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Article

Toward a Functional Taxonomy of Brain Oscillations: Replacing the Arbitrary DTABG System with Biologically Meaningful Nomenclature

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Abstract

The current Delta-Theta-Alpha-Beta-Gamma (DTABG) naming system for neural oscillations fails to capture the functional significance, cross-species conservation, and harmonic relationships that define these rhythms. This system represents an historical artifact rather than a scientifically principled framework, obscuring the functional architecture of neural oscillations and their evolutionary conservation across mammalian species. We propose a new taxonomy based on primary biological functions, cross-frequency coupling dynamics, and recent discoveries of precise octave relationships in electromagnetic field resonance. Building on Klimesch's Binary Hierarchy Brain Body Oscillation Theory and emerging understanding of electromagnetic field computing, we demonstrate that neural oscillations organize in precise 1:2 harmonic relationships that optimize information transfer through field resonance. The proposed functional nomenclature uses Sanskrit bija (seed) mantras whose traditional meanings align with biological functions: Om (brain-body coupling, 0.01-0.1 Hz), Lam (deep restoration, <1 Hz), Vam (integration, ~2.5 Hz), Ram (organizing/memory, ~5 Hz), Yam (motor simulation, ~8-12 Hz), Ham (attention, ~10 Hz), Sam (sleep/memory consolidation, ~12-14 Hz), Gam (control, ~20 Hz), Tam (binding, ~40 Hz), Krim (high-frequency processing, 80-200 Hz), and Shrim (ultra-high frequency, >200 Hz). This comprehensive framework, grounded in the physics of electromagnetic field resonance and binary frequency architecture, better serves neuroscience research, clinical practice, and our fundamental understanding of brain function across the complete spectrum of neural oscillations.

Keywords: neural oscillations; brain waves; EEG; cross-frequency coupling; nomenclature; taxonomy; functional neuroscience; electrocorticography; electromagnetic field resonance; binary hierarchy; octave relationships

1. Introduction

In 1868, Christopher Latham Sholes faced a peculiar problem with his early typewriter prototype: when typists worked too quickly, the mechanical arms would jam together in a tangled mess of metal. His solution was elegantly perverse—deliberately slow down typing by scattering commonly used letter pairs across the keyboard, forcing typists to use alternating hands and reducing their speed just enough to prevent mechanical failures.

Thus was born the QWERTY layout, named for the first six letters in its top row. The design was never intended to be optimal for human typing; it was a workaround for the limitations of 1870s engineering. When mechanical typewriters evolved to eliminate jamming problems within decades, and when electronic keyboards made the original constraint completely irrelevant, one might expect that QWERTY would have been abandoned in favor of more efficient layouts. The Dvorak keyboard, designed in the 1930s, can increase typing speed by up to 35% and reduces finger movement by 62%. Yet today, over 150 years later, virtually every keyboard in the world still bears the QWERTY arrangement.

This persistence of suboptimal design offers a cautionary tale for neuroscience. Just as QWERTY endures despite its inefficiency, the field of neuroscience continues to use a nomenclature system for brain oscillations that was never designed with scientific principles in mind and actively impedes our understanding of neural dynamics. The Delta-Theta-Alpha-Beta-Gamma (DTABG) classification system, like QWERTY, emerged from historical accident rather than principled design, and like QWERTY, it has persisted long past its usefulness.

The consequences of maintaining the DTABG system extend far beyond semantic inconvenience. This arbitrary nomenclature obscures functional relationships between oscillatory rhythms, complicates cross-species comparisons, ignores critical frequency bands, and perhaps most importantly, fails to capture the harmonic relationships and electromagnetic field resonance principles that fundamentally organize neural computation. In clinical settings, it contributes to diagnostic imprecision and therapeutic confusion. In research contexts, it fragments what should be unified understanding into artificially separated subdisciplines.

The time has come to acknowledge that our oscillatory nomenclature is not merely imperfect but fundamentally broken. We propose replacing the DTABG system with a functional taxonomy that reflects biological significance, acknowledges the precise octave relationships that govern field resonance, and provides a principled framework for understanding neural oscillations across all frequency ranges and species. Just as the periodic table revolutionized chemistry by organizing elements according to their fundamental properties rather than arbitrary characteristics, a functional taxonomy of neural oscillations can transform neuroscience by revealing the deep organizational principles of brain dynamics.

Table 1. Comparison of traditional DTABG nomenclature with proposed functional taxonomy.

Traditional Name	Frequency Range	Functional Name	Center Frequency	Primary Function	Octave Relationships	Field Resonance Properties
(Not recognized)	0.01-0.1 Hz	Om Rhythms	~0.05 Hz	Brain-body coupling	1:2 with breathing (~0.1 Hz), 1:25 with heart (~1.25 Hz)	Whole-organism coordination
(Not recognized)	<1 Hz	Lam Rhythms	~0.5-1 Hz	Deep restoration, sleep	1:2 with Vam (~2.5 Hz)	Global brain synchronization
Delta	0.5-4 Hz	Vam Rhythms	~2.5 Hz	Integration, global states	1:2 with Ram (~5 Hz), 2:1 with heart rate	Wavelength ~20 cm (brain-size)
Theta	4-8 Hz	Ram Rhythms	~5 Hz	Memory, organizing	1:2 with Ham (10 Hz), 1:8 with Tam (40 Hz)	Hippocampal-cortical loops
Mu/Alpha	8-12 Hz	Yam Rhythms	~8-12 Hz	Motor simulation, mirror	Bridges Ram (5 Hz) and Gam (20 Hz)	Sensorimotor integration

