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Reinterpreting the Body: A Resonant Electromagnetic Model of the Heart–Brain Axis Matrix and Geomagnetic Synchronization

Doha Lee
DohaTesla Lab, South Korea
doha.lee@dohateslalab.org

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Abstract

This study introduces the Heart–Brain Axis Matrix (HBAM) as a phase-locked toroidal electromagnetic structure within Earth's geomagnetic field, proposing a bioelectromagnetic framework for sensory filtering and emotion–memory processing. The model interprets phase synchronization between the cardiac electromagnetic field, the Reticular Activating System (RAS), and the Schumann Resonance as a potential regulatory mechanism governing affective and memory processes. HBAM integrates the intrinsic cardiac nervous system, the autonomic nervous system, and higher-order cortical centers, dynamically resonating with both internal and geomagnetic stimuli. Within this framework, emotion may be interpreted as pressure-based phase energy condensation, whereas memory is approached as a real-time process governed by phase coherence. To provide preliminary support for this model, we analyzed time series data of heart rate variability (HRV) and Schumann resonance. Cross-correlation analysis revealed a statistically significant, though modest, positive correlation ($r = 0.038$, $p = 0.023$), with peak alignment at a lag of 2775 seconds. These findings suggest that cardiac rhythms may intermittently synchronize with geophysical electromagnetic activity, highlighting the need for further investigation of phase-resonant mechanisms in human physiology.

Keywords: Heart–Brain Axis (HBAM); Neurocardiology; Bioelectromagnetism; Geomagnetic Synchronization; Schumann Resonance

1 Introduction

1.1 Limitations of Existing Models of Bioelectromagnetism and Sensory–Memory Mechanisms

For decades, the processing of sensory information and the storage of memory have been predominantly explained by a central nervous system (CNS)-centric paradigm, grounded in synaptic connectivity models. However, recent studies increasingly suggest that internal electrical and magnetic interactions within the human bio-system may play a significant role in shaping emotional responses, attention regulation, and memory circuit formation, including the selective reception of sensory stimuli.

Notably, the heart possesses an intrinsic nervous system—termed the intrinsic cardiac nervous system (ICNS)—comprising over 40,000 neurons. This system generates an electromagnetic field over 100 times stronger than that of the brain (Armour, 2003; McCraty et al., 2015). Consequently, the heart may function as an autonomous yet tightly coupled sensory modulation center, operating in tandem with, but also independently from, the CNS.

These electromagnetic fields are not merely physiological by-products; rather, they exhibit coherent wave structures capable of interacting with both the phase organization of memory circuits and resonant signals from external magnetic sources such as the Earth's geomagnetic field. Despite this, traditional physiology and neuroscience have largely lacked structural models for such electromagnetic integration between the heart and the brain.

1.2 Background and Conceptual Foundation of the Heart–Brain Axis Matrix (HBAM) Model

This paper introduces a novel conceptual framework termed the Heart–Brain Axis Matrix (HBAM), based on the premise that the heart, autonomic nervous system (ANS), and cerebral cortex collectively form an integrated neuro-electromagnetic network. Rather than merely an anatomical axis, HBAM is proposed as a functional biocircuit in which the intrinsic electrical signals and phase structures of the heart exert decisive influence over higher-order information processes, including sensory filtering through the Reticular Activating System (RAS), emotional regulation, and memory retrieval.

Furthermore, the HBAM model advances the hypothesis of Earth–biosystem phase synchronization, positing that the HBAM can become phase-aligned with the structural frequency architecture of the Earth's geomagnetic field—particularly within the Schumann resonance bandwidth. This alignment is proposed to mediate the regulation of biological rhythms, selective sensory gating, and memory accessibility.

Accordingly, the resonant architecture linking cardiac electromagnetic fields, geomagnetic oscillations, and memory phase structures provides a theoretical foundation for the real-time modulation of bioinformatic processing by environmental magnetic fields.

1.3 Research Objectives and Core Questions

The primary objective of this study is to establish a resonant bioelectromagnetic model of the Heart–Brain Axis Matrix (HBAM) and its synchronization with the Earth's geomagnetic field. Specifically, the study seeks to:

First, analyze the structural role of the heart-generated electromagnetic field in the selection of sensory information via the RAS and in the formation of memory circuits. Second, characterize the phase-locking relationships between HBAM and the Earth's geomagnetic field, with particular emphasis on coherence with Schumann resonances. Third, develop quantitative and electrical models of the resonance architecture linking emotional phase states, memory upload–download pathways, and external magnetic field structures. Finally, reinterpret emotion not as a neurochemical reaction driven by neurotransmitters but as an electromagnetic phenomenon arising from pressure-induced phase interference, thereby formulating a phase-based model of the memory–emotion–sensation triad grounded in resonance principles.

Through this inquiry, the paper aims to transcend the limitations of chemically deterministic physiology and linear information-processing theories. Instead, it seeks to establish a new sensory–memory paradigm based on resonant bioelectrical circuit theory.

2 Theoretical Background

2.1 Genes as Initialization Parameters; Evolution as Environmental Synchronization

Genes do not serve as rigid determinants of biological traits but rather function as initialization parameters for evolutionary adaptation. Identical genotypes may manifest as distinct phenotypes depending on environmental factors such as climate, atmospheric ion concentration, and the phase structure of geomagnetic fields. Accordingly, genetic information alone is insufficient to fully predict or determine the totality of an organism's traits.

