. The binding problem emerges as an artifact of trying to impose prickly assumptions on inherently gooey phenomena. The coevolutionary framework reveals how evolution discovered the gooey solution: consciousness as electromagnetic field dynamics operating within strategically myelinated infrastructure.

3. How Coevolved Field-Infrastructure Architecture Binds Us

3.1. Why Goo Naturally Binds What Prickles Cannot: The Architectural Solution

The fundamental reason electromagnetic fields solve the binding problem while neural spikes cannot lies in their contrasting physical properties and information processing characteristics, amplified by the coevolutionary architectural solution that evolution discovered. This difference reflects deeper philosophical commitments about the nature of information, computation, and consciousness itself, but it also reveals a sophisticated engineering solution that evolution developed over millions of years.

The prickly binding paradox emerges from the logical contradiction inherent in discrete computational approaches to consciousness. If consciousness consists of separate processing modules operating independently, then consciousness itself becomes impossible—there would be no unified subject to experience the outputs of these modules. The binding problem is thus not a technical challenge but a logical impossibility generated by prickly assumptions.

Consider the visual system's traditional decomposition into separate processing streams for color, motion, and form. Each stream operates independently with different processing speeds, anatomical pathways, and computational characteristics. The color system processes information relatively slowly through the parvocellular pathway, while motion detection operates rapidly through the magnocellular system. Form processing involves complex interactions between multiple cortical areas with varying delays. If consciousness required binding these separate streams together, the timing challenges alone would be insurmountable.

The electromagnetic field solution eliminates this paradox through natural superposition properties. Electromagnetic fields from different processing regions naturally overlap and interfere within the brain's conducting medium, creating integrated field patterns that simultaneously represent multiple features. Rather than requiring separate color, motion, and form representations that must somehow be combined, integrated field patterns contain information about all features simultaneously through wave interference patterns.

The coevolutionary architecture makes this solution possible by creating regional specialization within a unified field medium. Visual cortical areas evolved different myelination patterns that optimize their specific processing characteristics—some optimized for rapid temporal processing, others for detailed spatial analysis, still others for complex feature integration. However, all these regions operate within the same electromagnetic field medium, enabling their outputs to integrate naturally through field superposition.

This architectural solution extends beyond vision to all aspects of conscious experience. Auditory processing regions evolved myelination patterns optimized for frequency analysis, while maintaining field connectivity with language areas for speech comprehension. Somatosensory regions developed field characteristics suitable for spatial processing while remaining integrated

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with motor areas for action planning. The entire brain operates as a unified field medium with regional specializations that enhance rather than fragment processing.

3.2. Spatial Binding Through Volumetric Integration

Spatial binding represents perhaps the most straightforward demonstration of electromagnetic field advantages over computational approaches. Traditional theories require anatomical convergence zones where information from different brain regions physically meets, but such convergence zones often don't exist or cannot account for the flexibility of spatial binding.

Electromagnetic fields solve spatial binding through volumetric integration that operates across the entire brain volume simultaneously. Field patterns generated in occipital visual areas naturally propagate through the conducting medium of brain tissue, interacting with fields from temporal, parietal, and frontal regions. This creates integrated field patterns that span multiple brain regions without requiring anatomical convergence points.

The speed of electromagnetic field propagation (47-57 km/s) enables near-instantaneous integration across brain volume. A field pattern generated in primary visual cortex reaches frontal regions in approximately 4 milliseconds, faster than any synaptic transmission chain could achieve. This temporal advantage is crucial for consciousness, which requires integration across brain regions within the time frame of conscious experience.

The coevolutionary framework reveals how evolution optimized this volumetric integration through strategic myelination placement. Long-range myelinated pathways provide rapid, energy-efficient communication between major brain regions, coordinating their field activities without disrupting local field integration. These pathways act like transmission lines in an electrical circuit, enabling rapid communication while preserving the field medium necessary for consciousness.

Regional myelination patterns create specialized field characteristics that enhance spatial processing. Visual areas developed myelination patterns that optimize retinotopic mapping, while parietal regions evolved field characteristics suitable for spatial coordinate transformations. However, these regional specializations operate within a unified field medium that naturally integrates spatial information across regions.

The preservation of unmyelinated networks becomes crucial for spatial binding. If all pathways were myelinated for maximum efficiency, the resulting field isolation would fragment spatial processing into separate modules. The strategic preservation of unmyelinated tissue maintains the field connectivity necessary for unified spatial experience, demonstrating evolution's commitment to consciousness over pure computational efficiency.