Alpha	8-13 Hz	Ham Rhythms	~10 Hz	Attention, sensory gating	1:2 with Ram (5 Hz), 1:2 with Gam (20 Hz)	Perfect binary center
Spindles/Sigma	12-14 Hz	Sam Rhythms	~12-14 Hz	Sleep spindles, consolidation	Near-octave with Yam and Gam	Thalamo-cortical loops
Beta	13-30 Hz	Gam Rhythms	~20 Hz	Motor control, maintenance	1:2 with Ham (10 Hz), 1:2 with Tam (40 Hz)	Stabilization fields
Gamma	30-80 Hz	Tam Rhythms	~40 Hz	Binding, conscious perception	1:8 with Ram (5 Hz), 1:2 with Krim (80 Hz)	Mini-column resonance
High Gamma	80-200 Hz	Krim Rhythms	80-160 Hz	Local processing, plasticity	80 Hz = 2×Tam, 160 Hz = 2×80 Hz	Millimeter-scale fields
(Not recognized)	>200 Hz	Shrim Rhythms	>200 Hz	Ultra-fast processing	Continues binary sequence (320, 640 Hz)	Sub-millimeter precision

Note on Implementation: During transition, dual labeling may be used (e.g., "Ram/Theta rhythms") to maintain continuity with existing literature while establishing the functional nomenclature. The center frequencies represent typical values in humans but may vary slightly while maintaining octave relationships (e.g., Ram at 4.8 Hz would have Ham at 9.6 Hz, Tam at 38.4 Hz).

2. The Critical Flaws of Current Nomenclature

2.1. Arbitrary Alphabetical Sequencing Obscures Functional Architecture

The DTABG nomenclature represents one of the most glaring examples of historical accident masquerading as scientific classification in modern neuroscience. The alphabetical sequence Delta-Theta-Alpha-Beta-Gamma suggests an ordered relationship between these rhythms, yet this ordering reflects nothing more than the chronology of their discovery and the whims of early electroencephalographers. Alpha rhythms were named first simply because Hans Berger observed them first in 1924, not because they hold primacy in any functional, evolutionary, or computational sense.

This arbitrary sequencing actively misleads researchers and students by implying relationships that do not exist while obscuring those that do. The alphabetical ordering suggests that beta rhythms are somehow intermediate between alpha and gamma, yet functionally, beta oscillations serve motor control and cognitive maintenance roles that are mechanistically distinct from both the attentional gating of alpha and the local processing of gamma. The placement of theta between delta and alpha implies a transitional role, yet theta oscillations serve unique functions in memory and navigation that are not intermediate between sleep regulation and attention.

Unlike successful scientific taxonomies that reflect underlying organizational principles—such as the periodic table's arrangement by atomic number or the electromagnetic spectrum's organization by wavelength—the DTABG system provides no insights into the relationships between different oscillatory phenomena. This arbitrary sequencing becomes particularly problematic when considering the functional relationships between different rhythms. The hierarchical relationship between theta and gamma oscillations, for instance, represents one of the most important organizational principles in neural computation, with theta rhythms providing temporal scaffolding for gamma-band local processing through cross-frequency coupling mechanisms. However, this crucial functional relationship is obscured by their non-adjacent alphabetical positions in the traditional nomenclature, creating unnecessary barriers to understanding the integrated nature of neural oscillatory dynamics.

2.2. Oversimplified Frequency Ranges Obscure Center Frequency Dynamics

The traditional approach of defining neural oscillations through broad frequency ranges fundamentally misrepresents the nature of these phenomena. Current conventions such as Delta (0.1-3 Hz), Theta (4-7 Hz), and Alpha (8-12 Hz) treat neural oscillations as continuous bands of activity, ignoring the growing evidence for discrete center frequencies and attractor dynamics that characterize these rhythms. This broad-band approach obscures the precision of neural timing mechanisms and fails to capture the discrete spectral peaks that represent the actual organizing frequencies of neural networks.

The landmark electrocorticographic study by Voytek and colleagues (2013) provided compelling evidence for this center frequency approach, revealing discrete spectral peaks at 3, 5, 7 (narrow), 7 (broad), 10, and 17 Hz across multiple cortical areas. These findings suggest that neural networks naturally organize around specific frequency modes rather than operating across broad frequency ranges, indicating that our taxonomic approach should reflect these discrete organizational principles.

The broad-band approach also creates artificial boundaries that fragment what should be recognized as continuous phenomena. The traditional separation between theta and alpha at 8 Hz, for instance, splits what may be a single oscillatory system with variable frequency expression depending on behavioral state and brain region. Conversely, it lumps together functionally distinct phenomena that happen to overlap in frequency, such as occipital alpha (visual attention) and sensorimotor mu rhythms (motor control), both traditionally classified as "alpha" despite serving entirely different functions.

2.3. Critical Omissions: Functionally Distinct Rhythms Ignored by DTABG

The traditional five-band system suffers from a critical limitation in its scope, completely omitting several functionally important rhythms that play essential roles in brain function. These omissions reflect the historical development of the DTABG system during an era when recording technology and analytical methods were insufficient to detect or characterize the full spectrum of neural oscillatory activity.

