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Article

Vertical Resonance as a Control Parameter: Integrating a Phenomenological Self-Model into the Criticality of Active Inference

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Abstract

This theoretical paper proposes a novel synthesis of the neurodynamic framework of active inference with phenomenological and systemic models of psychological change. Building on the "criticality of consciousness" hypothesis (Tucker et al., 2025), consciousness is understood as the balanced interplay of an excitatory (E) predictive and an inhibitory (I) corrective limbic system. To imbue this formal architecture with content, concepts from the Resonance-Inference Model (RIM) are integrated (Leidig, 2025a) to describe the brain's generative model as a phenomenological self-pattern. The principles of synergetics (Haken, 1983) are applied to model psychological transformation as a non-linear phase transition. The central contribution is the thesis that the highest level of the self-pattern—the spiritual self (Leidig, 2025b)—acts as a synergetic control parameter governing the entire neurocognitive dynamic. Based on the slaving principle, a mechanism of downward causation is articulated, whereby a change in this high-level parameter directly modulates the precision-weighting of the neurodynamic E/I balance. The model offers a plausible, non-reductionist explanation for how mental states like meaning and belief can have causal effects on brain dynamics. It builds a bridge between computational neuroscience and humanistic psychology, providing a unified framework for understanding psychopathology and therapeutic change.

Keywords: active inference; criticality; consciousness; downward causation; synergetics; self-pattern; psychotherapy; resonance

Public Significance Statement

This article bridges the long-standing gap between computational models of the brain and the lived experience of psychological change and the search for meaning. It presents a new theoretical framework that explains how our highest values and sense of meaning are not just abstract ideas but can directly and causally influence the fundamental dynamics of our brain. This model provides a scientific basis for meaning-centered and contemplative psychotherapies by showing how a change in perspective and belief can lead to profound neurological reorganization. It offers an integrative, non-reductionist view that helps to understand the interplay of mind, brain, and therapeutic transformation.

Introduction: The Formal and the Phenomenal in Consciousness

Psychology faces the ongoing challenge of reconciling formal, computational models of brain function with the rich, subjective nature of human experience, especially in the context of psychological suffering and transformation. While frameworks like active inference provide a powerful, first-principles-based explanation for sentient behavior, they risk remaining abstract without a clear mapping to the contents of lived experience (Leidig, 2025a).

This article addresses this challenge by integrating two pillars of modern psychological theory. The first pillar is the neurodynamic model of Tucker, Luu, and Friston (2025), which situates consciousness in the balance of excitatory and inhibitory (E/I) limbic systems within the active

inference framework. This model provides a precise description of the "how" of conscious processing. The second pillar is the Resonance-Inference Model (RIM), a meta-model that provides the "what" and "why" by integrating phenomenological descriptions of the self (Gallagher, 2013), the dynamics of change (Haken, 1983), and motivational drives (Grawe, 2004; Ciompi, 1997) (Leidig, 2025a).

The central thesis of this paper is that the synthesis of these pillars reveals a mechanism for downward causation that explains how meaning-making can drive neurodynamic reorganization. It is argued that the highest level of the self-pattern—the spiritual self—functions as a synergetic control parameter that modulates the brain's fundamental E/I balance. The following paper will develop this argument step by step. First, the neurodynamic architecture of Tucker et al. (2025) will be presented. Next, the self-pattern will be introduced as the phenomenological content of this model. Building on this, synergetics will be introduced as a formal language for describing transformation. Finally, the synthesis of these elements will be presented to explain the mechanism of downward causation and discuss its implications for an integrative science of psychology and psychotherapy.

The Neurodynamic Architecture: Criticality, Affect, and Dual Memory Systems

A robust understanding of the dynamics of consciousness requires a solid neurobiological foundation. The model by Tucker et al. (2025) offers a pioneering architecture, postulating that the working memory capacity essential for consciousness is based on two complementary limbic memory systems, whose dynamic equilibrium forms the basis for inference processes.

