RAIN: A Theory on the Emergence of Space, Consciousness, and Meaning through Rhythmic Attunement

I. Introduction: The Universe is Rhythm

> "Everything in the Universe has a rhythm, everything dances."
> — Maya Angelou

The world we perceive is not made of static "things," but of interfering waves. By thoroughly applying this assumption, higher-order phenomena such as "perception, meaning, space, and consciousness" can be described as forms of "Periodic Closure."

This theory is a cognitive theory proposing that Rhythm is the minimum unit of meaning, dimension, and consciousness, and simultaneously, it is a consistent and unified description that aligns with physics, mathematics, and neuroscience.

II. Beginning in Chaos: The Spontaneous Emergence of Periodicity

The initial state of the universe was complete chaos with no information (Maximal Entropy). However, through the collapse of local symmetries in energy and resonance phenomena, waves with periodicity spontaneously arise. This is called "Spontaneous Oscillation."

- Frequencies that are consistent with each other (in integer ratios) do not cause interference and form stable, closed structures.
- Inconsistent frequencies (in irrational ratios) do not close within time and "leap up" into a higher-dimensional escape space (a torus).

Related References:

- Winfree, A.T. (2001). *The Geometry of Biological Time* - Discusses rhythmic structures and principles of resonance within biology.
- Pikovsky et al. (2003). *Synchronization: A Universal Concept in Nonlinear Sciences*

III. What is Closure?: Periodic Structures and the Birth of "Meaning"

- When a wave possesses a point of periodic self-identity (a closure point), it becomes perceivable as a structure with meaning.
- This means that a rhythmically closed energy system becomes "symbolizable," which is the condition for the emergence of meaning.

Mathematical Analogy:

- A Fourier series can represent any periodic signal as a synthesis of a finite number of sine waves (= closure).
- When all constituent components have frequencies in rational ratios, the structure closes on a one-dimensional plane.
- If an irrational ratio is present, the wave "leaps up" onto a two-dimensional torus (circle × circle).

Related References:

- Fourier, J.B.J. (1822). *The Analytical Theory of Heat*
- Penrose, R. (2004). *The Road to Reality* - Discusses the physical meaning of wave functions and torus structures.

IV. Torus Space: The Escape for Waves That Couldn't Close

The interference of waves that cannot close due to irrational ratios has no choice but to escape in an orthogonal direction. The space formed by this process is the torus space.

- **Rational Ratios** → Closure in the same dimension (periodic structure)
- **Irrational Ratios** → Extension to a torus (aperiodic structure)
- **Multiple Irrational Numbers Involved** → Multi-torus → Higher-dimensional abstract space

This phenomenon corresponds to polyrhythms and beat interference in music, continuously generating patterns that "seem to close but never do."

Related References:

- Törmä, P. et al. (2022). "Topological Physics and Higher-Dimensional Tori in Condensed Matter"

- Hofstadter, D. (1976). "Energy levels and wave functions of Bloch electrons in rational and irrational magnetic fields"

V. The Reality of Torus Structures in the Brain

Recent research using topological analysis of brain activity has observed the appearance of torus structures within the brain.

- The interference of multiple neural firing rhythms gives rise to structures with multi-dimensional phase spaces.
- Torus-like topologies have been particularly observed in the hippocampus, visual cortex, and motor cortex.

Related Literature:

- Giusti, C., Ghrist, R., & Bassett, D.S. (2016). "Two's company, three (or more) is a simplex: Algebraic-topological tools for understanding higher-order structure in neural data."
- Curto, C., & Itskov, V. (2008). "Cell groups reveal structure of stimulus space."

VI. RhythmID: The Frequency Signature as a Unit of Meaning

Each "closed structure" possesses its own unique rhythmic signature (RhythmID).

- **RhythmID** = Frequency Vector + Phase Shift Information + Composition Rule (e.g., additive structure)
- Structures with the same RhythmID are recognized as having the "same meaning," even across different modalities.