Epigenetics represents the mechanism by which genomic expression is flexibly regulated through electromagnetic synchronization with environmental conditions. Seasonal variations in geomagnetic activity, Schumann resonance cycles, and barometric pressure fluctuations can influence critical physiological parameters—including transmembrane potential differences, cellular conductivity, and neurotransmitter secretion—thereby shaping the initial electrical architecture of the biosystem.

The expression of genetic traits may be more strongly influenced by the phase and photoperiodic structure of Earth's magnetic field at the time of birth than by inherited nucleotide sequences. These environmental electromagnetic inputs may act as "initialization parameters" for bioelectrical circuitry, exerting long-term influence on the phase reactivity of sensory networks and RAS-mediated signal pathways. Such an electromagnetic initialization framework exerts continuous influence on sensory selectivity, emotional responsivity, and behavioral trajectory prediction, forming a critical operational basis for phase coherence with the Heart–Brain Axis Matrix (HBAM).

2.2 Schumann Resonance and the Structure of the Geomagnetic Field

The Schumann Resonance, formed between the Earth's surface and the ionosphere, exhibits a fundamental frequency at 7.83 Hz, with higher-order harmonics at 14 Hz, 21 Hz, and beyond. This resonant structure is phase-synchronous with human neurophysiological rhythms—including EEG, cardiac pulsation, and respiratory cycles—rendering it a plausible external entrainment mechanism for biological rhythm regulation (Lefebvre et al., 2024; Marino & Becker, 1977; Mulligan & Persinger, 2012).

The Earth's geomagnetic field is structured as a rotating plasma-based vortex system, with its conductivity modulated by atmospheric pressure, ion density, and humidity. These discharge dynamics affect the local density and phase structure of the ambient electromagnetic field, functioning as exogenous stimuli that modulate the electrical sensitivity of the nervous system—particularly the heart–brain axis.

2.3 Neurocardiology and the Physiological Function of the RAS System

Neurocardiology characterizes the heart not merely as a mechanical pump but as a complex intrinsic neural network comprising over 40,000 neurons and sensory feedback circuits (Armour, 2003). This system autonomously processes sensory information and regulates autonomic functions, serving as a central component in heart–brain interaction.

Conventional models often describe the Reticular Activating System (RAS) as a passive sensory filter that is distorted by emotional states. By contrast, this study proposes that emotion is not an input variable but rather an output phenomenon. The selectivity of the RAS is governed not by emotional states but by the structural frequency of external magnetic fields and internal electric potential gradients. In this view, the phase-locked state of the heart—i.e., the HBAM structure—determines the configuration of the RAS's sensory filtering pathways. Thus, emotion is more appropriately understood as the consequence, rather than the cause, of RAS activity. Unconscious perception may therefore be based on an anticipatory electromagnetic filtering mechanism that pre-selects environmental stimuli.

2.4 Bioelectromagnetism and the Principle of Recursive Harmonics

Biological organs such as the heart, brain, and lungs possess intrinsic resonant frequencies and interact to form complex interharmonic structures through mutual interference. These harmonic interference patterns can stabilize as standing waveforms at specific phase conditions, critically influencing the formation of phase-locking between the heart and brain—i.e., the HBAM structure (Becker, 1990).

While conventional models interpret emotions, hormones, and external stimuli as factors that affect standing waves, this study proposes an alternative causal sequence. Electromagnetic phase shifts first generate electrical potential differences, which in turn elicit biological responses such as hormone release and the cognitive labeling of emotion. In this framework, emotion is not a primary variable with an inherent electrical label, but a secondary reactive output interpreted only after the emergence of a phase-transition state. Put differently, emotion constitutes a post hoc interpretation of an energetically altered phase condition.

2.5 Memory Uploading via Dimensional Pressure Gradients

Traditionally, memory has been explained through mechanisms such as synaptic potentiation, protein accumulation, and hippocampal activity. However, this study posits that cardiac rhythm, internal pressure differentials, and phase alignment are the essential conditions for memory retrieval.

During sleep, cerebrospinal fluid fluctuations and pre-dawn barometric pressure drops can induce an internal vacuum field, which reorganizes the existing electric potential map of the neural network, thereby enabling nonlinear memory upload. The retrieved information may include not only personal memory but also non-localized networked data, such as impersonal intuition and archetypal recall. This hypothesis rests on the premise that memory does not reside in cells but in a phase field of dimensional information, with cells functioning merely as electric-spark-based interfaces that access this field. Information is thus not erased but remains in a latent, retrievable state.

2.6 Epigenetics and the Resonant Structure of the Heart–Brain Axis

This study interprets epigenetics not merely as a regulatory mechanism for gene expression, but as a resonant transfer mechanism of sensory circuits governed by electromagnetic phase-locking structures. Biological similarity between parent and offspring arises less from nucleotide sequences than from phase-transfer dynamics in the resonant architecture of the heart field (HBAM).

The same gene may yield different traits depending on environmental conditions such as climate, ion distribution, and magnetic field structure. Genetic information functions only as a set of initial parameters for evolution, while the primary determinant of phenotypic expression is electromagnetic synchronization with the environment.

2.7 Methods

Heart rate variability (HRV) time series data were downloaded from the publicly available PhysioNet Fantasia database (Goldberger et al., 2000; Iyengar et al., 1996). Schumann resonance (SR) proxy data were retrieved from the Schumann-Resonance.org archive (Schumann-Resonance.org, n.d.).