The Dual Limbic System as the Engine of Inference

The model describes two opposing limbic systems that steer the process of active inference (Tucker et al., 2025):

1. The dorsal (Papez) system: This system is characterized as an excitatory, feedforward-oriented, generative system. It is associated with generating predictions based on existing beliefs (priors), consolidation during REM sleep, phasic arousal, and the subjective affect of elation (E). Its function is to promote the realization of organismic possibilities (affordances).
2. The ventral (Yakovlev) system: This system is described as an inhibitory, feedback-oriented, corrective system. It is associated with correcting errors based on sensory evidence, consolidation during NREM sleep, tonic activation, and the subjective affect of anxiety (I). Its function is to impose constraints and update the model based on reality (Tucker et al., 2025).

Active Inference and Affect as Precision Weighting

These dual systems are formally linked to the mathematics of active inference. Active inference posits that the brain strives to minimize variational free energy (F), which can be defined as the difference between complexity and accuracy.

$$F(q,o)=D_KL[q(s)||p(s)]-E_q[\ln p(o|s)]$$

The crucial innovation of Tucker et al. (2025) is to reframe affects not as epiphenomena, but as decisive computational mechanisms for belief updating. Elation (E) and anxiety (I) function as gain-control parameters that modulate the precision (i.e., the confidence or weighting) of the two terms of free energy. Elation (E) increases the precision of a priori beliefs (priors), thus minimizing complexity, while anxiety (I) increases the precision of sensory evidence (likelihood), thus maximizing accuracy.

The Criticality Hypothesis of Consciousness

Consciousness, according to the hypothesis, arises at the point of criticality—a state on the border between order and chaos where the E and I systems are in a dynamic equilibrium, maximizing information processing capacity. This state, however, is fragile. The nightly phases of sleep serve to restore the conditions for criticality during wakefulness. The extreme deviations from equilibrium during sleep—subcritical inhibition in NREM sleep and supercritical excitation in REM sleep—are not pathological but essential for memory consolidation and synaptic homeostasis. They serve to effectively "tune" the generative model for the next day (Tucker et al., 2025).

This perspective suggests a deeper functional interpretation of sleep. The alternating sleep stages are not just a biological reset but a continuation of the brain's fundamental computational task—active inference—in an offline mode. Tucker et al. (2025) show that NREM sleep consolidates unpredicted events, corresponding to targeted error correction, while REM sleep reorganizes existing memory, corresponding to an update of priors. Thus, NREM sleep functions as a targeted "debugging" phase, where the model is updated based on the day's prediction errors. REM sleep, in contrast, acts as a "refactoring" phase, where the entire model (the Bayesian priors) is reorganized for higher efficiency and generalizability. The brain's ability for conscious, critical inference during the day is therefore directly dependent on the quality of its offline, non-critical inference processes during the night. This provides a profound functional explanation for the link between sleep quality and mental health.

The Content of Inference: The Self-Pattern as a Generative Model

The formal architecture described so far provides a precise framework for the 'how' of conscious dynamics. However, it leaves open the crucial question of 'what': What is the actual content of the generative model being balanced at this critical point? Without an answer, the model remains an elegant but ultimately empty "black box." The RIM builds the decisive bridge to phenomenology by postulating: The generative model is the self. It is not an abstract algorithm but the lived experience of being-in-the-world, conceptualized through Gallagher's self-pattern theory as a dynamic, embodied construct (Gallagher, 2013; Leidig, 2025a). This grounding in phenomenology is the key to understanding how formal processes lead to subjective experience. The minimization of free energy thus transforms from a purely information-theoretic goal to what it is phenomenologically: the fundamental striving for coherence, consistency, and meaning.

The Emergence of the Self-Pattern through Dual Memory Systems

The model explicitly links the neurodynamics of Tucker et al. (2025) with the phenomenology of the self, showing how our identity emerges from the constant dialogue of two fundamental memory processes. The fast, episodic, dorsal system acts as the archivist of our lived moments. It stores the raw, emotionally charged "film clips" of experience—vivid, context-rich, and sensorially dense episodes. One can think of it as the system that records the pain of rejection not as an abstract concept, but with the accompanying lump in the throat, the specific facial expression of the other person, and the atmosphere of the room. It is the source of our personal history in all its immediate and often unstructured intensity.

