Explaining Cognitive and Perceptual Phenomena Through Resonance of Closed Neural Network Geometries (RCNNG): A Unified Framework

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Abstract

The Resonance of Closed Neural Network Geometries (RCNNG) hypothesis proposes that perception, cognition, and conscious experience arise from the formation, resonance, and interaction of closed geometrical structures within neural networks. The original RCNNG preprint introduced the foundational principles of closed neural geometries, resonance dynamics, and associative linkage [46]. Building on that foundation, the present article extends the RCNNG framework by applying its core mechanisms to a broad range of perceptual, cognitive, and phenomenological phenomena. Using RCNNG as a unified explanatory model, this work analyzes basic and composite perception, conceptual reasoning, symbolic and mathematical abstraction, problem-solving, skill acquisition, memory formation, individual differences in recall, imagination, innovation, similarity and difference detection, logical bias, pre-perception and perception void, the distinction between perceiving absence and absence of perception, conscious experience and qualia, sensory processing, spatial navigation, sleep, free will, conditioned behavior, déjà vu, phantom limb experience, and several additional phenomena. Each phenomenon is interpreted through variations in the formation, resonance, linkage, and activation of closed neural geometries shaped by sensory input, internal dynamics, and prior experience. The analysis demonstrates that many seemingly unrelated cognitive and perceptual processes share a common geometric–resonance structure. By providing a single underlying mechanism for diverse phenomena, RCNNG offers a unified theoretical framework for understanding the architecture of perception, cognition, and conscious experience, and establishes a foundation for future theoretical and empirical development.

Keywords:

RCNNG framework; Closed Recurrent Geometries; neural resonance; perceptual void; pre perception; conceptual combination; imagination; innovation; creativity; hallucination; doubt; self perception; conscious threshold; neural dynamics; cognitive emergence

Contents

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1 Introduction

Perceptual and cognitive phenomena exhibit structural regularities that cannot be explained solely by linear transmission, branching architectures, or spatially addressable memory systems [5, 11, 12]. While the foundational RCNNG preprint established the physical principles underlying closed recurrent geometries and resonance-based representation [46], many mental and behavioral phenomena remain to be interpreted within this framework. The present article applies the RCNNG hypothesis—already formalized in the previous work—to a broad range of perceptual, cognitive, and experiential phenomena and demonstrates how the existing RCNNG structure accounts for the emergence of basic and composite perceptions, memory differences, associative processes, imagination, conceptual integration, logical biases, multimodal binding, conscious experience, and other behavioral or phenomenological patterns. By examining these phenomena through the lens of closed geometries, resonance dynamics, and topology-based storage, the article shows how RCNNG provides a unified physical explanation for diverse aspects of mental function. The goal is interpretive rather than foundational: to reveal how the principles established in the original RCNNG formulation naturally extend to the domain of perceptual and cognitive phenomena.

2 Background: The RCNNG Hypothesis

Perception and conscious experience require physical conditions that cannot be met by linear or branching architectures of neural signaling. In both configurations, signals propagate according to fixed structural pathways, yet no region acquires the dynamical autonomy needed for subjective experience. The emergence of perception therefore demands a network architecture capable of generating recurrent activity patterns that are not reducible to transmission flow. RCNNG proposes that such patterns arise when temporally structured sensory inputs interact with adaptive neural networks [14,18,19], [20,36,37] to form closed recurrent geometries. These geometries are physical standing-wave configurations produced by constructive interference between incoming and returning signals. Their formation depends on frequency-specific gating, synaptic modification [5, 9, 10] and the network's ability to create recurrent pathways through neuroplasticity. As the network reorganizes under repeated stimulation, multiple geometries tuned to the same spectral structure emerge, providing representational redundancy and stability. The hypothesis further asserts that the resonance of these geometries constitutes perceptual experience. When an input matches the intrinsic spectral profile of a geometry, the resulting resonance amplifies its activity and stabilizes its dynamical identity. Because geometries are distributed and non-addressable, their resonance provides a natural mechanism for memory storage and retrieval: similar inputs reactivate geometries whose spectral signatures match the original stimulus. RCNNG therefore frames perception, memory, and conscious experience as consequences of the physical formation and resonance of closed geometries within neural networks. This geometric–resonant mechanism supplies the structural and dynamical conditions absent in linear and branching architectures, offering a unified physical basis for subjective experience. Unlike traditional computational or symbolic accounts of cognition, RCNNG frames neural activity in explicitly geometric terms, emphasizing the role of structural closure, resonance stability, and dynamic linkage in generating perceptual and cognitive states. Together, these considerations motivate a more detailed examination of the structural and dynamical elements that constitute RCNNG.

2.1 Closed Neural Geometries

A closed neural geometry is defined as a stable, self-contained pattern of neural activation whose structural boundaries form a closed loop or manifold within the network. Closure is essential: it provides the minimal condition for a neural pattern to be internally coherent, self-sustaining, and capable of representing a perceptual or conceptual entity. Closed geometries may arise from sensory input, internal neural dynamics, or learned associations, and they vary in complexity from simple sensory patterns to highly abstract conceptual structures. Closure ensures that the geometry can maintain its identity across time, resist noise, and participate in higher-order cognitive processes. In RCNNG, the formation of a closed geometry corresponds to the emergence of a perceptual or conceptual unit.