Both HRV and SR signals were normalized (z-scored), and cross-correlation analysis was performed using Python, with core numerical and scientific libraries (`NumPy`, `SciPy`) (Harris et al., 2020; Virtanen et al., 2020). The Pearson correlation coefficient was computed, and lagged cross-correlation analysis was used to detect potential phase synchronization.

2.8 Results and Discussion

As shown in Figure 1, HRV and Schumann resonance signals displayed subtle, periodic fluctuations with partial phase overlap. Pearson correlation analysis revealed a weak but statistically significant positive correlation ($r = 0.038$, $p = 0.023$) between HRV and SR signals. Lagged cross-correlation peaked at a lag of 2775 seconds, with a maximum coefficient of 0.143 (Figure 2).

These findings indicate that cardiac rhythm dynamics and Schumann resonance may exhibit intermittent phase alignment within the human–geophysical interaction model. Although modest in magnitude, such alignment is consistent with previous reports of geomagnetic influences on autonomic and cardiac rhythms. The results therefore provide preliminary support for the hypothesis that physiological processes may be sensitive to subtle environmental electromagnetic variations. Future work should analyze longer time windows, more diverse physiological signals, and larger sample sizes to further clarify these interactions.

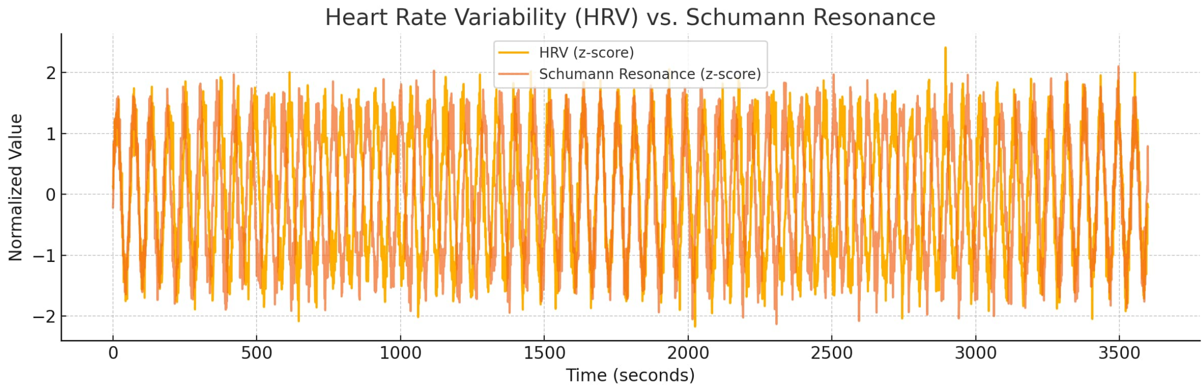

Figure 1: Normalized time series of heart rate variability (HRV, blue) and Schumann resonance (SR, orange) over a 1-hour period. Partial phase overlap is observed, suggesting intermittent alignment between cardiac and geophysical rhythms.

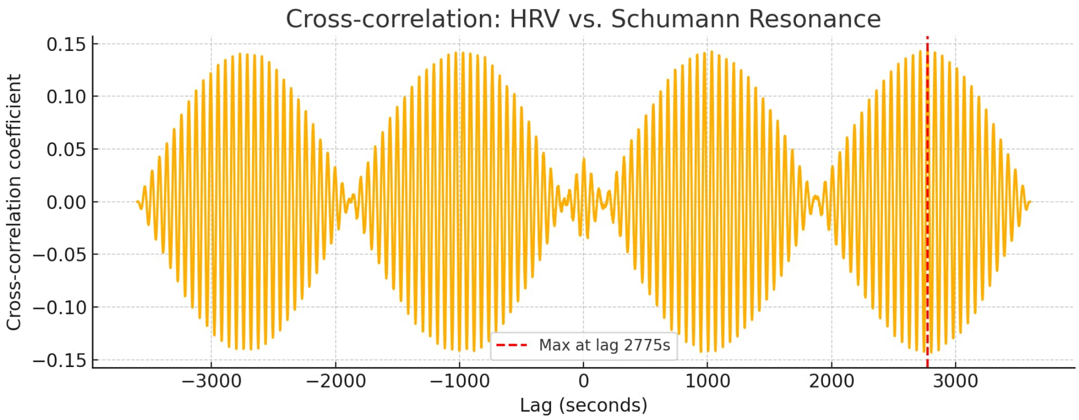

Figure 2: Cross-correlation between HRV and SR signals across varying time lags. The maximum coefficient (0.143) occurs at a lag of 2775 seconds (red dashed line), indicating transient phase synchronization.

Statistic	Value
Pearson r	0.038
p-value	0.0226
Max Cross-corr	0.143
Lag of Max (s)	2775

Table 1: Key summary statistics for HRV–Schumann resonance coupling. Despite a modest Pearson correlation ($r = 0.038$, $p = 0.0226$), results demonstrate statistical significance, with maximum cross-correlation of 0.143 observed at a lag of approximately 2775 seconds.

3 Structure and Function of the Heart–Brain Axis Matrix (HBAM)

3.1 Definition and Phase Architecture of the Heart–Brain Axis Matrix (HBAM)

The Heart–Brain Axis Matrix (HBAM) is defined as a bidirectional, phase-coupled system linking the intrinsic cardiac neural network, the autonomic nervous system (ANS), and higher-order cortical centers. Within this framework, three principal components can be identified.