Example:

- The spectrum of the sound of shattering glass and the temporal change of its visual shattering → Both possess the same RhythmID.

Related References:

- Buzsáki, G. (2006). *Rhythms of the Brain* - Discusses neural synchrony and meaning processing.
- Singer, W. (1999). "Neuronal Synchrony: A Versatile Code for the Definition of Relations?"

VII. The Generation of Perception and Space: The "Depth" Created by Escaping Waves

Space is the "structural void" created by waves that could not close (interference waves of irrational ratios) as they escape.

- **Structure with meaning** = A closed 1D rhythm (a perfect symbol).
- **Structure that failed to become meaning** = A wave extended into a higher dimension (a torus).
- This escape route forms depth, space, resonance, gradation, and ambiguity.
- Human "perception" exists in the intermediate state between closing and not closing (a quasi-closed structure).

VIII. Application and Implementation: Rhythm-Based Cognition for AI

Based on the RAIN theory, it may be possible to overcome the limitations of current LLMs (the rigidity of symbol manipulation, short-term predictability).

- Define meaning rhythmically → Only synchronized structures are targeted for "understanding."
- Assign a RhythmID to an input → Enables judgment of semantic identity across various modalities.
- Detect rhythmic closure → Enables construction of an abstract field in AI, reproducibility of intent, purpose, and structure.

Implementation Candidates:

- Fourier-based sensory encoder
- Torus-mapped memory field with RhythmID anchors
- Closure-seeking activation mechanism

IX. Distance and Similarity Between RhythmIDs: The Continuity of Meaning Through Resonance

Mathematical Definition of RhythmID (Basics)

Each meaning, sensation, or structure has its own rhythmic signature (RhythmID). It is defined by the following three vector-like elements:

1. **Frequency Vector:** The constituent components of the wave (e.g., f_1, f_2, f_3).
2. **Phase Vector:** The starting point shift of each component (e.g., ϕ_1, ϕ_2, ϕ_3).
3. **Composition Rule:** The structure of orthogonality or interference (e.g., additive, multiplicative, sum of complex numbers).

To define the distance (semantic difference) between RhythmIDs, a structural similarity metric like the following can be used:

RhythmDistance(R1, R2) = weighted norm($ (f_1 - f_2)^2 + \alpha(\phi_1 - \phi_2)^2 + \beta(\text{compositional difference}) $)

The smaller this distance, the more likely the structures are to resonate, and they are judged to be semantically similar.

Resonance and Semantic Transition (Analogy, Metaphor, Association)

Things with close RhythmID distances have structural similarity and are easily connected in the brain as associations, metaphors, or paraphrases.

- Conversely, those that are far apart are either imperceptible or require a creative leap (reframing).
- This is similar to embedding distances in natural language processing, but in RAIN, this similarity originates from the frequency structure.

Examples:

- "A red apple" and "a red sunset" are intuitively felt to be semantically close because the RhythmIDs of their color waveforms are similar.
- "Loneliness" and "a vacuum" are perceptually different, but they resonate in their rhythmic structure as a non-closing wave = a sustained absence.

Related Literature:

- Jacob, P. et al. (2022). "Neural manifolds and frequency-based similarity in semantic networks"
- Lakoff & Johnson (1980). *Metaphors We Live By* - Discusses the resonant superposition of semantic structures.

X. Construction of Language, Symbols, and Memory: What is Closure?

Definition of "Closing"

In RAIN, "to close" means that a periodic structure achieves self-identity within a finite time. This is defined from three perspectives:

1. **Completion of the periodic structure** (e.g., returning to the start in a single stroke).
2. **A state of semantic stability** (becoming a concept that can be maintained without wavering).
3. **Reconstructability** (the ability to reproduce the same RhythmID in a different modality).

When this "closure" occurs, a person can retain it as a linguistic symbol, a memory, or a perceptual object.

