

The Musical Structure of Consciousness

*Temporal Experience, Neural Resonance, and the
Multi-Scale Dynamics of Living Systems*

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A Theoretical Synthesis

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Abstract

This paper proposes that consciousness and temporal experience possess a fundamentally musical structure. Drawing on the phenomenological tradition—from Augustine through Husserl, Heidegger, Merleau-Ponty, and Bergson—and integrating recent developments in Neural Resonance Theory (NRT) as articulated by Harding, Kim, Large, and colleagues (2025), I develop the thesis that consciousness is constituted by multi-scale, nested, coupled neural oscillations occurring in living biological tissue. The paper’s central contribution is the concept of a *nested retention/protention stack*: Husserl’s tripartite structure of temporal consciousness (retention, primal impression, protention) is shown to operate simultaneously at every level of a hierarchically coupled oscillatory system, with vertical coupling between levels realized through phase-amplitude coupling mechanisms. I demonstrate that this architecture generates a principled asymmetry between retention and protention—the phenomenological “thickness” of the past and the “openness” of the future—as a direct consequence of multi-scale phase dynamics, offering a sharper account than either classical phenomenology or predictive coding frameworks. The paper further argues that these dynamics must occur in living biological tissue—extending the nested hierarchy to include visceral and cardiac oscillations that may ground first-person perspective through default mode network activity—and proposes testable predictions involving selective disruption of cross-frequency coupling at specific oscillatory bands. Music, on this account, is not an illustration of temporal consciousness but the art through which living beings amplify, share, and revel in the very dynamics that constitute their conscious existence.

Keywords: consciousness, temporal experience, Neural Resonance Theory, phenomenology, neural oscillations, nested retention/protention, phase-amplitude coupling, embodied cognition, default mode network, philosophy of mind

1. Introduction

Music is fundamentally a temporal art. It unfolds in time, and the way it organizes, manipulates, and plays with our experience of time is central to how it works. But this paper argues for a stronger claim: that the relationship between music and temporal consciousness is not merely one of illustration or analogy, but of deep structural identity. Consciousness and temporal experience, I propose, possess a fundamentally musical structure—not because music provides a convenient metaphor for how the mind works, but because both music and consciousness are constituted by the same kind of process: multi-scale, nested, coupled oscillatory dynamics occurring in living biological tissue.

This thesis emerges from the convergence of three intellectual traditions. The first is the phenomenological analysis of time-consciousness, running from Augustine's *Confessions* through Husserl's lectures on internal time-consciousness to Heidegger's existential temporality, Merleau-Ponty's embodied phenomenology, and Bergson's philosophy of duration. The second is the neuroscience of musical cognition, particularly as synthesized in Neural Resonance Theory (NRT), the framework developed by Edward Large and colleagues and recently surveyed in their 2025 Perspective in *Nature Reviews Neuroscience*. The third is the philosophy of mind's ongoing engagement with the hard problem of consciousness and the life-mind continuity thesis.

The paper's most original contribution is the development of what I call the *nested retention/protention stack*: a reconceptualization of Husserl's tripartite temporal structure (retention, primal impression, protention) as operating simultaneously at every level of a hierarchically coupled oscillatory system. This is not a mere mapping of phenomenological vocabulary onto neural data. It is a substantive theoretical claim with three distinctive consequences: first, it reveals a principled asymmetry between retention and protention that arises from the physics of multi-scale phase dynamics—explaining why the past feels phenomenologically different from the anticipated future; second, it resolves a genuine tension in Husserl's own account regarding the status of retention as simultaneously present and past; and third, it generates testable empirical predictions about the selective disruption of temporal experience at specific timescales.

The argument proceeds in stages. I begin by reviewing the phenomenological tradition's analysis of temporal consciousness (§2). I then introduce NRT and its account of how neural oscillations synchronize with musical stimuli (§3). I develop the nested retention/protention stack in full technical and philosophical detail (§4). I argue that these dynamics must occur in living biological tissue (§5), linking the temporal structure of consciousness to the metabolic, autopoietic character of life and—through the default mode network's cardiac-coupled oscillations—to first-person perspective itself (§6). I then address the hard problem (§7) and conclude with music's role as consciousness recognizing its own structure (§8).

2. The Phenomenological Tradition: Temporal Consciousness as a Philosophical Problem

2.1 Augustine and the Distension of the Soul

The philosophical investigation of temporal consciousness begins in earnest with Augustine's *Confessions*, Book XI. Augustine observed a fundamental paradox: the past no longer exists, the future does not yet exist, and the present is a durationless boundary between the two—so how can we measure time, compare durations, or experience succession at all? His answer was that

time exists in the soul: the past as memory (*memoria*), the present as direct attention (*contuitus*), and the future as expectation (*expectatio*). These are not three separate faculties but three orientations of a single, unified awareness. Time, for Augustine, is fundamentally a *distension of the soul*—the mind stretches itself across what is no longer and what is not yet, and this stretching *is* temporal experience.