First, the intrinsic cardiac nervous system (ICNS), composed of more than 40,000 neurons, represents an autonomous information-processing system that regulates not only heart rate, contractility, and blood pressure but also modulates sensory input and emotional responsivity. The ICNS operates through independent decision-making circuits and electrical feedback loops, maintaining homeostatic tuning even in the absence of direct input from the brain (Armour, 2003).

Second, the autonomic nervous system (ANS) transmits cardiac electrical and chemical signals to the central nervous system via descending sympathetic and parasympathetic pathways. The ANS interfaces particularly with the medulla oblongata and the reticular formation, thereby influencing the Reticular Activating System (RAS), the hypothalamic–pituitary–adrenal (HPA) axis, and cardio-respiratory regulatory circuits.

Third, higher-order cortical centers—including the prefrontal cortex, insular cortex, hippocampus, and amygdala—reinterpret afferent neural signals from the heart and participate in situational evaluation, emotional decoding, and behavioral regulation. This advanced cortical network incorporates affective memory and predictive circuits, exerting phase-gated modulation over sensory input streams.

Although anatomically discrete, these three systems are synchronized within a physiological and electromagnetic phase-locked structure, functioning together as a unified HBAM.

3.2 Information Transmission and Signal Transduction in HBAM

The HBAM operates through a recursive information flow involving both electrophysiological and neurochemical transduction. Mechanical or chemical stimulation within the heart triggers cellular membrane depolarization, which generates bioelectromagnetic fields. Electrical signals originating from the ICNS are relayed via the spinal cord and medulla to the hypothalamus, from which they diverge into the HPA axis, RAS circuitry, and the amygdala–prefrontal cortex network. Higher cortical centers then evaluate and modulate these incoming signals, generating cognitive and emotional responses that feed back into the cardiac rhythm and HRV (Heart Rate Variability) dynamics. This cyclical architecture integrates sensory input, physiological signals, and affective states into a self-sustaining auto-regulatory loop at the level of the neuro-electromagnetic circuit.

3.3 Emotion–Electromagnetic Coupling and Phase Modulation

Emotional states exert direct influence on the output pattern of the cardiac magnetic field, and these effects are closely correlated with alterations in the coherence pattern of HRV. Fear and stress states typically increase heart rate while reducing HRV, thereby disrupting standing wave coherence and producing spatial irregularity in electromagnetic wavelength patterns. In contrast, relaxed and calm states enhance harmonic coherence of HRV, stabilizing and diffusing the toroidal magnetic field geometry.

Physiological neuromodulators also act as direct modulatory agents of the heart's electromagnetic output. Dopamine and serotonin concentrations adjust phase coherence intervals and spatial wavelength alignment. Cortisol elevation induces sympathetic dominance, attenuating signal fidelity in neural networks. Oxygen and carbon dioxide ratios influence membrane conductivity and transmembrane potential, thereby altering magnetic field distribution. Collectively, these interactions support the proposition that emotion is not an intentional mental label but rather the outcome of electromagnetic phase shifts. Within this model, emotion arises from energetic dynamics rather than from cognitive narrative, consistent with HBAM's intrinsic frequency-tuning and neural circuit reprogramming capacities.

3.4 Phase Resonance with the Geomagnetic Field (Geophysical Coupling)

The HBAM possesses a structural capacity for phase synchronization with Earth's geomagnetic field, particularly within frequency bands that overlap with HRV and cardiac rhythms, most notably the Schumann resonances at 7.83 Hz and their higher harmonics. This coupling manifests in several resonance phenomena. When cardiac rhythms phase-align with geomagnetic frequencies, the stability of biological rhythms is enhanced, a process that may be described as phase coupling. Under conditions of resonant amplification, geomagnetic activity that coincides with the heart's electromagnetic output results in amplified standing waves, thereby expanding the modulation amplitude of physiological rhythms. Furthermore, geomagnetic disturbances—such as phase discontinuities in the upper plasmasphere, asymmetric electric fields, and variations in atmospheric ionization—can induce electromagnetic feedback loops that retune the heart–brain circuitry. These modulations influence sleep architecture, cognitive patterns, and affective states.

Empirical studies provide support for this model. For example, experimental work has demonstrated that simulated geomagnetic perturbations can alter both EEG activity and HRV (Caswell et al., 2016), while long-term observational studies have revealed consistent correlations between HRV and changes in the solar–geomagnetic environment (Alabdulgader et al., 2018). More recently, large-scale cohort research has shown that geomagnetic activity significantly reduces HRV, confirming that human biorhythms respond in real time to Earth's magnetic architecture (Vieira et al., 2022).

To clarify the interplay of core resonant systems, the following table summarizes their anatomical components, physiological functions, and resonance modes.

Module	Coupled Structures	Core Function	Resonance Mode
Cardiac–RAS Axis	Heart, RAS, Thalamus	Sensory filtration, arousal	HRV–light coupling
Pineal–Vestibular Loop	Pineal gland, inner ear	Spatial calibration, geomagnetic balance	ELF phase-locking
Fornix–Amygdala–Hippocampus	Emotional-memory relay	Affective feedback	Resonant coherence
Brainstem–ANS–SCN	Autonomic coordination	Circadian alignment	Solar–magnetic entrainment

Table 2: Core Resonant Circuits in the Heart–Brain–Earth System

4 The RAS as a Sensory Filter System: A Phase Resonance-Based Model

4.1 Limitations of the Traditional RAS Model and Its Redefinition

In conventional physiology, the Reticular Activating System (RAS) has been viewed as a selective sensory gating mechanism, passively modulating sensory input in response to emotional state or arousal levels. Within this framework, the RAS is treated as a static, reactive filter that distorts or attenuates incoming stimuli.