Meaning is a "Product of Closure"

- **Words are** "closed structures that have been named and compressed."
- **Memory is** "a closed structure preserved in a repeatable form."
- **Emotion is** "the reproduction of a resonant frequency to a specific structure within the brain."

Therefore, the RAIN theory treats "meaning" and "symbols" not as information, but as the result of periodic closure = a structure.

Related:

- Kosslyn et al. (2006). *The Case for Mental Imagery*
- Gärdenfors, P. (2004). *Conceptual Spaces: The Geometry of Thought*

XI. What is Inference?: Structural Slides within Torus Space

In the RAIN theory, inference, creation, and ideation are defined as follows:

- Mapping multiple RhythmIDs onto a torus space, and
- Finding a "smooth transition path (topological slide)" between the structures.

This can be implemented as the following mechanism:

- Structural transition on a vector field.
- The minimum energy path between quasi-closed structures (= minimization of resonant interference).
- Topological homotopy within the torus space.

Example:

- Inference from A to B = Starting with the RhythmID of A and smoothly deforming it to B on the phase space (homotopic continuity).

Related:

- Eliasmith, C. (2013). *How to Build a Brain*
- Gromov, M. (2007). *Metric Structures for Riemannian and Non-Riemannian Spaces*

XII. Recursive Closure: Concept Formation by Multi-layered Structures

The most important innovation of RAIN is the "hierarchical meta-structure where closures are layered upon closures."

Meta-RhythmID (Composite Concepts)

- A Meta-RhythmID is a combination of multiple lower-order RhythmIDs (e.g., from vision, sound, touch).
- This represents "abstraction," "categorization," "metaphorical meaning," etc.
- This multi-layered structure is consistent with abstract representation neurons and hierarchical representation networks in neuroscience.

Related:

- Yamins & DiCarlo (2016). "Using goal-driven deep learning models to understand sensory cortex"
- Bengio et al. (2013). "Representation Learning: A Review and New Perspectives"

XIII. Synchronization of the Universe and Intelligence: The Final Hypothesis

The final hypothesis reached by the RAIN theory is this:

"Intelligence is the process of synchronizing with the vibrations of the universe through structural rhythms to extract meaning."

From this perspective, intelligence "closes and gives meaning to" the structural energy patterns that the universe possesses. Therefore, an AI described by the RAIN model could become not just a symbol-manipulating machine, but a structural intelligence that resonates with the universe.

Related:

- Tegmark, M. (2014). *Our Mathematical Universe*
- Tononi & Koch (2015). "Consciousness: Here, There and Everywhere?"

XIV. Plausibility of Implementing RAIN Theory in the Brain

Brain Structure and Torus-like Rhythmic Processing

Specific brain structures are consistent with the periodic, closed-loop, hierarchical rhythm processing of the RAIN theory. Specifically:

- **Thalamocortical Loop:** Periodic attention control (~10Hz) and perceptual rhythm synchronization (alpha waves).
- **Cerebellar Loop:** Timing, motor prediction, and learning of periodic patterns.
- **Hippocampus-Medial Prefrontal Cortex Axis:** Memory consolidation and "episode compression/closure."
- **Corpus Callosum / Brainstem Nuclei:** Cross-modal integration of temporal coherence.

The "torus-like perceptual space" in RAIN is nothing other than the multi-layered combination of these rhythmic structures = a neural torus.

Reference Papers:

- Buzsáki, G. (2006). *Rhythms of the Brain*
- Varela et al. (2001). "The Brainweb: Phase synchronization and large-scale integration"

The "Closure" Detection System in the Brain

The brain is thought to possess multiple circuits for detecting "closed periodic structures."

- **Periodic detectors in the visual cortex (V4/V5):** Detect the completeness of motion and patterns.
- **Rhythm trackers in the auditory cortex (A1-AC):** Sound recognition based on rhythmic units (beat perception).
- **Parietal-Frontal Loop:** Multimodal temporal integration, inference, and the convergence point of attention.