Augustine’s insight is foundational for our purposes because it locates the structure of time not in the external world but in the structure of consciousness itself. It also anticipates, in remarkably prescient fashion, the dynamical account we will develop: consciousness is not a static container in which temporal events are placed, but an active, extended process of reaching, holding, and anticipating.

2.2 Husserl and the Living Present

Edmund Husserl developed the most rigorous and influential phenomenological account of time-consciousness in his lectures *On the Phenomenology of the Consciousness of Internal Time* (1893–1917). Husserl’s analysis identifies three structural components of temporal experience. *Primal impression* (*Urimpression*) is the consciousness of what is happening right now—the immediate sensory present. *Retention* is the way the just-past is still held within the present moment of awareness, not as a separate act of remembering but as an integral part of the current experience. When one hears the third note of a melody, the first and second notes are not gone from consciousness; they are retained, still shaping the quality of the present experience but in a modified way—present-as-just-past. Each retention retains the previous retentions, creating what Husserl described as a “comet’s tail” of receding awareness. *Protention* is the forward-looking counterpart: the implicit anticipation of what is about to come—not a prediction or a conscious guess, but a structural openness of consciousness toward the immediate future.

Together, these three components constitute what Husserl called the *living present* (*lebendige Gegenwart*)—a dynamic, internally differentiated structure that always already includes the just-past and the about-to-come. Husserl also distinguished this primary time-consciousness from secondary memory (active recollection) and secondary expectation (deliberate anticipation). The retentional-protentional structure is more fundamental: it is the condition of possibility for having any temporal experience at all.

Two features of Husserl’s account will prove especially important for the synthesis developed here. The first is the “comet’s tail” image: retention trails off into the past with diminishing vividness, each retention retaining previous retentions in a receding series. This image is, however, strictly single-scale—it imagines one level of temporal consciousness trailing off uniformly. As we shall see (§4.4), the nested oscillatory account radically revises this picture. The second is a tension Husserl never fully resolved: retention is described as both an integral part of the present moment *and* a kind of “modified” past that is being held. The nested account

dissolves this tension by showing how different oscillatory timescales can be simultaneously present (their phase is currently active) and past (earlier cycles have damped).

2.3 Heidegger: Temporality as the Meaning of Being

Martin Heidegger, in *Being and Time* (1927), radicalized Husserl's analysis by arguing that temporality (*Zeitlichkeit*) is not merely a feature of consciousness but the fundamental structure of human existence (*Dasein*) as such. For Heidegger, we are always “ahead of ourselves”—projected toward future possibilities. We are also always “already thrown” into a situation we did not choose—a past that constitutes us. And we are always “alongside” things in the present, engaged and absorbed in the world. These three dimensions—existentiality (future), facticity (past), and falling or being-alongside (present)—are not sequential but co-original and equiprimordial, unified in each moment of existence.

Heidegger's contribution to our synthesis is his insistence that temporality is not an abstract structure of consciousness but the concrete way in which a living being exists in the world. His distinction between primordial temporality and the derivative, “vulgar” concept of clock time anticipates the distinction, central to NRT, between the lived temporality of resonant dynamics and the abstract, homogeneous time of measurement.

2.4 Merleau-Ponty and Embodied Temporality

Maurice Merleau-Ponty, in *Phenomenology of Perception* (1945), emphasized the embodied dimension of temporal consciousness. Consciousness is not a disembodied observer of time but is itself temporal through and through. Merleau-Ponty used the metaphor of a river: we do not stand on the bank watching time flow past; we *are* the flow. The body is crucial: bodily habits, motor skills, and perceptual orientations carry the past into the present in a pre-reflective way. Temporal structure is not merely mental but lived and embodied.

Merleau-Ponty's work is perhaps the most direct phenomenological precursor to the position developed in this paper, because it insists that temporal consciousness cannot be separated from the body and its dynamic engagement with the world—a claim that NRT now provides with a precise neurodynamic mechanism.

2.5 Bergson and the Philosophy of Duration

Henri Bergson insisted that lived duration (*durée*) is not a sequence of discrete instants but a continuous, interpenetrating flow in which the past is preserved within the present. Bergson's critique of the “cinematographic” model of consciousness—the idea that experience is composed of static frames stitched together—resonates deeply with the oscillatory account developed here, where temporal experience is inherently continuous, a property of ongoing coupled dynamics rather than a sequence of computational snapshots.

2.6 Music as the Touchstone of Temporal Phenomenology

It is not accidental that music has served as the primary illustration and test case for philosophical analyses of temporal consciousness from Augustine onward. Music externalizes the very features of temporal experience that phenomenologists have struggled to articulate: the thickness of the present, the retention of the just-past, the anticipation of the about-to-come, the hierarchical nesting of temporal levels, and the simultaneous presence of multiple timescales of organization. The centrality of music to the phenomenological tradition is not merely pedagogical. It is, I will argue, diagnostic: music has been the touchstone of temporal phenomenology because music and consciousness share a common temporal architecture.