In contrast, the slow, integrative, ventral system works like an internal statistician, searching for patterns in this stream of data. It distills generalized, context-free rules and beliefs from countless individual experiences. From the repeated or particularly poignant pain of rejection, it extracts the seemingly logical conclusion: "Intimacy is dangerous." This process sacrifices the details of the original experience for an efficient, action-guiding heuristic. This is how the deep, often rigid priors are formed that constitute the core of the self-pattern and shape our expectations of the future (Leidig, 2025a). The interplay of these two systems is thus the engine of self-construction: one provides the rich material of experience, the other forges from it the stable, but also potentially rigid, structures of our identity.

The Vicious Cycle of Psychopathology

The interaction of these dual systems precisely explains how maladaptive patterns arise and solidify. A negative prior generalized by the slow system (e.g., "I am worthless") does not act as a passive belief but as a powerful perceptual filter. It assigns a negative valence to ambiguous social signals. A colleague's neutral facial expression is interpreted not as concentration but as disapproval; a delayed response to a text message is seen not as a sign of being busy but as proof of one's own insignificance.

This interpreted experience—now felt as painful reality—is stored by the fast, episodic system as a new, emotionally charged "film clip." This fresh, vivid memory of (supposed) rejection then serves the slow system as compelling evidence that confirms and strengthens the original negative prior. This creates a closed loop of circular causality, a self-reinforcing cycle. This mechanism illustrates the concept of Bayes-optimal pathology: The system is not "broken"; it functions perfectly, but on the basis of a flawed premise. From the perspective of prediction error minimization, it acts highly rationally by successfully confirming its own (negative) predictions, thereby creating a coherent, albeit painful, reality. The pathology thus lies not in the inference process itself, but in the deeply entrenched priors that guide it. The system becomes a perfectly functioning machine for generating self-fulfilling prophecies, trapping the individual in their suffering.

The Narrative Self

On this neuro-phenomenological basis, the crucial role of the narrative self can be understood. It is the highest level of cognitive organization where the raw data of the episodic system and the rigid rules of the integrative system are woven into a coherent life story. This narrative, however, is not a passive report of past events but an active, organizing principle. It functions as a higher-order prior that filters the perception of the present and generates predictions about the future ("This always happens to me").

This is precisely where the decisive lever for therapeutic change lies. While the deep, embodied priors are often unconscious and difficult to access, the narrative level is linguistically constituted and thus accessible to conscious reflection and modification. Therapy becomes a space where this story can be explored, questioned, and rewritten. By helping a client find alternative interpretations for past "film clips" or enabling new, corrective experiences, it is not just the story that is changed. Rather, a new, higher-order prior is created that guides the system to search for evidence for this new, healthier narrative through active inference (i.e., through new behavior). The narrative self is thus the primary access point for breaking the vicious cycle of Bayes-optimal pathology and initiating a reorganization of the entire self-pattern (Leidig, 2025a).

The Dynamics of Transformation: Synergetics and Psychological Change

To explain how a rigid self-pattern transforms, the RIM draws on the theory of synergetics, founded by Hermann Haken, which provides the formal language to describe change in complex, self-organizing systems (Haken, 1983).

Key Concepts in a Psychological Context

1. **Attractors:** Psychological states (healthy or pathological) are understood as stable attractor states in the system's energy landscape. A disorder like depression is a deep, maladaptive attractor.
2. **Phase Transitions:** Therapeutic change is not linear but a non-linear phase transition—a sudden, qualitative leap from one attractor to another.
3. **Control Parameters:** These are the slowly changing variables that drive the system toward a phase transition. The RIM identifies motivational states, beliefs, and ultimately the sense of meaning as central control parameters.
4. **Critical Instability:** To leave a rigid attractor, the system must be guided into a state of instability and "critical fluctuations"—this is the synergetic equivalent of the neurodynamic state of criticality as described by Tucker et al. (2025).