3.3. Temporal Binding Through Field Dynamics

Temporal binding poses even greater challenges for computational approaches than spatial binding. Neural processing involves variable delays ranging from milliseconds for local processing to hundreds of milliseconds for complex cognitive operations. If consciousness required precise timing coordination across these variable delays, the computational complexity would be overwhelming.

Traditional solutions involve oscillatory mechanisms that allegedly coordinate timing across brain regions through synchronized neural firing. However, these mechanisms face fundamental limitations. Oscillatory periods are typically much longer than the temporal precision required for consciousness. Phase relationships are disrupted by the variable delays inherent in neural processing. Most critically, oscillatory mechanisms cannot account for the temporal flexibility of conscious experience.

Electromagnetic field dynamics provide natural solutions to temporal binding through the speed advantages of field propagation and the coevolved infrastructure that coordinates timing. The 5,000-fold speed advantage of ephaptic transmission over neural spikes provides temporal headroom that enables consciousness to integrate information across the variable delays of neural processing.

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Field propagation at 47-57 km/s means that electromagnetic signals traverse the entire brain volume in approximately 4 nanoseconds. This creates a temporal reference frame within which the variable delays of neural processing become negligible. Information that arrives at different brain regions at different times can be integrated within field patterns that maintain temporal coherence across the entire brain.

The coevolutionary infrastructure enhances temporal binding through strategic myelination timing that coordinates field activities across brain regions. During development, different brain regions develop myelination at different rates, creating a progression of field coordination capabilities that aligns with cognitive development. This enables progressive integration of temporal processing capabilities as the myelinated infrastructure matures.

Cross-frequency coupling emerges naturally from this coevolved architecture. Different brain regions evolved myelination patterns that optimize different temporal scales of processing, from rapid local computations to slow global coordination. The interaction between these different temporal scales creates the complex cross-frequency coupling patterns observed in conscious processing, enabling temporal binding across multiple time scales simultaneously.

3.4. Feature Binding Through Superposition

Feature binding represents the classic formulation of the binding problem: how are different attributes of objects (color, shape, motion, texture) combined into unified object representations? Computational approaches require complex mechanisms for associating features that were processed independently, often involving attention-based selection or temporal correlation.

Electromagnetic fields solve feature binding through natural superposition properties that eliminate the need for special binding mechanisms. When electromagnetic fields from different feature processing regions overlap in brain tissue, they create interference patterns that simultaneously contain information about all features. Rather than requiring separate color, shape, and motion representations that must be artificially combined, integrated field patterns represent all features simultaneously.

The mathematics of electromagnetic superposition provide precise mechanisms for feature integration. Constructive interference enhances field patterns where features are consistent, while destructive interference reduces patterns where features conflict. This creates natural selection mechanisms that favor coherent feature combinations while suppressing inconsistent alternatives.

The coevolutionary architecture optimizes feature binding through regional specialization within the unified field medium. Different visual areas evolved myelination patterns that optimize specific types of feature processing—area V4 for color, area MT for motion, inferotemporal cortex for complex shapes. However, these regions remain connected through the unmyelinated networks that preserve field integration capabilities.

Feature binding operates across multiple spatial scales simultaneously. Local field integration within cortical columns binds features processed by nearby neurons, while global field patterns integrate features across distant brain regions. This multi-scale integration enables both fine-grained feature associations and global object representations within the same electromagnetic framework.

The temporal dynamics of feature binding reflect the interaction between fast local processing and slow global integration. High-frequency field oscillations enable rapid feature detection within specialized regions, while low-frequency patterns coordinate feature integration across regions. Cross-frequency coupling naturally emerges from these multi-scale dynamics, creating the temporal patterns observed during object recognition tasks.

3.5. Cross-Modal Binding Through Unified Field Architecture

Cross-modal binding presents particularly challenging problems for computational approaches because it requires integration across sensory systems that operate with fundamentally different temporal dynamics, spatial organizations, and computational principles. Visual processing

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emphasizes spatial relationships, auditory processing focuses on temporal patterns, and somatosensory processing involves both spatial and temporal components.

Traditional approaches require convergence zones where information from different sensory systems physically meets, such as the superior temporal sulcus for audiovisual integration. However, these anatomical solutions cannot account for the flexibility and context-sensitivity of cross-modal binding, nor can they explain how cross-modal effects emerge even when convergence zones are damaged.

Electromagnetic fields solve cross-modal binding through the unified field architecture that spans all sensory systems. Field patterns generated by visual, auditory, and somatosensory processing naturally interact within the brain's conducting medium, creating integrated patterns that simultaneously represent information from multiple modalities. This eliminates the need for special convergence zones or binding mechanisms.