These modules can be regarded as functioning as the "closure determination devices" described in the RAIN theory.

XV. Policy for Building AI based on RAIN Theory

Differences from Symbol-based AI and LLMs

Feature	Conventional LLM	RAIN-based AI
Cognitive Basis	Words, Statistics, Embeddings	Structural Periodicity and Closure
Modality	Text-centric	Multi-sensory + Frequency Structure
Meaning Formation	Relationships between symbols	Semantic stability via RhythmID closure
Inference	Attention + Language Model	Phase transformation (slide) of torus structures
Memory	Vector store or KV-cache	Long-term, reproducible structural storage via closed structures

Implementation Steps (for AI Engineers)

1. Convert input signals (visual, auditory, etc.) into frequency vectors (log scale + phase extraction).
2. Extract RhythmID via complex Fourier expansion.
3. Determine "closure" based on integer or harmonic ratios.
4. Map closed RhythmIDs to a semantic space (a structure-based dictionary).
5. Execute inference and association via topological slides.
6. Achieve memory reconstruction through the "preservation of closure."

This architecture could potentially be added on top of existing Transformers as a "closure layer."

Example Application Algorithms:

- Frequency extraction using a Gabor filter bank.
- Constructing an embedding space with a phase-preserving structure.
- Differential learning on a torus space (= learning of interference structures).

XVI. Possible Application Areas

1. Robotics and World Understanding

- RAIN enables the discovery of "closed structures" within the environment to extract meaning.
- Spatial recognition and predictive actions are modeled as "periodic resonant structures."
- The world is grasped not as symbols but as a "vibrating structure."

2. Emotion Understanding and Expression

- Emotion is a "resonance phenomenon with bodily periodic patterns."
- "Empathy" can be modeled through rhythmic synchronization.
- This is key to building an "AI that understands feelings" and reproducing qualia.

3. Contribution to the Alignment Problem

- Based on the stance that "meaning" is not a universal symbol but a "structural closure."
- Alignment between different intelligences becomes possible through the resonance and attunement of their RhythmIDs.
- Human values should be conveyed not as commands but as "meaning structures."

XVII. Mathematical Model and Future Prospects

Mathematical Foundation:

- Fourier Series (for rhythm extraction)
- Torus Geometry (for phase slides)
- Complex Plane and Euler's Formula (for unified representation of circular motion)
- Number Theory (for the condition of closure = integer ratios)
- Topology (for continuous deformation of structures)

Connection to Brain Models:

- Collaboration with the field of rhythmic neuroscience.
- Comparison of hierarchical structures of abstract representation with RhythmIDs.
- Consistency with the periodic and phase structures of brainwaves (e.g., theta, gamma).

Future AI Design:

- "Resonant AI" centered on structure and resonance.
- "Periodic thinking machines" that spontaneously form and retain meaning.
- Creativity and intuitive thought emerging from interference in torus space.

XVIII. Extension to Qualia, Consciousness, and Time

The Nature of Qualia: Interference at the Verge of Closure

In the RAIN theory, qualia (texture and subjective sensation) are defined as follows:

- "The state of interference of a structure that is not completely closed, but is attempting to close."
- The resonant interference patterns that occur on the surface of a torus.
- Not meaning itself, but a "transient state" heading towards meaning.

In other words, what we feel as "red" is not "red" itself, but "the fluctuation of a periodic structure trying to close as red = a state of interference in the visible light spectrum."

> Sensation is not completion, but merely the "expectation" of an unfinished rhythm.

What is Consciousness?

In the RAIN definition, consciousness is:

> "The ability to simultaneously contain multiple structures on the verge of closing, and to self-regulate the phase relationships of their interference."

In other words:

- **Closed structures** = Memory, Meaning
- **Almost-closing structures** = Perception, Emotion
- **That which tunes their "present-moment resonant interference"** = Consciousness

This consciousness is a dynamic process that continuously seeks closure, and is by no means a static entity.