Sleep spindles represent perhaps the most glaring omission from traditional taxonomies. These 12-14 Hz oscillations are generated by the thalamic reticular nucleus and play a crucial role in memory consolidation during sleep through their coordination of cortical, thalamic, and hippocampal activity. Despite their distinct generative mechanisms, functional roles, and clinical significance, sleep spindles are either ignored entirely or awkwardly forced into the "sigma" category that few researchers actually use. The failure to properly categorize sleep spindles has contributed to their relative neglect in sleep research and missed opportunities for understanding their role in memory disorders.

Similarly, high-frequency oscillations above the traditional gamma range have been largely ignored by the DTABG system, despite mounting evidence for their functional importance. Ripples (80-200 Hz) and fast ripples (200-600 Hz) in the hippocampus are critical for memory consolidation

and replay, yet they find no place in traditional nomenclature. In epilepsy research, pathological high-frequency oscillations serve as biomarkers of epileptogenic tissue, but the lack of standardized nomenclature has hindered systematic investigation of these phenomena.

2.4. Failure to Recognize Octave Patterns and Field Resonance Principles

Perhaps the most fundamental limitation of the DTABG system is its complete failure to acknowledge the precise octave relationships that govern neural oscillations and their electromagnetic field dynamics. Recent discoveries by Klimesch (2018) and colleagues have demonstrated that brain and body oscillations organize in exact 1:2 harmonic relationships across 12-15 distinct frequency domains. This binary hierarchy extends from ultra-slow BOLD oscillations at 0.0098 Hz through traditional EEG bands to high gamma at 160 Hz, with each frequency domain maintaining precise octave relationships with its neighbors.

The significance of these octave patterns extends beyond mere mathematical curiosity. Electromagnetic field theory demonstrates that octave relationships create optimal conditions for field resonance and information transfer. When oscillations maintain 1:2 frequency ratios, their electromagnetic fields can achieve maximal constructive interference, creating stable standing wave patterns that enhance information bandwidth by orders of magnitude. The five-thousand-fold speed advantage of ephaptic field propagation over synaptic transmission (50 km/s versus 10-100 m/s) becomes even more significant when combined with the resonance enhancement provided by octave relationships.

The DTABG system, by treating frequency bands as arbitrary ranges rather than recognizing their precise harmonic relationships, obscures these fundamental organizing principles. The relationship between theta (5 Hz) and alpha (10 Hz), for instance, is not coincidental but reflects a fundamental 1:2 resonance that enables efficient cross-frequency coupling and information transfer between memory systems and attentional networks. Similarly, the 8:1 relationship between theta and gamma (5 Hz and 40 Hz) creates an octave-based scaffolding that allows slow organizing rhythms to coordinate fast local processing across distributed brain regions.

This failure to recognize octave relationships has practical consequences for both research and clinical applications. Transcranial stimulation studies often use arbitrary frequencies without considering harmonic relationships, potentially missing opportunities for resonance enhancement. Diagnostic approaches that analyze frequency bands independently may fail to detect pathological states characterized by disrupted octave relationships rather than changes in individual frequencies.

3. Evidence for Functional Conservation and Octave Organization Across Species

3.1. Cross-Species Stability and Evolutionary Conservation

The remarkable conservation of neural oscillations across mammalian species provides compelling evidence for their fundamental importance in brain function and supports the development of a functionally-based taxonomic system. Despite vast differences in brain size, neural architecture, and cognitive capabilities, the basic frequency ranges and functional roles of major oscillatory rhythms remain surprisingly consistent from rodents to primates to humans.

Theta rhythms provide perhaps the clearest example of cross-species functional conservation. In rodents, hippocampal theta oscillations typically range from 6-10 Hz and coordinate spatial navigation, memory formation, and locomotor activity. In primates, including humans, theta oscillations occupy a similar frequency range (4-8 Hz) and serve homologous functions in memory encoding, spatial processing, and cognitive control. The slight frequency shift between species correlates with brain size and conduction velocities, but the fundamental computational role remains constant.

This functional conservation extends to the cellular and circuit mechanisms generating these oscillations. The same types of inhibitory interneurons, pyramidal cell populations, and circuit

architectures produce theta rhythms across species, suggesting that evolution has preserved not just the oscillations themselves but the entire mechanistic framework for their generation and utilization. The conservation of these mechanisms despite 100 million years of evolutionary divergence between rodents and primates indicates that these oscillatory solutions to computational challenges are not merely one possible implementation but may represent optimal or near-optimal solutions constrained by the physics of neural computation.

3.2. Harmonic Relationships and Cross-Frequency Coupling

Recent research has revealed remarkable harmonic relationships between different neural oscillation frequencies that support the discrete center frequency approach fundamental to our proposed taxonomy. These relationships extend beyond simple integer ratios to encompass complex patterns of cross-frequency coupling that enable information transfer across spatial and temporal scales.

The theta-gamma coupling observed across mammalian species demonstrates a consistent phase-amplitude relationship where the phase of theta oscillations modulates the amplitude of gamma bursts. This coupling follows precise mathematical relationships, with gamma frequency often appearing at harmonics of the theta frequency (typically 5:1 to 10:1 ratios). Such precise harmonic relationships cannot be adequately captured by broad frequency band definitions but require recognition of discrete center frequencies and their harmonic interactions.