Table 1. A Trans-theoretical Dictionary of System Dynamics.

Dynamic Principle	Resonance-Inference Model (RIM) / Synergetics (Haken)	Criticality of Consciousness (Tucker et al.)	Entropic Brain Hypothesis (Carhart-Harris et al., 2014)
Pathological Stability	Maladaptive attractor / Sub-critical state	Dominance of the inhibitory (I) system	Low-entropic state / Sub-critical
Optimal Flexibility	Resonant flow / Criticality	E/I balance at criticality	Critical state
Chaotic Dysregulation	Manic state / Super-critical state	Dominance of the excitatory (E) system	High-entropic / "Primary" state
Mechanism of Change	Phase transition via control parameters	Modulation of precision weighting	Collapse of DMN organization

Note. This table maps the terminologies of different theoretical approaches onto the same underlying dynamic principles.

This systemic perspective also illuminates the crucial role of the therapeutic relationship. While synergetics postulates that transitioning from a stable attractor requires a phase of instability and chaos, active inference teaches that organisms strive to minimize surprise (free energy) and would therefore actively avoid such an unstable state. Empirical psychotherapy research, in turn, emphasizes the therapeutic alliance as an essential factor for change. The synthesis of these

perspectives leads to a deeper understanding of therapeutic dynamics that integrates Gallagher's process-based view of the self. Gallagher describes the self-pattern as an emergent, self-organizing gestalt without a central control unit, akin to a jazz band where the musicians (the various self-processes) create a coherent whole through dynamic, reciprocal interplay. In this view, psychopathology is a disturbance of this interplay, where the pattern becomes rigid and dissonant. The crucial question is how such a self-organizing structure can be changed. This is where the concept of the Markov blanket becomes central. Phenomenologically, the Markov blanket is the boundary that separates our sense of self from non-self. It is not a physical wall but a statistical barrier maintained by our actions (active states) and perceptions (sensory states). The fundamental drive of any organism is to maintain the integrity of this blanket, i.e., to minimize surprise. Therapeutic resistance or stagnation can be reinterpreted from this perspective: it is not the client's unwillingness, but the homeostatic imperative of their system to protect its Markov blanket—and thus its coherent (albeit painful) self-model—from overwhelming prediction errors. A too-direct confrontation or too-rapid change is perceived by the system as an existential threat to its integrity, leading to a strengthening of defense mechanisms—the blanket becomes more rigid and impermeable. The predictability and safety of the therapeutic relationship (an external state of low surprise) creates the necessary stable boundary conditions that allow the client's internal system to tolerate the destabilization required for change. Here, something crucial happens: The therapist's Markov blanket couples with the client's to form a temporary, dyadic system. Within this larger, more stable, and safer system, the client's Markov blanket can relinquish its rigidity and become more permeable. The therapist essentially "lends" their regulatory capacity to the client, which lowers the free energy of the entire dyadic system, thus enabling the phase transition to a new, more adaptive state.

The Apex of the Hierarchy: The Spiritual Self as a Synergetic Control Parameter

The model's decisive extension lies in defining the spiritual self-pattern as the highest, most abstract layer of the generative model. This level transcends narrative identity. While working on the narrative self answers the question, "What is my story?", working on the spiritual self addresses a deeper level: "Who is the narrator of this story, and in what way is it being told?". It is no longer just about changing the narrative, but about becoming a different storyteller—one who is aware of the act of storytelling itself (Leidig, 2025b).

Phenomenological and Computational Correlates

The phenomenological description of this state is found in reports of non-dual experiences or "ego dissolution," as documented in contemplative traditions and psychological research. A characteristic feature is the collapse of the subject-object dichotomy: the feeling of being a separate, distinct self observing an external world dissolves. In its place emerges the experience of an undivided field of consciousness, where the distinction between inner and outer becomes meaningless.