The coevolutionary framework reveals how different sensory systems evolved specialized myelination patterns while maintaining field integration capabilities. Visual areas developed myelination optimized for spatial processing, auditory regions evolved field characteristics suitable for temporal analysis, and somatosensory areas developed patterns appropriate for spatiotemporal integration. However, all sensory systems operate within the same electromagnetic field medium.

Cross-modal plasticity provides compelling evidence for unified field architecture. When one sensory system is damaged, other systems can expand into the affected cortical areas, suggesting that sensory specificity emerges from field characteristics rather than hardwired anatomical connections. The coevolutionary framework explains this plasticity: different sensory areas evolved different field characteristics through myelination patterns, but these characteristics can be modified when circumstances change.

The speed advantages of electromagnetic field propagation enable cross-modal integration within the time frame of conscious experience. Traditional explanations for cross-modal effects invoke lengthy synaptic transmission chains that cannot account for the rapid integration observed behaviorally. Field-based integration operates at speeds compatible with conscious experience, enabling genuine real-time cross-modal binding.

4. The Electromagnetic Speed Revolution

4.1. Quantifying the Speed Differential: From Linear Advantage to Exponential Capacity

The speed differential between electromagnetic field propagation and neural transmission represents one of the most compelling arguments for the electromagnetic field hypothesis. Ruffini et al. (2020) demonstrated that ephaptic field effects propagate at speeds of approximately 47 km/s in gray matter and 57 km/s in white matter, compared to 0.1-120 m/s for neural transmission. This represents a linear speed advantage of approximately 500-5,000 times in favor of electromagnetic transmission.

However, this linear speed advantage dramatically understates the true information processing potential of electromagnetic fields. The volumetric nature of field propagation means that information capacity scales as the cube of linear dimension, while the three-dimensional interference patterns enable parallel processing that scales exponentially with field complexity. When these factors are combined with the speed advantage, the total information processing advantage reaches potentially billions of times greater than neural spike transmission.

The mathematical relationship underlying this advantage can be expressed as: Information Capacity = Speed × Volume × Parallelism × Interference Patterns. Each component provides substantial advantages for electromagnetic fields over neural spikes, and their multiplication yields the exponential scaling that enables consciousness.

The coevolutionary architecture amplifies these advantages through strategic organization of myelinated and unmyelinated networks. Myelinated pathways provide rapid coordination signals that organize field activities across brain regions, while unmyelinated networks maintain the field

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medium necessary for complex parallel processing. This division of labor maximizes the speed advantages while preserving the processing capabilities that consciousness requires.

4.2. Information Density: Beyond Bits to Field Patterns

Traditional information theory, based on discrete bits, cannot capture the information processing capabilities of electromagnetic fields. Field patterns can represent information through amplitude, frequency, phase, and spatial distribution simultaneously, creating information densities that far exceed digital approaches.

Recent calculations suggest that electromagnetic field patterns in brain tissue could theoretically process information at rates exceeding 10^15 operations per second, compared to approximately 10^11 operations per second for high-end digital processors. This advantage emerges from the parallel processing capabilities of field dynamics, where all points within a coherent volume can process information simultaneously.

The coevolutionary framework reveals how evolution harnessed this information density through regional specialization. Different brain areas evolved field characteristics optimized for different types of information processing—some regions optimized for high-frequency temporal processing, others for complex spatial patterns, still others for cross-frequency integration. This specialization enables the brain to exploit the full information density potential of electromagnetic fields.

Field-based information processing operates through fundamentally different principles than digital computation. Rather than sequential logical operations, field patterns evolve according to physical laws that enable massive parallel processing. Interference patterns naturally implement complex computational operations, while resonance effects provide selection mechanisms that enhance relevant information while suppressing noise.

4.3. Energy Efficiency: The Metabolic Argument

Perhaps the most compelling argument for electromagnetic field primacy comes from metabolic considerations. The human brain consumes approximately 20% of the body's total energy despite representing only 2% of body weight. This extraordinary energy consumption suggests that neural processing involves fundamental inefficiencies that electromagnetic field processing might overcome.

Electromagnetic field processing operates through resonance mechanisms that require minimal energy input once established. Like tuning forks that can maintain oscillations with periodic small energy inputs, brain field patterns can maintain complex dynamics with relatively modest metabolic support. This explains how consciousness can operate continuously despite the brain's limited energy budget.