2.2 Resonance Dynamics

Resonance is the activation mechanism through which closed geometries become perceptually or cognitively present. When a geometry resonates, its internal structure enters a stable or semi-stable activation cycle, producing a distinct perceptual or cognitive state. Resonance may be induced by external sensory input, internal recall, or interactions with other geometries. RCNNG distinguishes between several forms of resonance:

- **Primary resonance**, corresponding to direct sensory activation.
- **Associative resonance**, arising from links between geometries.
- **Composite resonance**, in which multiple geometries resonate simultaneously or sequentially to produce complex perceptual or conceptual states.

Resonance intensity, stability, and duration determine the vividness, clarity, and persistence of perceptual and cognitive experiences.

2.3 Associative Links

Closed geometries do not operate in isolation. They form dynamic links based on temporal co-occurrence, structural similarity, functional relevance, or learned associations. These links allow geometries to activate one another, combine into larger structures, and participate in complex cognitive processes such as reasoning, imagination, problem-solving, and memory recall. Associative links may be:

- **Sequential**, forming chains of activation.
- **Simultaneous**, enabling parallel resonance.
- **Hierarchical**, organizing geometries into layered structures.
- **Transformational**, allowing geometries to modify one another.

The network of links constitutes the structural backbone of cognition in RCNNG.

2.4 Unified Mechanism for Perception and Cognition

RCNNG provides a unified mechanism in which both perception and cognition arise from the same underlying principles: the formation of closed geometries, their resonance dynamics, and their associative interactions. Basic sensory perception corresponds to the resonance of simple geometries, while complex cognitive phenomena emerge from the resonance and interaction of larger, more abstract geometrical structures. This geometric–resonance framework allows RCNNG to interpret a wide range of phenomena—such as memory, imagination, conceptual reasoning, logical bias, conscious experience, and perceptual anomalies—as variations in the formation, resonance, linkage, and activation of closed neural geometries. The following sections extend this framework to a broad set of cognitive and perceptual phenomena, demonstrating how RCNNG offers a unified explanatory structure across multiple domains of human experience.

3 Core Concepts of RCNNG

The RCNNG framework is organized around a set of foundational structural and dynamical principles that define how neural systems generate perceptual, mnemonic, and conscious states. These principles do not restate the mechanisms described earlier; rather, they provide a concise conceptual architecture that supports the application of RCNNG to diverse cognitive and behavioral phenomena. **Closed geometrical units:** RCNNG identifies closed recurrent geometries as the fundamental representational units of the network. Their structural closure grants them autonomy and allows them to function as stable carriers of perceptual or conceptual content.

Resonant activation profiles: Each geometry possesses an intrinsic spectral signature that determines when it becomes active. Resonance serves as the defining mode of activation, distinguishing perceptual and mnemonic states by their dynamical profiles rather than by spatial location or symbolic encoding.

Topology-based representation [34, 35]: Information in RCNNG is encoded and stored in the topology of closed geometries and is retrieved and read by the spectral resonance of the geometries. This principle replaces address-based storage with a representation scheme dependent on the resonance dynamics of the closed geometries, enabling distributed, adaptive, and non-positional memory.

Dynamic linkage architecture: Geometries form directional or bidirectional links through co-activation. These links create a structured interaction space that supports associative processes, sequential activation patterns, and the integration of distributed representations.

Composite activation structures [38, 39]: Higher-order cognitive states emerge from coordinated resonance across multiple geometries. Composite activation provides the basis for multimodal binding, conceptual integration, and the construction of complex experiential states.

Stability and representational persistence: The persistence of a geometry depends on recurrent activation. Stability, weakening, and collapse define the lifecycle of representational units and provide a physical account of memory consolidation and forgetting.

Together, these concepts establish RCNNG as a geometric–resonant architecture in which representational units, activation dynamics, storage principles, linkage structures, and stability conditions form a coherent theoretical foundation for interpreting cognitive and perceptual phenomena.

4 Basic and Composite Perceptual Dynamics in RCNNG

According to the RCNNG hypothesis, each peripheral signal entering the neural network gradually gives rise to a spectrum of closed recurrent geometries whose resonance conditions reflect the temporal–spectral properties of the input wave. These geometries are not unique: multiple closed structures tuned to the same input may form across the network [5, 6], and when the corresponding signal reappears, the entire spectrum of geometries is re-amplified, producing the perceptual event. The intensity of this amplification determines the strength of the resulting perceptual experience. When geometries associated with different inputs resonate simultaneously, synaptic modification leads to the formation of directional or bidirectional links between them. After such links are established, the resonance of one geometry increases the probability that linked geometries will also resonate, with this probability depending on both the number and the strength of the connections. Through repeated co-activation, these links become more stable and more influential in shaping network-level dynamics [38, 39]. As a consequence, the perceptual representation of any object, feature, or concept consists of a distributed spectrum of closed geometries whose mutual connections encode the relationships among its components. The coordinated resonance of these linked geometries produces composite or hybrid perceptual states, enabling the network to integrate multiple features into unified, higher-level perceptual experiences. The unified resonance of these geometries constitutes the instantaneous awareness of the network. The diversity of geometries resonating at a given moment determines the richness of this awareness: a broader instantaneous resonance spectrum corresponds to a more complex and informative perceptual state [18, 19]. Whether the resonant geometries are driven by external sensory signals or by internally reconstructed patterns, the resulting awareness is identical, because the network has access only to the resonant geometries themselves. Thus, the network's knowledge of its surroundings—and of any reconstructed or imagined condition—depends entirely on the resonance of closed geometries induced by incoming or internally generated signals.