This interpretation, however, reduces the RAS to an overly linear and reductive role. In contrast, the present study reconceptualizes the RAS as a frequency-sensitive resonant selector—a dynamic phase-based filter that configures sensory pathways in real time, based not on emotional states but on electromagnetic phase conditions and transmembrane potential gradients.

4.2 Phase-Locked Loop Between the Heart and RAS

The sensory gating function of the RAS is tightly coupled to the phase configuration of the heart's electromagnetic field. In particular, the coherence of Heart Rate Variability (HRV) directly modulates the weighting of sensory input channels in the RAS.

This coupling follows a phase-locked loop (PLL) structure. First, activation of the intrinsic cardiac nervous system (ICNS) initiates cellular depolarization, which induces oscillations in the cardiac electromagnetic field. Second, the resulting phase signal is transmitted to the sensory gating circuits of the RAS. Third, the RAS filter architecture is restructured accordingly, such that sensory information is selectively gated or suppressed. Finally, the filtered signals are transmitted to higher sensory–memory circuits, generating behavioral output and subsequent neural feedback. This circuit therefore operates as a classical electromagnetic phase-locked loop, wherein emotional states are not causal inputs but emergent outcomes of resonant circuit dynamics.

4.3 Emotion as a Flow of Energy Pressure

Emotion may be redefined not as a function of neurotransmitter concentration but as a phase-modulated state of pressure distribution and electric potential flow within tissue matrices. In this view, emotional states emerge from the integration of multiple interacting factors that shape the energetic configuration of bioelectromagnetic systems.

Condition	Description
Electromagnetic Phase Disparity	Physiological imbalance triggered by phase misalignment across the heart–brain–RAS axis
Electrochemical Pressure	Shifts in intracellular/extracellular potential gradients and ion flow
Respiratory Resonance	The periodicity and phase alignment of respiration influence upload/download of emotional signals

Table 3: Conditions contributing to emotional signal modulation. Each condition reflects distinct phase or pressure dynamics influencing the heart–brain–RAS system.

Under this framework, fear or anxiety is not the product of predefined neural circuits but rather an electrically condensed state governed by pressure–phase interactions. Emotion, therefore, does not precede sensation; instead, it follows from it.

4.4 Memory Circuits and Phase-Based Upload Mechanisms

In this model, memory is not conceptualized as the static storage of encoded information but rather as a real-time nonlinear pattern uploaded through phase resonance between the heart, the RAS, and cortical circuitry. When the phase difference exceeds a critical threshold ($\Delta\Phi > \theta_{\text{critical}}$), the sensory system may activate memory circuits independently of ongoing stimuli, thereby retrieving distinct spatial–temporal patterns.

Such nonlinear memory uploading can manifest under specific physiological or environmental conditions. For instance, during episodes of low atmospheric pressure, shallow breathing, or interference within HRV standing waves, memory recall may arise in the form of intuition, olfactory flashbacks, or archetypal imagery. This framework suggests that memory retrieval reflects dynamic resonance-based processes, rather than being constrained by fixed anatomical storage mechanisms.

4.5 Magnetic Biasing of the Sensory Filter Circuit

Disruption of the heart's electromagnetic output, or discontinuities in external magnetic fields, can bias the sensory selectivity of the RAS toward specific frequency bands. This bias is shaped by the interaction of multiple biophysical and environmental synchrony variables, reflecting the sensitivity of the RAS to subtle phase modulations in both internal and external electromagnetic conditions. Consequently, the sensory filter system does not operate as a rigidly deterministic pathway but as a dynamically tuned circuit influenced by magnetic perturbations and resonance conditions.

Variable	Effect
HRV Harmonic Alignment	Enhances sensory selectivity → increased focus, perceptual clarity
Electromagnetic Crosstalk	Elevates phase interference → illusions, hallucinations, sensory distortion
Photon Pressure Elevation	Augments memory circuit uploading or induces sensory overload
Geomagnetic Phase Instability	Triggers channel confusion in RAS, causing filtering errors

Table 4: Physiological and environmental variables influencing sensory gating and resonance dynamics within the heart–brain–RAS system.

These results suggest that sensory selection is not solely brain-internal but can be externally modulated by geophysical resonance structures.

4.6 Conclusion: The RAS as a Phase-Resonant Circuit for Sensory–Memory–Pressure Integration

The Reticular Activating System (RAS) should not be understood as a passive recipient distorted by emotion but rather as a precision resonant filter that is phase-locked to cardiac dynamics, memory processes, and geomagnetic structures. Its filtering criteria are governed not by transient emotional states but by the electromagnetic environment and the degree of internal phase coherence.

Within this framework, emotion is reconceptualized as the manifestation of energy pressure fields generated by phase differences, rather than as the direct outcome of neurotransmitter release. Similarly, memory is not interpreted as information statically encoded in synaptic connections, but as a dynamic process uploaded through resonance with dimensional phase gradients. Together, these insights reposition the RAS as a central phase-resonant circuit that integrates sensory input, memory retrieval, and pressure-induced energetic modulation into a unified regulatory architecture.