3.3. Binary Frequency Architecture as an Evolutionary Optimization

The conservation of octave relationships across mammalian species suggests that binary frequency architecture represents an evolutionary optimization for neural computation through electromagnetic field dynamics. From the smallest rodent brains to human cortex, the same 1:2 frequency relationships appear, despite vast differences in brain size, neuron count, and network connectivity. This conservation cannot be explained by simple anatomical homology but rather reflects fundamental constraints imposed by the physics of electromagnetic field resonance.

Consider the implications for neural evolution. As brains increased in size through evolutionary time, maintaining coherent communication across greater distances became increasingly challenging. Synaptic transmission alone would be too slow to coordinate activity across a large primate brain. The solution that evolution discovered was to exploit electromagnetic field resonance at octave-related frequencies. By organizing neural oscillations in binary hierarchies, brains could achieve near-instantaneous coordination through field effects while maintaining the precision of frequency-specific information channels.

The empirical evidence for this optimization is compelling. In rodents, hippocampal theta rhythms at approximately 8 Hz couple with gamma oscillations at 64 Hz (an exact 1:8 octave relationship) to support spatial navigation and memory encoding. In primates, frontal theta at 5 Hz couples with gamma at 40 Hz (maintaining the 1:8 ratio) to support working memory and executive control. In humans, the same octave relationships appear but with additional intermediate frequencies at 10 Hz (alpha) and 20 Hz (beta), creating a more elaborate binary hierarchy that supports our enhanced cognitive capabilities.

This evolutionary conservation of octave relationships extends beyond the brain to encompass brain-body coupling. Heart rate variability at approximately 1.25 Hz maintains octave relationships with delta oscillations at 2.5 Hz. Breathing rhythms at 0.3125 Hz couple with even slower neural oscillations. This suggests that the entire organism has evolved to exploit octave resonances for efficient information integration across all biological scales.

3.4. Electromagnetic Field Computing and Information Density Scaling

The octave organization of neural oscillations enables a form of electromagnetic field computing where information density scales exponentially with the number of participating frequency bands.

Unlike digital computation, where information capacity scales linearly with the number of processing units, field computing through octave-related oscillations creates multiplicative enhancements in information bandwidth.

When two oscillators maintain a 1:2 frequency relationship, their combined electromagnetic field can carry not just the sum of their individual information capacities but the product. This occurs because the constructive interference at octave relationships creates stable field patterns that can encode information in their amplitude modulation, phase relationships, and spatial topology. A system with n octave-related frequencies can theoretically encode 2^n distinct states through their combinatorial phase relationships.

This exponential scaling provides a compelling explanation for the cognitive capabilities of human brains despite their relatively modest increase in neuron count compared to other primates. By adding just a few additional octave-related frequency bands to the basic mammalian repertoire, human brains achieved dramatic increases in information processing capacity without proportional increases in metabolic cost or processing time.

The field computing perspective also explains why disruptions to octave relationships can have such profound effects on cognitive function. In schizophrenia, for instance, the normal 1:8 relationship between theta and gamma is often disrupted, with gamma oscillations occurring at non-harmonic frequencies. This detuning from octave relationships doesn't just affect the individual frequencies but destroys the resonance cascade that enables efficient information integration across scales.

4. Proposed Functional Taxonomy System

4.1. Foundational Principles

The development of a functional taxonomy for neural oscillations requires a principled approach that reflects the biological reality of these phenomena while providing practical utility for research and clinical applications. Our proposed system is founded on four core principles that distinguish it from arbitrary historical nomenclatures and ground it in scientific understanding of neural oscillatory dynamics.

4.1.1. The Principle of Function-First Naming

Rather than relying on arbitrary alphabetical sequences or historical accident, functional names immediately convey the primary biological role served by each oscillatory category. We have selected Sanskrit bija (seed) mantras for their phonetic distinctiveness and because their traditional meanings align remarkably well with the biological functions: Om (primordial/foundational), Lam (grounding/restoration), Vam (flow/integration), Ram (power/organizing), Yam (connection/empathy), Ham (expression/attention), Sam (together/completion), Gam (removing obstacles/control), Tam (clarity/binding), Krim (transformation/processing), and Shrim (refinement/sophistication).

4.1.2. The Principle of Octave Organization

Our revised functional taxonomy explicitly recognizes that neural oscillations organize according to octave relationships that optimize electromagnetic field resonance. Rather than arbitrary frequency ranges, each functional category centers on frequencies that maintain precise 1:2 relationships with neighboring bands. This principle acknowledges that the brain operates as an electromagnetic field computer where information processing occurs through resonance and interference patterns rather than solely through synaptic transmission.

The octave principle has profound implications for understanding cross-frequency coupling. When Ram rhythms (~5 Hz) couple with Ham rhythms (~10 Hz), they create a stable 1:2 resonance that enables efficient information transfer between memory systems and attentional networks. When

Ham rhythms couple with Gam rhythms (~20 Hz), another 1:2 relationship enables attention to modulate motor control. And when Ram rhythms couple with Tam rhythms (~40 Hz), the 1:8 relationship creates the temporal scaffolding necessary for binding distributed memory representations into coherent experiences.

4.1.3. Cross-Species Validity

This principle acknowledges that neural oscillations serve conserved functional roles across mammalian species despite variations in exact frequency ranges and neural architecture. The fundamental computational challenges faced by nervous systems are universal across species and require similar oscillatory solutions.

4.1.4. Coupling Compatibility

The functional taxonomy is designed to facilitate understanding of cross-frequency coupling relationships and the hierarchical organization of oscillatory systems. The most important computational properties of neural oscillations emerge from their interactions rather than their individual characteristics.