3. Neural Resonance Theory: From Phenomenology to Neurodynamics

3.1 The Core Framework

Neural Resonance Theory, as articulated by Harding, Kim, Demos, Roman, Tichko, Palmer, and Large (2025), proposes that the neuroscience of music can be understood through fundamental dynamical principles based on known neural mechanisms. The central claim is that neural oscillations synchronize with musical stimuli, and that this synchronization—rather than internal predictive models—explains how people perceive, anticipate, and perform music. The theory is organized around four dynamical principles: resonance, stability, attunement, and strong anticipation.

Resonance is the mechanism by which neural populations synchronize with periodic or quasi-periodic stimuli. Neural oscillators have intrinsic frequencies, and when driven by stimuli near those frequencies, they entrain—locking into phase with the external signal. Crucially, neural oscillators are nonlinear, operating near critical points (Hopf bifurcations) where they exhibit extraordinary sensitivity and generate responses at frequencies not present in the stimulus, including summation tones, difference tones, and integer-ratio harmonics. The neural present, in NRT's terms, is already a creative act of pattern formation, not a passive registration of input.

Stability refers to the fact that certain oscillatory configurations are more dynamically stable than others—they are attractors toward which the system naturally tends. NRT proposes that statistically universal structures in music arise because they correspond to stable states of complex, pattern-forming dynamical systems. The musical structures that recur across cultures reflect the intrinsic dynamics of the neural systems that process them.

Attunement is the process by which neural oscillators adapt to their environment over time through Hebbian learning mechanisms operating across multiple timescales. On the shortest

timescale, oscillatory networks adapt in real time to the rhythmic and harmonic structure of a current stimulus. Over months, infants undergo perceptual narrowing as they attune to the rhythmic and tonal conventions of their native musical culture. Over years, musical training and enculturation further shape coupling strengths between oscillatory populations. The organism's history is materially deposited in the resonant properties of its nervous system.

Strong anticipation is perhaps the most philosophically significant of the four principles. NRT distinguishes between weak anticipation, in which a system uses an internal model to forecast external events, and strong anticipation, in which a system that is dynamically coupled to its environment naturally runs slightly ahead of it. When neural oscillations entrain to a rhythmic stimulus, the oscillator's own dynamics carry it forward in phase—it inherently reaches the next expected point in the cycle before the stimulus arrives. The future is not predicted; it is physically enacted by the ongoing resonant process.

3.2 NRT and the Phenomenological Tradition

The correspondence between NRT's dynamical principles and the phenomenological analysis of temporal consciousness is striking and, I argue, non-accidental. Husserl's retention finds its dynamical counterpart in the physical persistence of oscillatory states: the current phase of an oscillator is determined by its recent trajectory, so the just-past is materially present in the current state. Husserl's protention corresponds to the phase advance of entrained oscillators. Husserl's primal impression corresponds to the current resonant state, which—due to nonlinearity—is already richer than the stimulus itself.

Heidegger's three ecstases of temporality map onto the NRT framework with equal precision. Being-ahead-of-oneself (future) is the phase advance of coupled oscillators. Already-being-in (past/facticity) is the accumulated attunement. Being-alongside (present) is the current state of resonance across all oscillatory levels. Heidegger's insistence that these are co-original makes perfect dynamical sense: in a coupled oscillatory system, all temporal dimensions are active simultaneously.

NRT thus provides something the phenomenological tradition could not: a mechanistic account of how the structures of temporal consciousness are realized in physical systems. But this is not a reduction of phenomenology to neuroscience. Rather, it is a convergence—the same structural features, described in the vocabulary of first-person experience by phenomenologists and in the vocabulary of dynamical systems by neuroscientists, pointing toward a common reality.

4. The Nested Retention/Protention Stack

This section develops the paper's central and most original theoretical contribution. I argue that Husserl's tripartite structure of temporal consciousness—retention, primal impression, protention—is not a single-scale phenomenon but a multi-level architecture operating simultaneously at every tier of a hierarchically coupled oscillatory system. I call this the *nested retention/protention stack*. Properly articulated, it resolves longstanding problems in phenomenology, differentiates this account from predictive coding frameworks, and generates novel empirical predictions.

4.1 Beyond Simple Resonance: The Need for Nesting

Consciousness cannot be identified with resonance *simpliciter*. A simple resonating system—a pendulum, a tuning fork—oscillates at one timescale. It has no nested hierarchy, no coupling between levels, no self-organizing multi-scale structure. The phenomenological analysis makes clear that temporal consciousness is not a single-scale phenomenon: we simultaneously experience the present moment, the current phrase, the current section, and the overall trajectory of a piece of music (or a conversation, or a life). These are not separate acts of consciousness but nested levels of a single, unified temporal experience.