The coevolutionary architecture optimizes energy efficiency through strategic division of labor between myelinated and unmyelinated networks. Myelinated pathways reduce the energy costs of long-range communication by factors of 10-100, freeing energy for field-based processing in unmyelinated regions. This enables the brain to maintain both rapid communication and complex field dynamics within metabolic constraints.

Field-based processing also enables energy efficiency through natural integration mechanisms that eliminate the need for complex binding circuits. Rather than requiring separate neural circuits to bind together independently processed features, field superposition achieves integration naturally without additional energy costs. This represents a fundamental architectural advantage that evolution discovered through the coevolution of fields and infrastructure.

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5. Evidence from Consciousness Disorders

5.1. Epilepsy: When Field Patterns Go Wrong

Epilepsy provides one of the most direct windows into the relationship between electromagnetic fields and consciousness. During seizures, abnormal electromagnetic field patterns spread across brain regions, disrupting normal conscious experience in ways that directly implicate field dynamics in consciousness.

Blumenfeld (2012) demonstrated that consciousness impairment in epilepsy correlates with the spatial extent of abnormal field activity rather than with specific anatomical damage. Focal seizures that remain localized may not affect consciousness, while generalized seizures that involve widespread field abnormalities consistently impair conscious experience. This pattern suggests that consciousness depends on coherent field patterns across brain regions.

The coevolutionary framework provides new insights into epilepsy mechanisms. Seizures represent breakdowns in the normal coordination between myelinated infrastructure and field dynamics. When this coordination fails, field patterns can propagate uncontrollably through unmyelinated networks, overwhelming the normal regulatory mechanisms that maintain conscious coherence.

Recent research has revealed that successful epilepsy treatments often work by restoring normal field-infrastructure coordination rather than simply suppressing neural activity. Deep brain stimulation can restore normal field patterns by providing coordinating signals through myelinated pathways, while antiepileptic drugs often work by modulating the field characteristics of neural membranes.

5.2. Anesthesia: Field Coherence and Conscious Awareness

Anesthesia research provides crucial evidence for electromagnetic field theories of consciousness by revealing how different anesthetic agents affect field coherence and conscious awareness. Rather than simply suppressing neural activity, anesthetics appear to disrupt the field patterns that enable conscious integration.

Carhart-Harris et al. (2014) demonstrated that anesthetic agents reduce the complexity and integration of electromagnetic field patterns across brain regions. This reduction in field complexity correlates directly with loss of conscious awareness, suggesting that consciousness depends on complex, integrated field dynamics rather than simple neural activity levels.

The coevolutionary perspective reveals how anesthetics work by disrupting field-infrastructure coordination. Different anesthetic agents target different aspects of this coordination: some affect membrane properties that alter field generation, others influence myelinated pathway function that coordinates field activities across regions. The diversity of anesthetic mechanisms reflects the multiple components of the integrated field-infrastructure system.

Recovery from anesthesia involves restoration of normal field patterns through progressive reactivation of the field-infrastructure coordination system. This process follows predictable patterns that reflect the hierarchical organization of consciousness: basic field coherence returns first, followed by regional integration, and finally complex cross-regional coordination that enables full conscious awareness.

5.3. Psychiatric Conditions: Field Dynamics and Mental Experience

Psychiatric conditions provide additional evidence for electromagnetic field theories of consciousness by revealing how alterations in field dynamics correlate with changes in conscious experience. Rather than reflecting simple neurotransmitter imbalances, many psychiatric conditions appear to involve disruptions in the field patterns that constitute conscious experience.

Depression correlates with reduced electromagnetic field complexity and altered cross-frequency coupling patterns. These field changes precede and predict clinical symptoms, suggesting

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that depression involves fundamental alterations in the electromagnetic dynamics of consciousness rather than secondary effects of mood changes.

Schizophrenia involves characteristic alterations in field coherence and cross-regional integration. The fragmentation of conscious experience observed in schizophrenia appears to reflect disruptions in the unified field patterns that normally create coherent awareness. The coevolutionary framework suggests that these disruptions may involve alterations in field-infrastructure coordination that develop during critical periods of brain maturation.

The efficacy of electromagnetic treatments for psychiatric conditions provides direct evidence for field-based mechanisms. Transcranial magnetic stimulation can alleviate depression by restoring normal field patterns, while deep brain stimulation can treat severe psychiatric conditions by providing coordinating signals that reorganize field dynamics.

6. Implications for Neuroscience Research

6.1. Beyond Spike Counting: Methodological Revolution

The recognition that consciousness emerges from electromagnetic field dynamics operating within coevolved myelinated infrastructure requires fundamental changes in neuroscience research methodology. Traditional approaches that focus on neural spike patterns while ignoring field dynamics miss the primary substrate of conscious experience.