Computationally, this state can be elegantly framed as the ultimate minimization of free energy. The free energy principle states that any self-organizing system strives to minimize the difference between its predictions about the world and the actual sensory signals. In the state of ego dissolution, this prediction error converges to zero. This happens not because the model perfectly predicts the world, but because the distinction between the model (self) and the world itself collapses. When there is no longer a boundary, there is no longer an error at that boundary. This is the state of maximal resonance and coherence, in which the system has found the simplest yet most comprehensive explanation for its existence: the unity of the observer and the observed. This connection is of central importance as it presents the highest states of human experience not as mystical anomalies, but as the logical endpoint of the most fundamental principle of brain function—active inference.

The Spiritual Self as a Master Control Parameter

The central claim of this paper is: This highest-ranking state of the self-pattern, representing the most fundamental assumption about the relationship between self and world, functions as the master synergetic control parameter for the entire neurocognitive system. Unlike subordinate parameters that control specific behaviors or emotional reactions, this master parameter operates at the most global level. It sets the fundamental "grammar" according to which all other mental processes unfold. A change at this level is not merely a content correction (e.g., changing a single belief), but a fundamental reconfiguration of the entire "attractor landscape" of the mind. It changes the probability of all possible thoughts, feelings, and actions, thus representing the most effective lever for profound and sustainable psychological transformation.

A Mechanism for Downward Causation: How Meaning Modulates Neurodynamics

This section describes the core mechanism of the proposed synthesis by applying Haken's slaving principle from synergetics (Haken, 1983). This principle offers a formal, physically grounded explanation for how macroscopic patterns can control the behavior of microscopic components. It states that in a self-organizing system, a change in a slow-moving, high-level order parameter (the control parameter) inevitably "enslaves" and reorganizes the dynamics of the fast-moving, subordinate components. A classic example is the laser: when the energy input (the control parameter) exceeds a critical threshold, the emerging coherent light field (the order parameter) forces all individual, chaotically oscillating photons (the subordinate components) to move in unison. Transferred to the brain, the spiritual self acts as the coherent field that forces chaotic neural activity into an ordered pattern.

The Causal Chain

1. A change occurs at the highest level: a shift in the sense of meaning, a non-dual insight, or the adoption of a new attitude towards suffering (e.g., through Frankl's "attitudinal values"). This is a change in the control parameter.
2. This change in the system's global organizational pattern causally constrains the subordinate dynamics.
3. Specifically, it directly modulates the precision weighting of the E/I balance. For example, an attitude of acceptance can down-regulate the precision of aversive interoceptive prediction errors (thereby reducing the influence of the I-system) while simultaneously up-regulating the precision of internal, value-based priors (thereby increasing the influence of the E-system).

The Resolution of the Mind-Body Problem

This model offers a solution to the classic philosophical dilemma by undermining its dualistic premise. The traditional problem asks how an immaterial "mind" can act on a material "body" (the brain) without violating the laws of physics. The solution presented here does not build a new bridge between two separate entities but dissolves the premise of separation itself.

The "mind," represented here by the spiritual/narrative self, is not conceptualized as a separate substance but as an emergent order parameter. It is a macroscopic pattern that arises from the interplay of billions of microscopic neural processes—just as the shape of a wave arises from the interplay of water molecules. The wave is nothing other than "moving water," but it has properties and a causal power that no single molecule possesses. Crucial is the principle of circular causality: The neural processes (bottom-up) generate the global pattern of the mind. However, once this pattern exists, it acts back on the neural processes (top-down). It "enslaves" them by constraining the probabilities of future neural activity patterns.

This "downward causation" is not a physical force that pushes neurons, but an informational process. A change in the sense of meaning—a change in the order parameter—modulates precision weighting. It adjusts the gain (precision) assigned to different information streams (priors vs. evidence). A change in meaning thus literally changes how much the brain trusts its own models versus incoming data. This redirects the entire flow of neural activity and behavior without violating physical laws. Mind and brain are therefore not two different things that interact, but two descriptive levels of a single, self-organizing system, inextricably linked in a relationship of circular causality. This provides a complete, coherent, and scientifically testable model of mental causation.