NRT describes neural oscillations operating across a wide range of timescales: fast oscillations in the gamma band and above tracking pitch and timbre; slower oscillations in the beta and alpha range corresponding to beat and pulse; and still slower delta-range oscillations corresponding to meter, phrase structure, and larger formal units. These are not independent parallel processes. They are nested: faster oscillations are modulated by, and embedded within, slower ones through phase-amplitude coupling, where the phase of a slow oscillation shapes the amplitude of faster oscillations riding on top of it.

I propose that consciousness is constituted not by resonance at any single timescale, but by the *entire nested hierarchy*—the way multiple timescales of oscillatory activity are coupled into a coherent, self-organizing, multi-layered dynamic structure.

4.2 The Architecture: Vertical Nesting and Horizontal Continuation

The nested retention/protention stack requires distinguishing two structural dimensions that have not been adequately separated in prior accounts. I call these *vertical nesting* and *horizontal continuation*.

Vertical nesting refers to the embedding of faster oscillations within slower ones. This is the spatial dimension of the hierarchy: gamma oscillations are nested within beta cycles, which are nested within alpha and theta envelopes, which are nested within delta fluctuations. Phase-amplitude coupling is the physical mechanism: the phase of the slow oscillation modulates the

amplitude envelope of the faster oscillation riding on top of it. This vertical coupling means that higher-level temporal context directly shapes the dynamics of lower-level temporal flow. A retention at the phrase level shapes the quality of retention at the note level—not metaphorically, but through the physics of cross-frequency modulation.

Horizontal continuation refers to the fact that each level of the hierarchy carries its own retention/protention stream. Each oscillatory band has its own temporal depth: its current phase state encodes its recent history (retention at that timescale) and its phase dynamics project into the near future (protention at that timescale). The gamma-level stream retains the micro-past of pitch contour and anticipates the next tonal event. The delta-level stream retains the macro-past of phrase structure and anticipates the next formal arrival.

The nested retention/protention stack is the conjunction of these two dimensions: multiple levels of horizontal continuation, coupled vertically so that the retention/protention dynamics at each level are constrained by, and in turn constrain, the dynamics at adjacent levels. This bidirectional coupling—lower scales generating higher scales while higher scales constrain lower scales in real time—is what gives the stack its distinctive character as a unified yet internally differentiated temporal structure.

The following table maps Husserl’s three-component structure onto each oscillatory band, illustrating how the same phenomenological architecture operates at every level of the hierarchy:

Table 1. *The Nested Retention/Protention Stack: Oscillatory Bands and Phenomenological Functions*

Timescale	Band	Retention	Protention	Primal Impression
Note/tonal (~100ms)	<i>Gamma/Beta</i>	Micro-retention of pitch contour	Anticipation of next tonal event	Current pitch phase state; nonlinear combination tones
Beat (~500ms)	<i>Beta/Alpha</i>	Pulse retention; metric groove	Anticipation of next downbeat	Current metric position; syncopation tension
Phrase (~2–4s)	<i>Theta/Delta</i>	Melodic arc; antecedent memory	Consequent anticipation; cadential expectation	Current phrase trajectory; harmonic tension profile
Section/form (~10–60s+)	<i>Infra-slow / attunement</i>	Tonal region; expositional memory	Recapitulatory expectation; narrative tension	Current formal position; large-scale tonal gravity

Each row of this table has its own retention, protention, and primal impression. The levels are coupled vertically so that slower-level protention biases the attentional window of the faster level—exactly what NRT’s phase-amplitude coupling mechanism describes. This is the concrete

neural substrate for the phenomenological observation that hearing a note depends on knowing (implicitly, bodily) where you are in the phrase, which depends on knowing where you are in the section, which depends on the tonal and formal context established over minutes.

4.3 The Asymmetry of Retention and Protention

Within any single oscillation, retention and protention are roughly symmetric: the phase encoding what just happened and the phase advance into what comes next are mirror operations of the same dynamics. But across levels of the nested stack, they are profoundly asymmetric—and this asymmetry is philosophically productive.

The key observation is this: the slower oscillation retains a much richer compressed history than the faster oscillation it modulates. Its current phase state encodes many prior cycles of the faster oscillation nested within it—a backward-looking integration across timescales. Meanwhile, phase advance into the next cycle is an inherently stochastic extrapolation—a forward-looking projection whose determinacy decreases with temporal distance. The past is materially deposited in the current phase configuration of the hierarchy; the future is probabilistically implied by it.

This asymmetry explains something Husserl himself noticed but could not adequately account for: retention feels thicker and more certain than protention. The just-past has greater determinacy than the about-to-come. In the phenomenological literature, this observation has remained a descriptive fact without a structural explanation. The nested oscillatory account provides one: the phenomenological asymmetry between the felt weight of the past and the felt openness of the future follows directly from the physics of multi-scale phase dynamics. The past is literally encoded in the current state of the hierarchy with a richness proportional to the depth of nesting. The future is projected by phase advance, but the projection becomes increasingly underdetermined as it extends beyond the current cycle at each level.