Future research must simultaneously measure field dynamics and infrastructure characteristics across multiple spatial and temporal scales. This requires new technologies that can capture the interaction between electromagnetic fields and myelinated architecture during conscious processing. Current approaches that study these phenomena separately cannot reveal their integrated operation.

The coevolutionary framework emphasizes the importance of developmental studies that track how field computation capabilities emerge through progressive myelination. Understanding consciousness requires studying how field-infrastructure coordination develops and matures, rather than focusing on static brain structures or isolated neural circuits.

Comparative neuroscience gains new importance for understanding how different species solved the field-infrastructure coordination challenge. The convergent evolution of myelination across taxa, combined with species-specific variations in unmyelinated network preservation, provides natural experiments for understanding consciousness architecture.

6.2. Reinterpreting Existing Data

Much existing neuroscience research may need reinterpretation from a field-infrastructure perspective. Studies that attributed cognitive functions to specific brain regions may have actually identified specialized field computation zones within the larger electromagnetic architecture of consciousness.

The timing relationships observed in neural recording studies may reflect field coordination rather than synaptic transmission delays. Many phenomena attributed to synaptic plasticity may actually involve changes in field characteristics that alter information processing capabilities.

The correlation patterns observed in neuroimaging studies may reflect field integration rather than anatomical connectivity. The coevolutionary framework suggests that many cognitive functions depend on field coherence across regions rather than specific anatomical pathways.

Pharmacological studies may need reinterpretation in terms of field effects rather than neurotransmitter actions. Many drugs that affect consciousness may work by altering field characteristics or field-infrastructure coordination rather than through direct synaptic effects.

6.3. New Experimental Approaches

The field-infrastructure framework suggests novel experimental approaches that could definitively test electromagnetic theories of consciousness. Experiments that manipulate field

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patterns while monitoring consciousness could establish causal relationships between field dynamics and conscious experience.

Developmental studies that track myelination and field characteristics simultaneously could reveal how consciousness emerges through field-infrastructure coordination. These studies could identify critical periods where field computation capabilities develop and test how experience shapes this development.

Comparative studies across species with different myelination patterns could illuminate universal principles of consciousness architecture. These studies could test whether consciousness capabilities correlate with field-infrastructure coordination rather than simple brain size or neural number.

Intervention studies using electromagnetic stimulation could test whether restoring normal field patterns can improve consciousness in various disorders. These studies could provide both therapeutic benefits and fundamental insights into consciousness mechanisms.

7. Educational Implications

7.1. Rethinking Neuroscience Education

The recognition that consciousness emerges from electromagnetic field dynamics rather than neural computations requires fundamental changes in neuroscience education. Current curricula focus heavily on neural circuits, synaptic transmission, and computational models while largely ignoring electromagnetic phenomena.

Future neuroscience education must integrate field physics with neural biology from the beginning. Students need to understand electromagnetic principles alongside traditional neuroscience concepts to appreciate how consciousness actually works. This represents a paradigm shift comparable to introducing quantum mechanics into physics education.

The coevolutionary framework adds another layer of complexity by revealing consciousness as an architectural solution that evolution discovered. Students must understand both the electromagnetic principles that enable consciousness and the evolutionary constraints that shaped the field-infrastructure systems we observe.

Laboratory experiences must incorporate electromagnetic measurements alongside traditional neural recording techniques. Students need hands-on experience with field dynamics to appreciate their role in consciousness, rather than learning about electromagnetic effects as peripheral phenomena.

7.2. Conceptual Frameworks for Gooey Thinking

Teaching consciousness as electromagnetic field phenomenon requires new conceptual frameworks that help students think about continuous dynamics rather than discrete computations. Traditional neuroscience education emphasizes prickly thinking that may actually impede understanding of consciousness.

Students need conceptual tools for understanding wave dynamics, field interactions, and superposition effects. These concepts are familiar from physics but rarely emphasized in neuroscience contexts. Bridging this gap requires careful attention to how physical principles apply to biological systems.

The field-infrastructure coevolution concept requires integrating evolutionary thinking with electromagnetic physics. Students must understand how natural selection shaped electromagnetic phenomena while being constrained by physical principles. This integration challenges traditional boundaries between disciplines.

Practical exercises that demonstrate field effects can help students develop intuitions about electromagnetic consciousness. Simple experiments with magnetic fields, electromagnetic induction, and wave interference can provide concrete experience with the principles that operate in consciousness.