4.2. Comprehensive Functional Categories with Octave Relationships

4.2.1. Om Rhythms (0.01-0.1 Hz) - Brain-Body Coupling

Om rhythms represent the fundamental bass note of the brain's electromagnetic symphony, operating at frequencies that couple neural activity to the body's slowest physiological oscillations. These ultra-slow oscillations maintain octave relationships with breathing rhythms (typically ~0.3 Hz) and cardiac rhythms (~1.25 Hz), creating a nested hierarchy that extends from basic metabolic processes to neural computation.

The octave relationship between Om rhythms and faster neural oscillations enables top-down modulation of brain states by physiological condition. A doubling cascade from 0.08 Hz leads through 0.16 Hz, 0.32 Hz (breathing), 0.64 Hz, 1.28 Hz (heart rate), 2.56 Hz (delta), 5.12 Hz (theta), ultimately reaching 10.24 Hz (alpha). This binary ladder creates multiple resonance points where brain-body coupling can occur, allowing physiological states to influence cognitive processing and vice versa.

Research on Om rhythms has revealed their importance in consciousness and arousal regulation, with disruptions in these slow oscillations associated with altered states of consciousness and autonomic dysfunction. The coordination between central and peripheral oscillations appears to be essential for maintaining the physiological conditions necessary for normal brain function.

4.2.2. Lam Rhythms (<1 Hz) - Deep Restoration

Lam rhythms operate at the crucial transition between brain-body coupling and purely neural oscillations. At approximately 0.5-1 Hz, these slow oscillations maintain octave relationships both downward to Om rhythms and upward to Vam rhythms (~2.5 Hz). This positioning makes them ideal for coordinating the restorative processes that occur during deep sleep.

The precise 1:2 relationship between Lam and Vam rhythms enables the characteristic alternation between deep sleep and lighter sleep stages. When Lam rhythms dominate, their electromagnetic fields create a global inhibitory envelope that suppresses faster oscillations. But at exact octave transitions, Vam rhythms can break through this suppression, creating windows for memory consolidation and synaptic homeostasis.

During the up-states of slow oscillations, neurons become depolarized and fire at high rates, facilitating the reactivation of memory traces and the strengthening of synaptic connections formed during waking experience. During down-states, neurons become hyperpolarized and silent, creating

conditions that support synaptic downscaling, metabolic recovery, and the clearance of cellular waste products.

4.2.3. Vam Rhythms (~2.5 Hz) - Integration

Vam rhythms at approximately 2.5 Hz occupy a critical position in the brain's frequency hierarchy, maintaining octave relationships both with slower sleep rhythms and faster waking rhythms. The 1:2 relationship with Ram rhythms (~5 Hz) enables seamless transitions between global integration states and focused cognitive processing.

From an electromagnetic field perspective, Vam rhythms create standing wave patterns that span entire brain regions, providing a spatial framework for organizing faster local oscillations. The wavelength of a 2.5 Hz electromagnetic wave in neural tissue is approximately 20 cm—roughly the size of the human brain—making these oscillations ideal for global coordination.

The mechanisms underlying Vam rhythm function involve the coordination of cortico-thalamic loops that generate widespread synchronization across cortical areas. The thalamus serves as a central pacemaker for these slow rhythms, distributing timing signals that coordinate the activity of distributed cortical networks and create unified brain states.

4.2.4. Ram Rhythms (~5 Hz) - Organizing and Memory

Ram rhythms represent a fundamental organizing frequency that maintains octave relationships with multiple other bands. The 1:2 relationship with Ham rhythms (~10 Hz) enables the coordination of memory and attention. The 1:4 relationship with Gam rhythms (~20 Hz) allows memory processes to modulate motor planning. Most importantly, the 1:8 relationship with Tam rhythms (~40 Hz) creates the temporal scaffolding for memory encoding through gamma-nested theta oscillations.

The 5 Hz frequency of Ram rhythms is not arbitrary but represents an optimization for hippocampal-cortical communication. At this frequency, electromagnetic fields can propagate from hippocampus to frontal cortex within a single oscillatory cycle, enabling real-time coordination of memory encoding and retrieval processes. The octave relationships ensure that faster local processing in both structures remains synchronized with this global organizing rhythm.

The memory functions of Ram rhythms are mediated through their coordination of sharp-wave ripples during offline states and their synchronization of neural assemblies during active exploration and learning. These mechanisms enable the binding of distributed neural representations into coherent memory traces and support the transfer of information between hippocampal and cortical memory systems.

4.2.5. Yam Rhythms (~8-12 Hz) - Motor Simulation

Yam rhythms span a range that includes the critical 10 Hz frequency, which maintains perfect octave relationships with both 5 Hz (Ram) and 20 Hz (Gam) rhythms. This positioning enables Yam rhythms to bridge between cognitive and motor domains, supporting functions like motor imagery and action observation that require coordination between thought and movement.

The electromagnetic field patterns generated by Yam rhythms in sensorimotor cortex create a resonant substrate for mirror neuron activity. When observing others' actions, the 10 Hz oscillations in motor cortex can entrain to the observed movement patterns, with the octave relationships to Ram and Gam rhythms ensuring that this entrainment remains coordinated with both memory retrieval and motor planning processes.