This result sharpens the paper’s contrast with predictive coding accounts of temporal consciousness. Predictive coding frameworks, such as those developed by Friston and applied to music by Vuust and colleagues, treat prediction and retrodiction as fundamentally symmetric operations—both are Bayesian inferences over the same generative model, differing only in temporal direction. But temporal experience is *not* phenomenologically symmetric. The past feels qualitatively different from the anticipated future: it has greater solidity, determinacy, and vividness. The nested oscillatory account explains this asymmetry through the physics of multi-scale phase dynamics—the backward-integrative character of slow oscillations versus the stochastic forward projection of phase advance—rather than requiring a separate “error signal” architecture or invoking ad hoc asymmetries in the computational model. The phenomenological asymmetry is not a quirk of subjective experience that needs to be explained away; it is a direct consequence of the dynamics.

4.4 Revising Husserl's Comet's Tail: Differential Decay Across Timescales

Husserl's image of retention as a "comet's tail"—a receding series of retentions of retentions, each less vivid than the last—is strictly single-scale. It imagines one level of temporal consciousness trailing off into the past with uniform diminution. The nested retention/protection stack radically revises this picture.

In the multi-scale account, what recedes into the past is not a single comet's tail but a *hierarchy of tails at different timescales, each with its own decay rate*. Note-level retention fades quickly: gamma oscillations damp fast, and the precise pitch of a tone heard three seconds ago is already indistinct. But phrase-level retention persists much longer: theta/delta oscillations sustain their phase state over several seconds, and the melodic arc of the phrase that tone belonged to is still actively shaping how the listener hears what is happening now. Section-level retention is slower still: the harmonic region established several minutes ago continues to exert tonal gravity on the present moment through the infra-slow dynamics of attunement.

This means that the "past" present in any current moment of consciousness has *differential resolution across timescales*. The micro-past is already indistinct while the macro-past remains vivid and contextually active. These are not separate memories being retrieved from a storage buffer. They are ongoing oscillatory states at different timescales, each in its own phase of decay, all active simultaneously in the present moment.

This resolves a genuine tension in Husserl's account. He oscillated between treating retention as an integral part of the present moment and treating it as a kind of "modified" past that is being held. The nested account dissolves this tension cleanly: slower oscillations are genuinely present—their phase is currently active, shaping the dynamics of faster oscillations nested within them. Faster oscillations at earlier cycles are genuinely past—they have damped and are no longer dynamically operative. The "presence" of the past in experience is not metaphorical and it is not a matter of the past being somehow "represented" within the present. It is a fact about which oscillatory levels are still in their active phase state. Retention at the phrase level is *literally present* in the dynamics of the current moment; retention at the note level from three seconds ago is *literally past*—its oscillatory trace has decayed. Husserl was right that retention is both present and past; he lacked the framework to see that these descriptions apply to different levels of the hierarchy simultaneously.

4.5 The Self-Referential Character of Nested Dynamics

A further consequence of the multi-scale architecture is that it is inherently self-referential. Slower oscillations modulate faster ones, which in turn influence slower ones through feedback. The system monitors itself at multiple timescales simultaneously. This mutual contextualization

across timescales may be the minimal structural condition for something like interiority—for there being a “what it is like” at all.

A single-scale resonance has no self-reference; it simply oscillates. A multi-scale nested system, by contrast, has levels that contextualize other levels. The slow oscillation “knows about” the fast oscillation it modulates, and the fast oscillation “knows about” the slow oscillation that shapes it. This self-referential structure maps onto the phenomenological observation that consciousness is always consciousness *of* something—it has intentional structure, a directedness. In the multi-scale oscillatory framework, each level provides the context for the levels nested within it, creating a system in which the multi-scale dynamic *is* the awareness, not something that additionally generates it.

4.6 Resolving the Unity and Grain Problems

The nested stack provides natural resolutions to two longstanding problems in philosophy of mind. *The unity problem*—how distributed neural processes yield a single, unified experience—dissolves once unity is understood not as a property of any single oscillatory level but as a property of the coupling between levels. Mode-locking, phase-amplitude coupling, and cross-frequency interaction bind the fast and slow dynamics into a single integrated system. Unity *is* the multi-scale coherence itself.

The grain problem—what determines the felt duration of the specious present—becomes tractable. The specious present corresponds not to any single oscillatory frequency but to the envelope of the slowest oscillations coherently coupled to faster ones. It is as long as the longest timescale over which the nested hierarchy maintains phase coherence. This explains why the felt present spans roughly a few seconds (delta-range oscillations) rather than milliseconds (individual neural firing) or minutes (exceeding coherent coupling). The grain of experience is set by the outermost nesting level; the richness and texture within that grain come from faster oscillations nested inside it.