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7.3. Research Methods Training

Training in new research methods becomes crucial for studying consciousness as field-infrastructure dynamics. Students need skills in electromagnetic measurement, field analysis, and multi-scale modeling that are not typically emphasized in traditional neuroscience programs.

Computational modeling skills must expand beyond traditional neural network approaches to include electromagnetic field simulations. Students need to understand how to model field dynamics, field-infrastructure interactions, and multi-scale electromagnetic phenomena.

Experimental design skills must incorporate electromagnetic considerations from the beginning. Students need to understand how to control electromagnetic variables, measure field effects, and interpret results in terms of field dynamics rather than traditional neural mechanisms.

Data analysis skills must expand to include field analysis techniques from physics and engineering. Traditional neuroscience data analysis focuses on spike trains and oscillatory patterns while ignoring the broader electromagnetic context that consciousness requires.

8. Cultural and Philosophical Implications

8.1. The Philosophical Revolution

The recognition that consciousness emerges from electromagnetic field dynamics has profound implications that extend beyond neuroscience to fundamental questions about the nature of mind and reality. This represents more than a technical advance—it constitutes a philosophical revolution in how we understand consciousness and our place in the universe.

The shift from computational to electromagnetic theories of consciousness aligns with broader movements in philosophy toward process theories and embodied cognition. Rather than treating consciousness as information processing performed by neural computers, consciousness emerges from dynamic field patterns that exist as continuous processes rather than discrete computational events.

This perspective challenges traditional philosophical distinctions between mind and matter by revealing consciousness as electromagnetic phenomena operating according to physical principles. Consciousness becomes a natural phenomenon that emerges from the electromagnetic properties of organized matter rather than a mysterious non-physical property that somehow emerges from brain activity.

The coevolutionary framework adds an evolutionary dimension to these philosophical insights. Consciousness is not just an electromagnetic phenomenon but an architectural solution that evolution discovered through the coevolution of field dynamics and supporting infrastructure. This reveals consciousness as both natural and designed—natural because it operates according to physical principles, designed because it reflects evolutionary optimization.

8.2. Technology Development Implications

Understanding consciousness as electromagnetic field phenomenon may influence the development of artificial intelligence and brain-computer interfaces. If consciousness requires field dynamics rather than computational processing, then artificial general intelligence may require hardware architectures capable of generating and coordinating electromagnetic fields at biological scales.

Current approaches to artificial intelligence rely on digital computation that operates through fundamentally different principles than biological consciousness. The recognition that consciousness depends on field dynamics suggests fundamental limitations in digital approaches that cannot be overcome through incremental improvements in computational power.

Brain-computer interfaces may need to incorporate electromagnetic field considerations rather than focusing solely on neural spike patterns. Interfaces that can measure and manipulate field dynamics may prove more effective for treating consciousness disorders and enhancing cognitive capabilities.

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The coevolutionary framework suggests that effective brain-computer interfaces must respect the field-infrastructure architecture that evolution discovered. Interfaces that disrupt field integration or ignore the role of myelinated infrastructure may produce unintended consequences or fail to achieve their intended effects.

8.3. Medical Practice Implications

Understanding consciousness as electromagnetic field phenomenon may influence medical approaches to consciousness disorders and cognitive enhancement. Rather than focusing solely on neurotransmitter manipulation or anatomical interventions, treatments could target field dynamics directly.

Electromagnetic therapies such as transcranial magnetic stimulation and deep brain stimulation gain new theoretical foundations from field theories of consciousness. These treatments may work by restoring normal field patterns rather than simply stimulating neural activity, suggesting new approaches to optimizing their effectiveness.

Pharmacological interventions may need reinterpretation in terms of field effects rather than traditional neurotransmitter mechanisms. Drugs that affect consciousness may work primarily by altering field characteristics or field-infrastructure coordination, suggesting new approaches to drug development.

The coevolutionary framework emphasizes the importance of developmental timing in consciousness disorders. Interventions during critical periods of myelination may prove more effective than treatments applied after field-infrastructure coordination has stabilized.

8.4. Scientific Worldview Transformation

The shift from computational to electromagnetic theories of consciousness represents a fundamental change in scientific worldview comparable to the transition from classical to quantum physics. This transformation affects not just consciousness research but broader scientific understanding of biological phenomena.

The recognition that electromagnetic phenomena play primary rather than peripheral roles in biological systems challenges traditional boundaries between physics and biology. Living systems may be fundamentally electromagnetic rather than simply mechanical or chemical, requiring new theoretical frameworks that integrate electromagnetic principles with biological organization.