Implications for an Integrative Science of Psychology and Psychotherapy

The synthetic model outlined here offers a common language and a theoretical foundation that can bridge the gap between computational neuroscience, clinical psychology, and humanistic-phenomenological traditions.

Reinterpreting Therapeutic Modalities

The model reframes established therapeutic approaches and provides a unifying mechanistic explanation for their effectiveness. Meaning-centered therapies (e.g., Frankl's logotherapy) and contemplative practices are transformed from "soft" interventions into precise methods for deliberately modulating the brain's highest control parameter. Their efficacy lies in their ability to readjust precision weighting at the most global level. Similarly, experiential approaches like Coherence Therapy become understandable as a dyadic process of guided active inference, where the therapist helps the client's system to generate and integrate the very prediction errors necessary to uncover and update maladaptive priors.

The therapeutic and coaching frameworks of the RIM (Resonance-Inference Therapy and Coaching) are direct applications of this model. The "three acts" of RIT—de-escalation, destabilization, and reorganization—provide a practical guide for inducing a synergetic phase transition by managing the client's E/I balance and updating their self-pattern (Leidig, 2025a).

Future Research Directions

The model opens up new avenues for research, such as using neuroimaging (e.g., EEG) to measure shifts in E/I balance and criticality in response to meaning-centered interventions, thus making the model empirically testable.

Conclusions: Towards a Re-Enchanted Science of the Mind

This paper has presented a synthesis of computational neuroscience, phenomenology, and systems theory. The result is an integrated model that shows how meaning and purpose function not as epiphenomena, but as causally effective control parameters that steer the brain's predictive machinery.

Instead of reducing human experience to mere computation, this scientific model achieves the opposite. It elevates the deepest aspects of our humanity—meaning, purpose, resonance, and transcendence—by showing that they are not ephemeral illusions, but the central, causally potent drivers of the self-organizing dynamics that constitute our being. By framing meaning as the highest control parameter of our neurobiology, a "re-enchantment" of the scientific worldview becomes possible (Leidig, 2025a).

References

1. Carhart-Harris, R. L., Leech, R., Hellyer, P. J., Shanahan, M., Feilding, A., & Nutt, D. J. (2014). The entropic brain: A theory of conscious states informed by neuroimaging research with psychedelic drugs. *Frontiers in Human Neuroscience*, 8, 20. <https://doi.org/10.3389/fnhum.2014.00020>
2. Ciompi, L. (1997). *Die emotionalen Grundlagen des Denkens: Entwurf einer fraktalen Affektlogik* [The emotional foundations of thinking: A draft of a fractal affect logic]. Vandenhoeck & Ruprecht.
3. Frankl, V. E. (1984). *Man's search for meaning*. Washington Square Press.
4. Gallagher, S. (2013). A pattern theory of self. *Frontiers in Human Neuroscience*, 7, 443. <https://doi.org/10.3389/fnhum.2013.00443>
5. Grawe, K. (2004). *Neuropsychotherapie* [Neuropsychotherapy]. Hogrefe.
6. Haken, H. (1983). *Synergetics: An introduction*. Springer-Verlag.
7. Leidig, G. (2025a). *The resonance-inference-modell (RIM): A multilayered, process-based framework for a unified, neuroscience-informed psychotherapy*. PsyArXiv. <https://doi.org/10.31234/osf.io/7hd4a>
8. Leidig, G. (2025b). *The spiritual self-pattern: A neurocognitive extension of the resonance-inference model for psychotherapy*. PsyArXiv. <https://doi.org/10.31234/osf.io/xneq7>
9. Tucker, D. M., Luu, P., & Friston, K. J. (2025). The criticality of consciousness: Excitatory-inhibitory balance and dual memory systems in active inference. *Entropy*, 27(8), 829. <https://doi.org/10.3390/e27080829>

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