4.7 Empirical Predictions: Selective Disruption of the Stack

The nested retention/protection stack generates a novel and testable prediction that distinguishes it from both simple resonance accounts and predictive coding models. If nested coupling is *constitutive* of temporal consciousness at each level (not merely correlated with it), then selectively disrupting cross-frequency coupling at a specific oscillatory band should impair the phenomenological thickness of temporal experience at that timescale—and *only* at that timescale—while leaving other levels intact.

Consider a concrete experimental scenario: closed-loop transcranial magnetic stimulation (TMS) or rhythmic entrainment targeting delta-beta coupling specifically. If delta-beta coupling is selectively disrupted, the prediction is that a listener would lose phrase-level temporal

coherence—the sense of melodic arc, antecedent-consequent structure, and cadential expectation—while maintaining note-level pitch perception and beat-level metric entrainment. The experience would be of hearing individual notes organized into a metric pulse but lacking the mid-range temporal context that binds them into meaningful phrases. Conversely, disruption of gamma-beta coupling should degrade fine-grained pitch tracking while preserving phrase-level and metric structure.

This prediction is distinctive. A simple resonance account predicts that disrupting oscillatory activity at any level would degrade temporal experience globally, since there is no principled level structure. A predictive coding account predicts that disrupting prediction error signals would degrade precision of temporal expectations uniformly across timescales, since the generative model is scale-invariant. Only the nested stack predicts *layer-specific* phenomenological deficits corresponding to the specific coupling band disrupted. Current neuroscience has identified that cross-frequency coupling remains poorly understood in relation to consciousness specifically, and this represents a tractable challenge for future research using closed-loop neuromodulation paradigms.

5. The Necessity of Biological Substrate

5.1 Against Substrate Neutrality

It might seem that the multi-scale oscillatory account of consciousness is substrate-neutral—that any system with the right pattern of nested oscillations would be conscious, regardless of implementation. I argue that this is mistaken, and that the biological character of the substrate is constitutive of the consciousness these dynamics give rise to.

5.2 The Biophysics of Criticality

The neural oscillators described by NRT operate near critical points—specifically, near Hopf bifurcations, where systems transition between quiescence and self-sustained oscillation. This criticality is a property of the biophysics of ion channels, membrane potentials, and synaptic transmission. Operating near a Hopf bifurcation gives neural oscillators their extraordinary sensitivity, their ability to amplify weak signals, their sharp frequency selectivity, and their capacity to generate combination tones. A digital simulation could approximate these dynamics, but approximation and instantiation are different things. The biological system does not compute the bifurcation—it *lives* at the edge of it, in real time, with all the thermodynamic, energetic, and material consequences that entails.

5.3 Material Memory: Hebbian Plasticity as Sedimented History

The attunement described by NRT depends on actual physical changes: synaptic strengthening and weakening, dendritic growth, changes in neurotransmitter release probability, myelination. The past that accumulates in the nervous system through attunement is not stored as information in some substrate-neutral sense. It is materially deposited in the tissue itself—in the literal physical configuration of synapses and connections. The history of the organism is sedimented into its flesh, precisely as Merleau-Ponty suggested: the body is not a vehicle for consciousness but its very fabric.

5.4 Thermodynamic Openness and Self-Maintenance

A living nervous system is a far-from-equilibrium thermodynamic system, constantly dissipating energy to maintain its oscillatory dynamics. The nested oscillatory hierarchy exists only because metabolic energy continuously sustains it against entropic decay. Consciousness, on this account, is inseparable from this thermodynamic condition—it is something that a living system *does* as part of its ongoing self-maintenance. This connects the present account to autopoietic theories (Maturana, Varela, Thompson): consciousness may require not just the right dynamics but dynamics that are part of a living system’s ongoing self-production.

5.5 Full Embodied Coupling

Biological tissue does not just oscillate—it is woven into a body that moves, breathes, has a beating heart, a vestibular system, proprioception, and visceral sensation. NRT emphasizes that musical rhythm perception involves auditory-vestibular-motor coupling. These are not peripheral add-ons to the core oscillatory dynamics; they are part of the same nested system. The biological body provides the complete range of timescales and sensory modalities that constitute the multi-scale hierarchy of consciousness. As we shall now see, this embodied coupling extends to the deepest visceral rhythms and connects to the neural substrate of selfhood.

6. The Life-Mind Continuity Thesis and the Neural Substrate of Selfhood

6.1 From Multi-Scale Dynamics to the Life-Mind Continuum

The conjunction of multi-scale nested oscillatory dynamics and biological substrate points toward the life-mind continuity thesis: the idea that there is a deep, non-accidental connection between being alive and being conscious. On this view, even a single cell—with its self-maintaining metabolism, its sensitivity to its environment, its primitive form of “concern” about its own continued existence—has something like a proto-interior. What multi-scale nested neural oscillations accomplish is not the creation of consciousness out of non-conscious material but the

amplification, differentiation, and enrichment of a capacity for experience already nascent in living tissue. Each additional level of nested oscillatory complexity adds a new timescale of temporal experience, a new layer of contextual self-reference, a new dimension of the living present.