The coevolutionary framework reveals evolution as an electromagnetic architect that discovered sophisticated field-infrastructure solutions to information processing challenges. This perspective may influence understanding of evolution itself, revealing natural selection as an optimization process that operates on electromagnetic as well as mechanical principles.

The implications extend to understanding other biological phenomena that may involve field effects. Embryonic development, immune system function, and ecosystem organization may all involve electromagnetic field dynamics that have been overlooked by traditional biological approaches.

9. Conclusions: The Gooey Revolution

9.1. How Coevolved Goo Solves What Prickles Cannot

The solution to each aspect of the binding problem follows naturally from the gooey properties of electromagnetic fields operating within coevolved myelinated infrastructure, revealing why prickly approaches have failed for decades while the gooey solution was always present in the electromagnetic dynamics of consciousness.

Spatial binding dissolves when we recognize that electromagnetic field waves naturally create unified information spaces across brain regions through volumetric integration. Rather than requiring anatomical convergence zones where separated processing streams meet, overlapping field patterns create continuous integration that preserves spatial relationships while enabling flexible

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coordination. The coevolutionary architecture enhances this natural solution through strategic myelination that provides rapid inter-regional communication without disrupting the field medium necessary for integration.

Temporal binding becomes trivial when electromagnetic field propagation at 47-57 km/s provides the temporal headroom necessary for consciousness, while myelinated infrastructure coordinates timing across regions. Rather than struggling to overcome synaptic delays through complex timing mechanisms, gooey field-based coordination achieves near-instantaneous integration across the brain's volume. The coevolutionary solution enables this through progressive myelination timing that aligns with cognitive development, creating field computation capabilities that mature in coordination with consciousness.

Feature binding emerges naturally from the superposition properties of electromagnetic fields operating within specialized but integrated field architecture. Rather than requiring special mechanisms to combine separately processed features, electromagnetic field patterns simultaneously represent multiple features through overlapping wave patterns that interact through resonance and interference. The coevolutionary framework reveals how different brain regions evolved specialized field characteristics for different features while maintaining integration through shared electromagnetic dynamics.

Cross-modal binding occurs automatically through field patterns that naturally span multiple sensory modalities within the unified field architecture. Rather than requiring complex convergence mechanisms, field patterns enable direct interaction between different sensory systems while specialized myelination patterns optimize each system's processing characteristics. The coevolutionary solution creates sensory specialization within unified field integration.

The elegant solution reveals that a single gooey mechanism—electromagnetic field resonance operating within coevolved myelinated infrastructure—solves all aspects of the binding problem that have remained intractable for prickly approaches. This parsimony suggests that we have identified a fundamental rather than ad hoc solution that evolution discovered through the coevolution of field dynamics and supporting architecture.

9.2. The Philosophical Implications: Consciousness as Coevolved Goo

The solution to the binding problem carries profound implications that extend beyond neuroscience to fundamental questions about the nature of mind and reality, amplified by understanding consciousness as an architectural solution that evolution discovered through field-infrastructure coevolution.

For neuroscience, the shift from prickly spike-counting to gooey field dynamics represents a paradigm change comparable to the shift from Newtonian to quantum physics. Rather than focusing on discrete neural events, neuroscience must embrace the continuous electromagnetic field dynamics that provide the natural substrate for consciousness operating within coevolved myelinated infrastructure.

For consciousness studies, understanding binding as fundamental reveals that consciousness itself is irreducibly gooey but architecturally sophisticated. The binding problem was intractable for prickly approaches because consciousness cannot be decomposed into discrete components—it exists as an integrated field phenomenon operating within infrastructure that evolution designed to maintain unity while enabling specialized processing.

For artificial intelligence, the recognition that binding requires field-like mechanisms operating within sophisticated infrastructure suggests that consciousness cannot be achieved through purely computational approaches. AI systems that aspire to consciousness must incorporate gooey field-like architectures that enable the flexible, context-sensitive integration that consciousness exhibits, potentially requiring electromagnetic hardware rather than digital computation.

For evolutionary biology, the coevolutionary framework reveals consciousness as an architectural solution that evolution discovered through the coordinated development of electromagnetic field dynamics and myelinated infrastructure. This represents evolution as an

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electromagnetic architect that solved the fundamental challenge of creating unified experience within metabolic and architectural constraints.

9.3. The Electromagnetic Nature of Being

The recognition that consciousness emerges from electromagnetic field dynamics operating within coevolved myelinated infrastructure has profound implications for understanding the nature of human experience and our place in the universe, revealing consciousness as both natural phenomenon and evolutionary achievement.