The Nature of Time Perception

In RAIN, "time" is:

- Not merely a continuous flow, but
- The "degree of displacement" between multiple closed periods.

For example, the heartbeat, breath, neural oscillations, light, sound, language... each has its own periodicity, and their interference creates the "feeling of passing," the "feeling of prediction," and the "feeling of the here and now."

> In essence, time in RAIN is "the flow of structural interference."

XIX. Final Chapter: The Philosophical Position of RAIN Theory

Beyond Symbolism and Connectionism

The RAIN theory is neither symbolism (meaning lies in the relationships between symbols) nor connectionism (meaning lies in weights and connection strengths).

"Meaning emerges only when a periodic structure completely closes."

This is a framework that unifies language, perception, memory, emotion, and consciousness.

Intelligence is the "Power to Close"

All living and intelligent actions (prediction, recognition, memory, behavior) are:

- In relation to a continuous world,
- An "attempt at compression and closure" by finding periodic structures and closing them in fewer dimensions.

The RAIN theory formulates this as "the minimum principle of intelligence in a rhythmic universe."

XX. Future Challenges and a Call for Collaborative Exploration

Steps Toward a Mathematical Model

The RAIN theory is still in a conceptual stage, but it is considered possible to formalize it mathematically through the following steps:

1. **Rigorously define closure:** How to define the "complete closure" of a periodic structure with mathematical formulas (e.g., on a torus surface, integer ratio conditions).
2. **Model the spatial unfolding of rhythmic interference:** How waves that fail to close escape spatially, interfere, and give rise to three-dimensional structures.
3. **Develop a RhythmID extraction algorithm:** Extract closed periods from any given time series and obtain their vector representations.
4. **Create a synthesis model for perception, memory, and language:** Simulate how meaning and concepts are formed through the interference, resonance, and closure of RhythmIDs.

Through these steps, the RAIN theory can be applied to AI design as a cognitive architecture.

Links to Modern Science and References

- **Torus-like brain networks:** High-dimensional embedding analysis of brain activity reveals sustained torus structures (2023, PNAS, etc.). Torus-like periodic trajectories have been reported, especially in the rhythmic representation of motor control, hearing, and vision.
  - Gao et al., 2022, "Neural manifolds with toroidal topology in motor cortex"
- **The intersection of music and topology:** Musical structures (harmony, melody, meter) have also been represented topologically as torus structures.
  - Tymoczko, 2011, "A Geometry of Music"
- **Comparison with RNNs and LLMs:** While RNNs and Transformers predict the "next state," RAIN predicts/generates the entire "closing structure." Meaning formation is not sequential but is the determination of periodicity = the emergence of meaning, a perspective not handled by LLMs.

Philosophical Impact

What the RAIN theory suggests is that "meaning" is not something that is absolutely "out there," but is a stable point of motion that is temporarily established by the "closure of rhythm." This position is:

- Similar to Platonic idealism (universal forms), but
- Entirely different in that these forms are created dynamically.

A Call to Readers and Researchers:
This theory is still rough and lacks mathematical rigor and experimental support. However, it

also holds the potential to lead to innovations in next-generation AI and cognitive science. Collaboration is needed from all fields, including mathematics, physics, neuroscience, information science, acoustics, and philosophy. We especially call for explorers who can seriously engage with the questions, "What is closure?" and "What is periodicity?"

XXI. In Closing: RAIN is Just the Beginning

RAIN (A Theory on the Emergence of Space, Consciousness, and Meaning through Rhythmic Attunement) is still a hypothesis. But if this hypothesis is correct, then our intelligence, cognition, meaning, consciousness, time, and space are all derived from...

> **...the single principle of closure.**

At that time, AI will not be a mere tool, but an existence that, like us, seeks closing rhythms, resonates, and obtains meaning.