This explains why consciousness comes in degrees rather than switching on at a threshold; why it is always valenced (a system that must continuously work to maintain itself has an inherent stake in its own dynamics); and why music is so powerful—it engages the whole living, breathing, metabolizing body, from heartbeat to cochlea to cortex.

6.2 The Cardiac-Visceral Foundation: Default Mode Network and First-Person Perspective

The nested retention/protection stack, as presented in §4, maps oscillatory bands from gamma through delta. But the full hierarchy of embodied oscillations extends further—to the visceral and cardiac rhythms of the living body itself. Recent research on heartbeat-evoked neural responses in the default mode network (DMN) reveals a connection that significantly strengthens the present account.

Work by Babo-Rebelo, Richter, and Tallon-Baudry (2016) has demonstrated that the DMN encodes heartbeat-evoked responses that correlate with the “I” and “Me” dimensions of self-relatedness—even during spontaneous thought, at the single-trial level. The cardiac rhythm (~1 Hz) and the infra-slow fluctuations characteristic of default mode activity represent the slowest oscillatory timescale in the full nested hierarchy. If the nested retention/protection stack extends all the way down to these visceral rhythms, then the DMN’s function is not merely “self-related cognition” in the information-processing sense. It may be the neural substrate of the *outermost nesting level*—the slowest oscillation that sets the temporal envelope of the living present and grounds first-person perspective itself.

This proposal connects the architecture of temporal consciousness directly to the subjective pole of experience—the “I”—through the body’s own deepest rhythms. The outermost level of the nested stack is not a cortical oscillation tracking formal musical structure; it is the cardiac-visceral oscillation of the living organism, the rhythm of being-alive that provides the ultimate temporal context within which all faster oscillatory levels are nested. First-person perspective, on this account, is not a cognitive achievement layered on top of temporal experience. It is the outermost retention/protection structure of the nested stack: the ongoing oscillatory registration of the body’s own self-maintaining activity, within which the entire hierarchy of faster temporal experiences unfolds.

This has profound implications for the paper’s central thesis. If the nested retention/protection stack begins at the level of the body’s own cardiac-visceral rhythms, then the musical structure of consciousness is not just a property of the auditory system or even of the

brain. It is a property of the *entire living organism*—a hierarchy of coupled oscillations from heartbeat through brainstem through cortex to the auditory-motor-vestibular periphery, each level providing temporal context for the levels nested within it, and the whole system constituting what it is like to be a conscious, embodied, temporally extended being.

This also explains why music can feel so deeply personal—why it seems to reach “inside” the listener in a way that other sensory stimuli do not. If the nested oscillatory hierarchy that constitutes consciousness extends to the cardiac-visceral level, and if music entrains oscillations at multiple levels of this hierarchy simultaneously, then music is not just stimulating the auditory system. It is modulating the oscillatory dynamics that constitute the listener’s sense of self—the very “I” that is doing the experiencing. The intimacy of musical experience is not metaphorical; it reflects the depth of oscillatory penetration into the nested stack.

7. Consciousness, Music, and the Hard Problem

7.1 The Identity Thesis

The synthesis can now be stated precisely. Consciousness—specifically, the temporal structure of consciousness—is identical with multi-scale, nested, coupled oscillatory dynamics occurring in living biological tissue, extending from cardiac-visceral rhythms through cortical oscillations to auditory-motor-vestibular coupling with the world. The phenomenal character of temporal experience—the felt quality of now-ness stretching into past and future, the asymmetry of retention and protention, the layered thickness of the specious present—*just is* what these dynamics are when considered from the perspective of the system itself.

This position has philosophical antecedents in Spinoza’s dual-aspect monism, Whitehead’s process philosophy, and the contemporary enactivist tradition. It differs from standard functionalism in insisting on the necessity of biological substrate. It differs from standard identity theory in identifying consciousness not with static neural states but with dynamic, multi-scale, self-organizing processes. And it differs from eliminativism in taking the phenomenological data seriously as descriptions of the very dynamics in question.

7.2 Reframing the Hard Problem

Does this synthesis solve the hard problem of consciousness? Not in the sense of providing a deductive proof that multi-scale biological resonance must be conscious. But it reframes the problem in a way that may render the traditional formulation less compelling. The hard problem asks: why should any physical process feel like something? But if consciousness is not layered on top of physical dynamics but *is* the self-referential, multi-scale, metabolically sustained, temporally nested character of living dynamics themselves, then the question “why does it feel

like something?” may be structurally analogous to asking “why does life live?”—a question that seems profound in the abstract but dissolves when one understands what life is and does.