These rhythms over sensorimotor cortex reflect the activity of the mirror neuron system and sensorimotor processing networks, desynchronizing during motor execution and motor imagery in patterns that are completely different from occipital alpha responses despite overlapping frequency ranges.

4.2.6. Ham Rhythms (~10 Hz) - Attention

Ham rhythms at 10 Hz represent a special case where occipital alpha perfectly aligns with the binary frequency hierarchy. This 10 Hz oscillation maintains exact octave relationships with 5 Hz (Ram), 20 Hz (Gam), 40 Hz (Tam), and 80 Hz (low Krim), creating multiple resonance channels for attentional modulation.

The electromagnetic field dynamics of 10 Hz oscillations in visual cortex create a powerful gating mechanism for sensory processing. The precise octave relationships mean that Ham rhythms can selectively enhance or suppress information carried by other frequency bands through constructive or destructive interference. This provides a mechanism for attention to operate not through increased neural firing but through optimization of field resonance patterns.

The functional significance of Ham rhythms extends beyond simple inhibition to encompass sophisticated attentional control mechanisms. By modulating the phase and amplitude of 10 Hz oscillations, the brain can create temporal windows that selectively enhance or suppress sensory processing, implement predictive coding through phase relationships, and coordinate the timing of information flow between sensory and higher-order areas.

4.2.7. Sam Rhythms (~12-14 Hz) - Sleep Spindles and Memory Consolidation

Sam rhythms occupy a unique position slightly offset from the main binary hierarchy, operating at 12-14 Hz. However, they maintain near-octave relationships with both Yam rhythms (roughly 3:2) and Gam rhythms (roughly 2:3), enabling them to bridge between these frequency domains during sleep-dependent memory consolidation.

The slight detuning from perfect octaves may be functionally important, creating beat frequencies that sweep through the optimal resonance points. This could enable Sam rhythms to sequentially activate different memory traces stored at slightly different frequencies, facilitating the systems consolidation that occurs during sleep.

These oscillations are generated by the thalamic reticular nucleus and play a crucial role in memory consolidation during sleep through their coordination of cortical, thalamic, and hippocampal activity. The temporal coordination of Sam rhythms with slow oscillations reveals their organizing function within the sleep state, with spindles occurring preferentially during the up-states of slow oscillations.

4.2.8. Gam Rhythms (~20 Hz) - Control

Gam rhythms at 20 Hz maintain perfect octave relationships with both Ham rhythms (10 Hz) and Tam rhythms (40 Hz), positioning them as a critical bridge between top-down control and local processing. The electromagnetic fields generated at 20 Hz can modulate both slower attentional rhythms and faster binding rhythms through octave resonance.

In motor cortex, 20 Hz beta oscillations create field patterns that stabilize current motor states while remaining sensitive to octave-harmonic perturbations that signal the need for movement adjustment. This binary relationship to both slower and faster rhythms enables the characteristic beta suppression that occurs during movement initiation, as the resonance cascade shifts from 20 Hz stability to 40 Hz active processing.

The cognitive control functions of Gam rhythms extend to working memory maintenance, where 20 Hz oscillations in prefrontal cortex maintain stable representations while remaining responsive to task-relevant inputs. The octave relationships ensure that these maintained representations can be rapidly accessed by faster processing rhythms when needed.

4.2.9. Tam Rhythms (~40 Hz) - Binding

Tam rhythms at 40 Hz represent a cornerstone frequency in the brain's binary hierarchy, maintaining octave relationships with 5 Hz (Ram), 10 Hz (Ham), 20 Hz (Gam), and 80 Hz (Krim). This positioning enables Tam rhythms to bind information across multiple spatial and temporal scales through electromagnetic field resonance.

The 40 Hz frequency is optimal for creating standing wave patterns in cortical minicolumns, with wavelengths that match the typical spacing of pyramidal cell dendrites. When these local field patterns achieve octave resonance with slower organizing rhythms, they create the conditions for conscious perception—binding distributed local processing into unified experiences through electromagnetic field coherence.

These oscillations bind distributed neural activity into coherent percepts, coordinate the timing of neural firing within local circuits, and support the fast temporal dynamics necessary for real-time neural computation. The mechanisms underlying Tam rhythm function involve the coordinated activity of interneuron-pyramidal cell networks that generate high-frequency oscillations through precisely timed inhibitory and excitatory interactions.

4.2.10. Krim Rhythms (80-200 Hz) - High-Frequency Processing

Krim rhythms extend the binary hierarchy into the high-gamma range, with 80 Hz maintaining perfect octave relationships with 40 Hz (Tam), 20 Hz (Gam), and 10 Hz (Ham). The 160 Hz upper range represents another octave doubling, creating a nested high-frequency structure for the fastest neural computations.

At these frequencies, electromagnetic field effects become increasingly local, with wavelengths measured in millimeters. However, the octave relationships to slower rhythms ensure that even these rapid local computations remain coordinated with global brain states. The field resonance at these frequencies may be particularly important for the precise spike timing required for synaptic plasticity and learning.

These high-frequency oscillations likely serve specialized functions in local neural processing and may support the fastest aspects of neural computation. In the hippocampus, ripple oscillations in this frequency range are critical for memory consolidation and replay, coordinating the reactivation of neural ensembles that encode specific experiences.