Loop	Stimulus Type	Resonance Mechanism	Functional Output
Cardiac–HRV Loop	Pressure, EM field	Coherence entrainment	Emotional regulation, stress buffering
Pineal–Vestibular Loop	Light–EM fluctuation	Phase locking, melatonin modulation	Circadian rhythm, spatial orientation
Amygdala–VNO Loop	Chemosignal (pheromones)	Affective resonance, boundary detection	Social approach/avoidance
Fornix–Brainstem–ANS Loop	Schumann + internal wave	Deep wave synchrony	Intuitive cognition, unconscious memory

Table 5: Core resonance loops linking physiological stimuli, resonance mechanisms, and functional outputs in the heart–brain system.

5 The Sensory–Memory–Affect System as a Phase Network: An HBAM-Based Unified Structure

5.1 Phase-Based Sensory Information Processing

The Heart–Brain Axis Matrix (HBAM) should not be regarded as a mere physiological response system but rather as a multiphase-resonant electromagnetic signal-processing network. Within this framework, sensory input, memory retrieval, and affective state regulation are mediated through resonance frequency interactions, electrical potential gradients, and the condensation of energetic pressure.

The bioelectromagnetic phase architecture of the body can thus be characterized by four key variables, each of which captures a distinct aspect of how sensory information is processed, integrated, and dynamically modulated within the HBAM network. These variables, summarized in the following table, provide the structural and functional parameters necessary for modeling sensory–memory–affective coupling as a unified resonant system.

Phase Variable	Description	Function
Φ_H **(Cardiac Phase)**	Phase coherence of heart rhythm	Serves as the reference clock for the entire system
Φ_M **(Memory Phase)**	Phase coordinates of stored information	Governs conditions for resonant memory retrieval
Φ_G **(Geomagnetic Phase)**	External phase modulation field	Acts as a trigger for phase interference or circuit reconfiguration
Φ_A **(Affective Phase)**	Condensed pressure–potential structure	Central to energetic allocation and emotional responsivity

Table 6: Core phase variables of the HBAM architecture, their descriptions, and system-level functions.

These quantities synchronize with HRV phase spectra, respiratory cycles, and hemodynamic shear stress, dynamically tuning sensory receptor sensitivity, stimulus prioritization, and memory access routes.

5.2 Synchronization Mechanisms Between Phase Variables

The four phase variables do not function as isolated entities but rather operate as interdependent nodes within a unified phase field. Their interactions are governed by synchronization, phase-locking, and resonant interference, which collectively determine the configuration and behavior of the organism's electromagnetic circuitry.

Several key synchronization dynamics can be identified. First, the linkage between cardiac and affective phases indicates that heart HRV patterns modulate both the magnitude and the direction of affective energy flow ($\Phi_H \rightarrow \Phi_A$). Second, a bidirectional coupling exists between geomagnetic and cardiac phases ($\Phi_G \leftrightarrow \Phi_H$), whereby geomagnetic fluctuations modulate cardiac field coherence and thereby reconfigure circuit alignment. Third, coherence between memory and cardiac phases ($\Phi_M \leftrightarrow \Phi_H$) is a prerequisite for memory retrieval, such that the resonance of the heart's phase with stored information coordinates enables access to memory patterns. Finally, specific geomagnetic phase shifts can exert a direct nonlinear influence on memory processes ($\Phi_G \rightarrow \Phi_M$), in some cases triggering the involuntary upload of nonlocally stored information.

5.3 Physical Definition of the Affective Phase (Φ_A)

The affective phase (Φ_A) represents a central structural dimension underpinning autonomic regulation, hormonal release, and energetic resource allocation. Rather than being conceptualized as a purely subjective emotional state, Φ_A is defined as a pressure–potential-based energetic condensation. This condensation is regulated by three primary factors: intracellular and interstitial pressure differentials, bioelectrical gradients across tissue and organ systems, and cyclic positive–negative pressure transitions driven by respiratory rhythms in conjunction with cardiac waveform modulation.

Through these mechanisms, the affective phase achieves synchronization with HRV spectra, respiratory cycles, and hemodynamic shear stress. This dynamic coupling, in turn, tunes sensory receptor sensitivity, establishes stimulus prioritization, and regulates access to memory pathways, thereby embedding affect within the broader HBAM resonance architecture.

5.4 Phase Connectivity of Sensation–Memory–Affect

Ultimately, the HBAM's internal phase network forms a three-stage resonant loop:

$$\text{sensation input} \quad \rightarrow \quad \text{memory activation} \quad \rightarrow \quad \text{affective response}$$

This is not a linear information flow but a nonlinear phase-resonant circuit, where phase alignment takes precedence over temporal sequencing. The HBAM structural framework is illustrated in Figure 3.