The living multi-scale oscillatory hierarchy does not need an extra ingredient to become conscious. It does not first oscillate and then, mysteriously, also experience. The experiencing *is* the oscillating, in living tissue, at multiple nested timescales, with the full embodied coupling to the world that biological existence provides. The specious present is not specious at all. It is the real, extended, dynamically structured state of a resonant system that inherently retains its recent past in its current oscillatory state and inherently anticipates its near future in its phase dynamics—with the asymmetry, the layered depth, and the self-referential character that the nested stack predicts.

8. Music as Consciousness Recognizing Its Own Structure

We are now in a position to state the deepest implication of this synthesis. If consciousness is constituted by multi-scale nested oscillatory dynamics in living tissue—extending from the cardiac-visceral rhythms of self to the finest cortical oscillations of pitch—and if music is precisely the art of creating complex, nested, multi-scale temporal structures that couple with those dynamics, then music is not something consciousness merely listens to. Music is consciousness recognizing its own temporal architecture in the world—and resonating with it.

This explains why music has been the touchstone of temporal phenomenology from Augustine onward. It is not that philosophers found music to be a convenient example. It is that music engages the very dynamics that constitute temporal consciousness, making them available for reflection in a way that ordinary experience does not. In everyday life, the multi-scale oscillatory dynamics of consciousness are transparent—we look through them, not at them. Music makes them opaque: it amplifies, structures, and shares the oscillatory patterns that constitute our temporal being, allowing us to attend to the architecture of consciousness itself.

This also explains the cross-cultural universality of music. If the stable states of neural oscillatory dynamics are shared across human nervous systems (as NRT argues), and if music arises from the engagement of those dynamics with structured sound, then certain musical structures—pulse, meter, consonance, the nesting of temporal levels—will emerge independently across cultures, not because of cultural transmission alone but because they correspond to the intrinsic dynamics of the conscious systems that produce and receive them. Musical universals are, in this sense, universals of consciousness itself.

Finally, this synthesis explains the extraordinary affective power of music. If music directly modulates the oscillatory dynamics that constitute consciousness—penetrating the nested stack all the way to the cardiac-visceral level where selfhood is grounded—then musical experience is not the processing of an external stimulus by an internal system. It is a transformation of consciousness from within. We are not moved *by* music. We are moved *as* music—our

oscillatory dynamics reshaped, entrained, and amplified by the nested temporal structures of organized sound, from the outermost rhythm of our beating hearts to the innermost oscillations of pitch perception.

9. Conclusion

This paper has argued that consciousness and temporal experience possess a fundamentally musical structure. Drawing on the phenomenological tradition from Augustine through Husserl, Heidegger, Merleau-Ponty, and Bergson, and integrating the dynamical framework of Neural Resonance Theory, I have proposed that consciousness is constituted by multi-scale, nested, coupled neural oscillations occurring in living biological tissue.

The paper's central contribution—the nested retention/protention stack—reconceptualizes Husserl's tripartite temporal structure as a multi-level architecture operating simultaneously at every tier of a hierarchically coupled oscillatory system. This reconceptualization yields three principal results. First, it reveals a principled asymmetry between retention and protention grounded in the physics of multi-scale phase dynamics, explaining why the phenomenological past and future have qualitatively different characters and offering a sharper account than either classical phenomenology or predictive coding frameworks. Second, it resolves Husserl's unfinished problem of the comet's tail by showing that retention has differential resolution across timescales—fast oscillations decay quickly while slow oscillations persist, so the past is simultaneously present (at slow timescales) and past (at fast timescales). Third, it generates a novel empirical prediction: selective disruption of cross-frequency coupling at a specific oscillatory band should produce layer-specific phenomenological deficits in temporal experience, distinguishable from the predictions of both simple resonance accounts and predictive coding models.

The paper has further argued that these dynamics must occur in living biological tissue, linking the temporal structure of consciousness to the metabolic, autopoietic character of life—and extending the nested hierarchy to the cardiac-visceral level where, through default mode network activity, first-person perspective itself may be grounded. This extension turns the nested retention/protention stack from a theory of temporal consciousness into a theory of *who* is experiencing that temporal consciousness.

The phenomenological tradition described the architecture of temporal consciousness with extraordinary precision but lacked the mechanistic vocabulary to explain how it is realized. Neuroscience has provided increasingly detailed accounts of neural oscillatory dynamics but has struggled to connect these dynamics to the felt quality of experience. The synthesis proposed here suggests that these two enterprises have been describing the same thing in different vocabularies. The task going forward is not to build a bridge between phenomenology and neuroscience but to develop a richer and more precise bilingual language—one that does justice

to both the lived texture of temporal experience and the dynamical structure of the living systems that constitute it.

Music, as we have seen throughout this paper, is the ideal domain in which to develop that language. It is where the resonance dynamics are most precisely structured, most directly accessible to scientific measurement, and most vividly available to introspective report, all at the same time. In the musical structure of consciousness, the inner and the outer, the felt and the physical, the past and the future, are not two things brought together but one thing experienced whole.

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