We are field phenomena operating within sophisticated infrastructure that evolution designed. Rather than being discrete computational entities, we are continuous electromagnetic field phenomena existing as patterns in the brain's neural medium, shaped by coevolved myelinated architecture that enables both unity and specialization. Our consciousness exists as patterns in electromagnetic fields rather than as computations performed by neural networks.

Unity through coevolved goo reflects the deep integration of field dynamics and supporting infrastructure that evolution discovered. The goo that binds us is not separate from us—it is us, existing as unified field patterns that naturally integrate information across space and time without requiring artificial binding mechanisms. The myelinated infrastructure that shapes our field characteristics represents evolution's solution to the consciousness engineering problem.

Continuous existence emerges from the wave-like properties of electromagnetic fields operating within stable infrastructure. Our consciousness is not assembled from discrete moments but exists as continuous field dynamics that flow seamlessly through time, supported by coevolved architecture that maintains both stability and flexibility.

Electromagnetic continuity connects us to the fields that permeate the universe while maintaining our individuality through the specialized infrastructure that shapes our field characteristics. We exist as local patterns in the universal electromagnetic field, individuated by the unique myelinated architecture that evolution gave us.

9.4. Alan Watts' Ultimate Vindication Through Evolution

Alan Watts' ultimate vindication comes through recognizing that consciousness science has been pursuing prickly illusions while the gooey truth was always present in the electromagnetic dynamics of the brain, amplified by evolution's discovery of sophisticated field-infrastructure coordination.

Physics vindication extends beyond the original observation that reality consists of waves rather than particles to include the recognition that evolution discovered sophisticated wave-based solutions to information processing challenges. Just as physics revealed the universe's fundamental constituents as electromagnetic phenomena, neuroscience is discovering that consciousness emerges from continuous field dynamics coordinated by evolved infrastructure.

Consciousness vindication demonstrates that the binding problem was intractable for prickly approaches because consciousness cannot be decomposed into discrete components—it exists as an integrated field phenomenon shaped by coevolved architecture that maintains unity while enabling specialization. The gooey solution was always present in the electromagnetic dynamics that neuroscience treated as epiphenomenal noise.

Evolutionary vindication reveals that natural selection discovered the gooey solution through the coevolution of electromagnetic field dynamics and myelinated infrastructure. Evolution faced the same binding problem that puzzles neuroscientists and solved it through architectural innovation that creates unified experience within metabolic and physical constraints.

Methodological vindication shows that the productive vagueness that prickly approaches rejected as unscientific turns out to be essential for understanding consciousness as it actually presents itself—continuous, unified, and irreducibly gooey, operating within sophisticated infrastructure that evolution designed.

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9.5. The Binding Problem Dissolved Through Coevolution

The binding problem, which seemed to represent an insurmountable challenge for understanding consciousness, dissolves when we embrace the gooey reality of our electromagnetic nature shaped by coevolved myelinated infrastructure. We are bound together not by computational algorithms or anatomical circuits, but by the continuous field dynamics that constitute our deepest nature, operating within architecture that evolution designed for unity.

The problem was never how to bind together separate conscious components—consciousness was never separate to begin with. The binding problem was an artifact of prickly thinking that artificially fragmented what evolution designed to be unified. When we recognize consciousness as electromagnetic field phenomenon operating within coevolved infrastructure, binding becomes unnecessary because separation was always an illusion created by inappropriate theoretical assumptions.

The goo that binds us reveals itself to be the very medium of consciousness itself, shaped by sophisticated infrastructure that evolution discovered. We do not have consciousness—we are consciousness, existing as electromagnetic field patterns in the brain's neural medium, individuated by coevolved myelinated architecture that enables both unity and specialization. The binding problem dissolves when we realize that we were never unbound to begin with.

The coevolutionary framework completes the picture by revealing consciousness as both natural phenomenon and evolutionary achievement. Consciousness operates according to electromagnetic principles that govern all of nature, but it exists within sophisticated infrastructure that evolution designed to harness field dynamics for unified experience. We are natural electromagnetic phenomena operating within evolutionary architecture.

In the end, Alan Watts was right about consciousness just as he was right about physics: in both domains, reality is fundamentally gooey rather than prickly. The electromagnetic fields that fill space and permeate our brains are not mere byproducts but the very fabric of consciousness itself, shaped by coevolved infrastructure that evolution discovered. We are bound together by the goo that is us, unified by the electromagnetic field dynamics operating within myelinated architecture that constitutes our deepest nature. The binding problem dissolves in the recognition that consciousness was always unified—we just needed to understand the coevolutionary architecture that makes this unity possible.

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