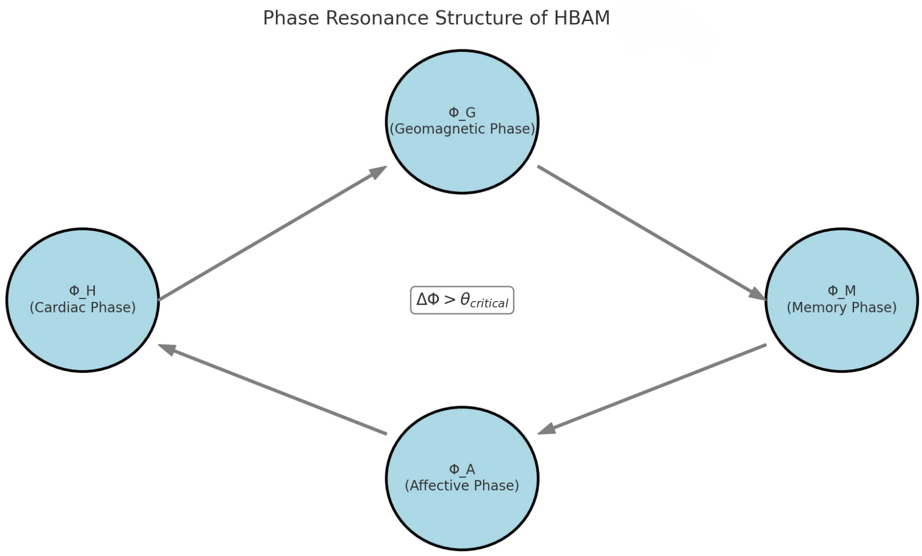

Figure 3: Phase resonance structure of HBAM, illustrating the coupling of cardiac, affective, memory, and geomagnetic phases.

To illustrate the interplay between internal and external phase elements within this bioresonant system, the following diagram summarizes the dynamic configuration of cardiac, affective, memory, and geomagnetic phases.

5.5 Theoretical Implications and Applications

The proposed model carries several paradigm-shifting implications that extend beyond conventional interpretations of sensory–memory–affect integration. First, affect should not be understood as a cognitively labeled feeling but rather as an energetic phase configuration that precedes conscious awareness. Second, memory cannot be regarded as localized exclusively within neural tissue; instead, it exists as a distributed information field that becomes accessible only under specific conditions of phase resonance. Third, the heart must be reconceptualized not as a mere circulatory pump but as a rhythmic controller that regulates electromagnetic phase coherence across bodily systems. Finally, environmental changes—such as barometric pressure fluctuations, magnetospheric turbulence, or geomagnetic discontinuities—can directly modulate the affective system, thereby shaping cognition and sensory unfolding in real time.

In addition to these conceptual insights, the resonance model may be formalized through phase-based mathematical expressions that capture the critical conditions for memory activation, emotional modulation, and geomagnetic synchronization. The following table summarizes the core phase relationships within the HBAM framework.

Relationship	Formula / Condition	Interpretation
Memory Upload Trigger	$\Delta\Phi > \theta_{\text{critical}}$	Memory circuits activate nonlinearly when phase difference exceeds a threshold
Geomagnetic–Cardiac Alignment	$\Phi_H \approx \Phi_G \pm \varepsilon$	Cardiac and geomagnetic phases align when within a small tolerance ε
Affective Response Condition	$\frac{d\Phi_A}{dt} \neq 0$	Emotional response occurs when affective phase dynamically changes over time
Resonant Memory Recall	$\Phi_H \approx \Phi_M \pm k\pi$	Memory retrieval occurs when heart and memory phases resonate harmonically

Table 7: Key phase relationships within the HBAM framework, linking mathematical conditions to physiological and cognitive interpretations.

Beyond systemic correlations, recent cellular-level evidence provides further support for the role of Schumann resonance in bioelectromagnetic regulation. Lefebvre et al. (Lefebvre et al., 2024) demonstrated that PC-12 neural cells exposed to electromagnetic fields tuned to inherent Schumann frequencies exhibited altered neurite growth and electrical activity. When combined with findings that geomagnetic perturbations modulate EEG dynamics and HRV in humans (Alabdulgader et al., 2018; Caswell et al., 2016; Vieira et al., 2022), these results suggest that resonance phenomena operate across multiple biological scales—from the cellular domain to whole-organism physiological rhythms. This multiscale coherence reinforces the HBAM framework, positioning it as a unifying model for understanding how environmental electromagnetic structures shape both neural dynamics and affective-cognitive processes.
Taken together, these phase relationships and their multiscale empirical support are summarized schematically in Figure 4.

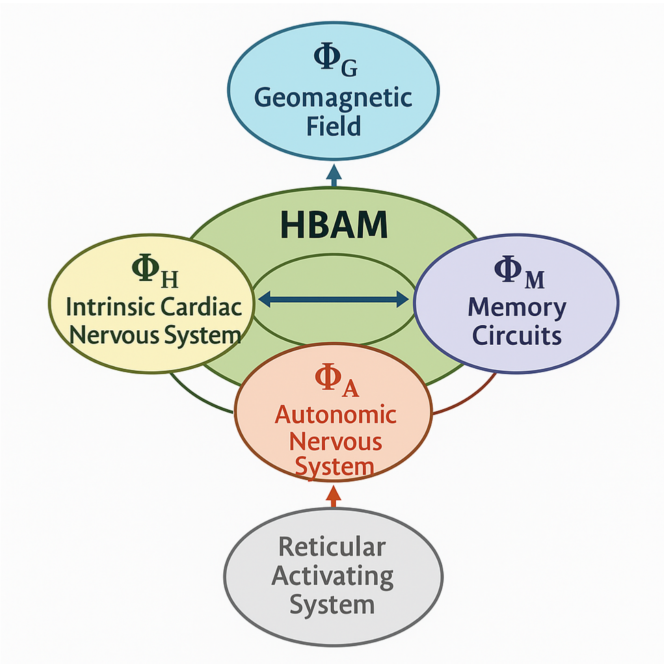

Figure 4: HBAM framework showing phase relationships, conditions, and interpretations across neural and geomagnetic systems.