4.2.11. Shrim Rhythms (>200 Hz) - Ultra-High Frequency

Shrim rhythms extend beyond 200 Hz into frequencies that push the limits of neural oscillation. While their functional roles remain largely mysterious, their position as further octave extensions of the binary hierarchy (320 Hz, 640 Hz) suggests they may support ultra-fast local processing or specialized forms of information encoding that require extreme temporal precision.

The technical challenges associated with studying Shrim rhythms include the need for extremely high sampling rates, sophisticated artifact rejection methods, and specialized recording equipment. Despite these challenges, evidence from epilepsy research suggests that these ultra-high frequency oscillations may serve as biomarkers of pathological network states and could play important roles in normal brain function that remain to be discovered.

5. Advantages of the Functional System with Octave Organization

5.1. Scientific Coherence and Electromagnetic Field Computing

The recognition of octave relationships in our functional taxonomy reveals the brain's elegant solution to the problem of coherent information processing across multiple scales. By organizing oscillations in binary hierarchies, the brain achieves electromagnetic field coherence that would be impossible with arbitrary frequency relationships.

This coherence has profound implications for computational efficiency. Rather than requiring separate mechanisms for each type of cognitive function, the brain can use octave resonance to flexibly recruit and coordinate different processing modules. A single frequency shift—say from 5 Hz to 10 Hz—immediately alters the resonance relationships with all other frequency bands, enabling rapid state transitions and flexible cognitive control.

The scientific coherence of the functional approach extends beyond individual oscillatory categories to encompass the relationships between different frequency bands and their roles in integrated neural systems. The recognition of hierarchical organization and cross-frequency coupling relationships creates a unified theoretical framework that explains how different oscillatory phenomena work together to support complex brain functions.

The biological meaningfulness of functional nomenclature also facilitates cross-disciplinary communication by providing meaningful labels that can be understood by researchers from diverse backgrounds. Rather than requiring extensive training in historical electroencephalographic conventions, functional names immediately convey the biological significance of oscillatory phenomena.

5.2. Clinical Applications and Precision Neuromodulation

Understanding the octave organization of neural oscillations opens new possibilities for clinical intervention through precision electromagnetic field modulation. Rather than using arbitrary stimulation frequencies, therapeutic interventions can target specific octave relationships to enhance or restore normal resonance patterns.

For instance, transcranial alternating current stimulation (tACS) at 10 Hz doesn't just affect alpha rhythms—it creates resonance cascades at 5 Hz, 20 Hz, 40 Hz, and 80 Hz through octave harmonics. By understanding these relationships, clinicians can design stimulation protocols that leverage the brain's natural frequency architecture rather than fighting against it.

Similarly, diagnostic approaches can use octave relationships to identify pathological states more precisely. A disruption in the normal 1:2 relationship between Ram and Ham rhythms, for instance, might indicate specific memory-attention integration deficits that wouldn't be apparent from analyzing these frequencies independently.

The functional taxonomy offers significant advantages for clinical applications by providing direct links between oscillatory phenomena and their associated functional systems. When clinicians encounter disrupted "Gam Rhythms" in a patient, the functional nomenclature immediately suggests examination of motor control and cognitive maintenance functions, facilitating more targeted diagnostic approaches.

The precision medicine implications of the functional approach are particularly significant in the context of individual differences in oscillatory patterns. Rather than relying on population-averaged frequency ranges that may not accurately reflect individual neural dynamics, the functional approach supports personalized approaches that calibrate therapeutic interventions to individual oscillatory profiles.

5.3. Theoretical Unification with Physics and Consciousness Studies

The octave-based functional taxonomy provides a natural bridge between neuroscience and fundamental physics. Just as electromagnetic radiation organizes in octave relationships across the spectrum—from radio waves through visible light to gamma rays—neural oscillations follow the same mathematical principles. This suggests that consciousness and cognition emerge from universal physical principles rather than biological accidents.

Furthermore, the exponential scaling of information capacity through octave relationships may help explain the "hard problem" of consciousness. If electromagnetic field resonance at octave frequencies creates information integration that scales exponentially rather than linearly, this could account for the rich, unified nature of conscious experience emerging from relatively simple neural oscillations.

The framework also provides new perspectives on altered states of consciousness. Psychedelic experiences, meditation states, and even pathological conditions like schizophrenia may involve shifts in the normal octave relationships between frequency bands. Rather than simply increasing or decreasing certain frequencies, these states might involve detuning from optimal resonance patterns, creating novel forms of information integration and conscious experience.

5.4. Educational Clarity and Research Integration

The functional taxonomy dramatically simplifies education in neuroscience by providing an intuitive framework that connects form to function. Students learning about "Ram rhythms for memory" and "Tam rhythms for binding" immediately understand not just what these oscillations are called but what they do. The octave relationships provide a mathematical structure that makes the entire system easier to remember and understand.

For research, the functional taxonomy facilitates integration across previously disparate subfields. Researchers studying sleep spindles (Sam rhythms) can immediately see the connections to memory researchers studying theta oscillations (Ram rhythms) through their harmonic relationships. This cross-pollination of ideas accelerated by clearer nomenclature could lead to breakthrough insights that are currently hidden by arbitrary categorical boundaries.

6. Implementation Challenges and Future Directions

6.1. Measuring and Validating Octave Relationships

While the theoretical framework for octave organization is compelling, empirical validation requires new experimental approaches that can capture electromagnetic field dynamics rather than just electrical potentials. Current EEG and MEG technologies measure field effects indirectly, potentially missing crucial resonance patterns that occur in the electromagnetic near-field.