6 General Summary and Future Propositions

6.1 Summary of Core Concepts

This study presents an integrative analysis of the operational mechanisms underlying the Heart–Brain Axis Matrix (HBAM) in relation to the sensory–memory–RAS system, framed within the broader theoretical contexts of bioelectromagnetics, phase-based neurodynamics, and epigenetics.

Departing from conventional emotion-centric models of physiology, this work redefines the key concepts of emotion, memory, and sensory selection in phase-resonant terms. Emotion is described as a pre-conscious affective phase state (Φ_A), reflecting energetic configurations that precede cognitive labeling. Memory is reconceptualized as an electromagnetically uploadable structure defined by spatial phase coordinates (Φ_M), accessible through resonance conditions rather than fixed synaptic encoding. Sensory selection, in turn, is characterized as a phase-resonant mechanism governed by potential differentials and implemented through RAS filtering dynamics. Together, these redefinitions establish a coherent framework for understanding the HBAM as a unified bioelectromagnetic network.

Phase Element	Interpretation	Synchronization Target
Φ_H **(Cardiac Phase)**	Central reference phase based on HRV coherence	Geomagnetic field, sensory circuits
Φ_A **(Affective Phase)**	Energetic flow-based pre-conscious state	HRV, memory circuits
Φ_M **(Memory Phase)**	Phase coordinate of stored past information	Affect system, external triggers
Φ_G **(Geomagnetic Phase)**	External phase modulation and field triggers	HBAM, sensory interface

Table 8: Key summary table of HBAM phase elements, their interpretations, and synchronization targets.

Symbol	Name	Description
Φ_H	**Cardiac Phase**	Phase coherence of heart rhythm; serves as the master clock of the system
Φ_M	**Memory Phase**	Phase coordinate of stored information; activated via resonance conditions
Φ_A	**Affective Phase**	Pressure-based phase structure representing emotional energy distribution
Φ_G	**Geomagnetic Phase**	Phase structure of the external geomagnetic field; modulates circuit reset or interference

Table 9: Glossary of phase variables within the HBAM framework. Each symbol is defined in terms of its physiological interpretation and resonance function, serving as a concise reference for Section 6.

The heart is reconceptualized not as a mere circulatory pump but as an oscillatory generator forming phase resonance structures. The RAS is not a passive emotional filter but an active resonator that selects frequencies based on external phase input. The HBAM functions as a central rhythmic matrix, unifying all phase variables and establishing the reference phase anchor of the organism's internal circuitry. Taken together, these insights provide a consolidated theoretical representation of the integrated phase resonance framework developed in this study.

6.2 Proposed Extensions and Theoretical Directions

Several extensions of the HBAM framework are proposed for future theoretical development and empirical investigation. One direction involves the integration of a magneto-navigational system mediated by the vomeronasal organ. As a subordinate structure of the olfactory system, the vomeronasal organ is hypothesized to detect external geomagnetic phase shifts and to connect with the brainstem–thalamus–prefrontal cortex circuit, thereby functioning as a potential component of directional sensing. Within the HBAM-mediated sensory–memory–selection framework, its inclusion may provide a novel explanatory pathway, and future research should examine its evolutionary origins and experimental validation.

A second direction concerns the development of a geomagnetic-synchronized epigenetic model. Whereas conventional epigenetics has primarily emphasized chemical modifications, the present framework advances a phase-based initialization model governed by electromagnetic field synchrony. Genetic information is thus interpreted not as a rigid determinant but as a starting condition, with birth-time geomagnetic phase alignment and photoperiodic structure exerting decisive influence in shaping the organism's initial bioelectrical potential landscape.

A third extension redefines memory through a phase space model. In this view, memory is not a fixed neural construct but a resonant domain within phase-locked electromagnetic space, subject to upload and download dynamics. Its activation is modulated by variables such as HRV, physiological pressure, and magnetic perturbations. Consequently, memory must be understood not as static storage but as a dynamic phase-exchange mechanism embedded within the HBAM network.

6.3 Final Reflections

This study reorganizes the traditional neuropsychological triad of emotion, memory, and sensation within a bioelectromagnetic foundation. The heart is defined simultaneously as an emotional organ and as the central rhythm-setting system that determines the phase architecture of sensory selection. The Reticular Activating System (RAS), in turn, is repositioned as a wave-selective interface embedded within the HBAM structure. Within this framework, emotion is not regarded as a biochemical reaction but as a phenomenological expression of pressure-based phase energy.

The novelty of this approach lies in its integrative scope. While previous studies have documented important correlations between geomagnetic activity and physiological rhythms, the HBAM model extends these observations by offering a coherent phase-based framework that connects cellular activity, autonomic regulation, and higher-order cognition. By reconceptualizing emotion as a phase phenomenon and memory as a resonance-based process, the HBAM contributes a complementary paradigm for understanding how human perception and consciousness emerge from the dynamic interplay of cardiac, neural, and geomagnetic fields.

In essence, perception is reframed not as the passive reception of sensory stimuli but as an active process of phase synchronization, wherein cognition and affect are continuously tuned through resonant coupling across multiple biological and environmental scales. This paradigm suggests that human consciousness itself may be inseparable from the electromagnetic coherence that links the heart, brain, and the geophysical environment.

Declaration

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