Future research should employ multiple complementary techniques including high-density EEG arrays, magnetic field imaging, and novel approaches for directly measuring electromagnetic field propagation in neural tissue. Computational modeling of field dynamics will also be essential for understanding how octave relationships emerge from the biophysics of neural tissue.

Advanced signal processing techniques will be needed to identify and quantify octave relationships in neural recordings. Traditional spectral analysis methods may not be sufficient to capture the dynamic phase relationships and cross-frequency coupling that characterize octave resonance. New analytical approaches based on information theory, phase dynamics, and field topology will be essential for validating the octave organization hypothesis.

6.2. Individual Variations and Frequency Tuning

While the binary hierarchy provides a general framework, individual brains may tune their specific frequencies slightly differently while maintaining octave relationships. Some individuals might have a fundamental Ram frequency of 4.8 Hz with corresponding octaves at 9.6 Hz, 19.2 Hz, and 38.4 Hz, while others operate at 5.2 Hz with octaves at 10.4 Hz, 20.8 Hz, and 41.6 Hz.

Understanding these individual variations will be crucial for personalized medicine approaches. Future diagnostic tools should measure not just the power at different frequencies but the precision of octave relationships, potentially identifying pathological states through detuning of normal harmonic relationships.

Research into frequency tuning mechanisms will be essential for understanding how the brain maintains octave relationships despite changes in temperature, neuromodulator levels, and other factors that affect neural dynamics. The discovery of active tuning mechanisms that maintain harmonic relationships would provide strong evidence for the functional importance of octave organization.

6.3. Transitioning from DTABG to Functional Nomenclature

The practical challenge of transitioning from the entrenched DTABG system to functional nomenclature should not be underestimated. Like the persistence of QWERTY keyboards, the DTABG system benefits from massive institutional inertia, with thousands of published papers, textbooks, and clinical protocols using the traditional nomenclature.

A successful transition will require coordinated effort across the neuroscience community, including endorsement by major journals, adoption in educational curricula, and integration into clinical practice guidelines. The transition period will likely require dual labeling (e.g., "Ram/Theta rhythms") to maintain continuity with existing literature while introducing the new system.

However, the benefits of transition far outweigh the temporary inconvenience. Just as the adoption of standardized anatomical nomenclature revolutionized medicine in the early 20th century, a functional taxonomy of neural oscillations can catalyze advances in neuroscience by providing a clearer conceptual framework for understanding brain dynamics.

7. Conclusion

The transition from the arbitrary DTABG nomenclature to a functional taxonomy based on octave relationships represents more than semantic improvement—it reflects a fundamental reconceptualization of how neural oscillations organize and operate. By recognizing that brain rhythms follow the same binary harmonic principles that govern electromagnetic field resonance throughout physics, we gain a more principled understanding of neural computation and consciousness.

The functional taxonomy proposed here, grounded in both empirical observation and electromagnetic field theory, provides a framework that unifies previously disparate findings about neural oscillations, cross-frequency coupling, and information integration. It suggests that evolution discovered and optimized the same mathematical principles that govern resonance in physical systems, applying them to create biological computers that operate through field dynamics rather than just synaptic connections.

The evidence for octave organization is compelling across multiple levels of analysis. From the conservation of frequency relationships across species to the exponential scaling of information capacity through harmonic resonance, the binary hierarchy appears to be a fundamental organizing principle of neural computation. The correspondence between neural oscillation frequencies and optimal electromagnetic field wavelengths for different spatial scales of brain organization further supports the idea that these frequencies are not arbitrary but physically optimal.

As we move forward, this octave-based understanding should guide both research and clinical practice. Rather than studying neural oscillations as independent frequency bands, we must investigate how their harmonic relationships create the electromagnetic field patterns that support cognition and consciousness. Rather than applying neuromodulation at arbitrary frequencies, we should target specific octave relationships to restore healthy resonance patterns.

The persistence of QWERTY keyboards reminds us how difficult it can be to change established conventions, even when better alternatives exist. However, the stakes in neuroscience are far higher than typing efficiency. By adopting a functional taxonomy that reflects the true octave organization of neural oscillations, we can accelerate our understanding of the brain and develop more effective interventions for neurological and psychiatric disorders.

The brain's electromagnetic symphony follows precise harmonic laws—it's time our nomenclature reflected this fundamental truth. Just as music theory recognizes that octaves, fifths, and other harmonic relationships create the structure of musical composition, neuroscience must recognize that octave relationships create the structure of neural computation. The functional taxonomy proposed here is not merely a new naming system but a recognition of the deep mathematical principles that organize brain dynamics.

In the grand tradition of scientific progress, we stand at a moment where accumulated evidence demands a paradigm shift. The DTABG system served its purpose in the early days of electroencephalography, but it has become a hindrance to progress. By embracing a functional taxonomy grounded in the physics of electromagnetic field resonance and the mathematics of octave relationships, we can unlock new understanding of how the brain computes, how consciousness emerges, and how we might intervene when these processes go awry.

The brain is not a digital computer processing information through discrete logical operations. It is an electromagnetic field computer, processing information through resonance and interference

patterns organized according to precise harmonic laws. Our nomenclature should reflect this fundamental insight. The future of neuroscience lies not in arbitrary alphabetical sequences but in recognizing the functional architecture and harmonic organization that evolution has crafted over millions of years. It's time to tune our scientific language to the actual frequency of discovery.

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