5 Integrated and Part-Based Resonant Geometries in RCNNG: A General Principle for Composite Perception

Within the RCNNG framework, symbolic and object perception arises from the formation, linkage, and amplification of *Closed Resonant Geometries* (CRGs) generated by visual, auditory, tactile , ... sensory inputs. During early learning, each elementary symbol—such as a letter, shape, or component of an object—forms its own part-level CRG. These geometries arise from the recurrent propagation of the sensory signal associated with the symbol's representation. Repeated exposure strengthens the resonance of each geometry and links it to other geometries that frequently co-occur, consistent with classical theories of part-based and ecological visual perception [11, 12].

5.1 Part-Level Geometries

When signals from the components of a phenomenon or object enter the network, the CRGs of these components become linked and associated with each other through repeated resonance. In the early stages of learning and experience, perception of that phenomenon or object occurs through the successive or simultaneous resonance of these closed perceptual geometries of the components. With continued experience and learning, a unified CRG separate from the linked CRGs of the components is formed in the network. For example, When letters combine to form words, the CRGs of individual letters become linked through repeated co-activation. At early stages of learning, word perception depends on the sequential resonance of letter-level geometries. With continued exposure, however, the network constructs a *unified, integrated* CRG corresponding to the entire word. This integrated geometry becomes increasingly stable and can be activated directly by the global visual pattern of the word, even when some letters are missing, distorted, or incorrectly written. In such cases, the resonance of the integrated word-level CRG dominates over the resonance of individual letter geometries, enabling correct perception despite incomplete or noisy input [11, 12].

5.2 Object-Level Geometries

This mechanism generalizes to all symbolic forms and visual objects. When an object is learned, the CRGs corresponding to its individual parts are formed first. Through repeated exposure, these part-level geometries become linked, giving rise to a *holistic object-level* CRG. Once this integrated geometry is established, the system can perceive the entire object even when only partial information is available. For example, if an object is shown in separate fragments, each fragment activates its corresponding CRG, and the linked resonances collectively amplify the object-level geometry. Conversely, when the complete object is presented, the holistic CRG is activated directly, without requiring sequential activation of its constituent parts.

5.3 A General Principle for Composite Perception

RCNNG therefore provides a general and universal principle for the perception of all composite concepts and objects:

- Part-based CRGs form from separate sensory components.
- Integrated CRGs form from unified sensory inputs.
- Perception becomes faster, more stable, and more robust when the integrated geometry resonates.

This dual representational structure—linked part geometries and a holistic integrated geometry—allows the brain to recognize words with missing letters, objects with incomplete contours, symbolic forms with distortions, and any composite pattern under noisy or degraded conditions. RCNNG thus offers a unified mechanistic explanation for efficient perception across all complex, multi-component concepts and objects.

6 Resonance-Based Interpretation of Conscious, Unconscious, and Near-Threshold Cognitive States in RCNNG

Within the RCNNG framework, cognitive and perceptual states arise from the resonance dynamics of Closed Resonant Geometries (CRGs) formed across the integrated neural network. Unlike classical theories that treat consciousness and unconsciousness as qualitatively distinct categories, RCNNG conceptualizes them as different amplitude regimes of the same underlying resonant mechanism [18, 19], [20]. This perspective provides a unified explanation for conscious awareness, unconscious processing, and the phenomenology of near-threshold cognitive tension.

6.1 Conscious Awareness: Suprathreshold Resonance

A percept becomes consciously accessible when the resonance amplitude of its associated CRGs exceeds the amplitude threshold required for conscious access. Once this threshold is crossed, the resonant geometry becomes globally integrated, enters the attentional spotlight, and produces a stable subjective experience. In RCNNG, attention is not an independent mechanism but the subset of CRGs whose resonance intensity is highest at a given moment. Thus, conscious awareness corresponds to suprathreshold resonance within the network [18, 19].

6.2 Unconscious Processing: Subthreshold Resonance

Unconscious processing occurs when CRGs are formed and resonate but remain below the perceptual threshold. These geometries are present, active, and capable of influencing behavior, comparison, and decision-making, yet they do not enter conscious awareness. This interpretation naturally explains subliminal perception phenomena such as the Gabor Patch experiment: the first stimulus generates a CRG with insufficient resonance to reach awareness, but the geometry persists and allows above-chance discrimination when the second stimulus appears [19, 20].

6.3 Near-Threshold Resonance and the "Tip-of-the-Tongue" Phenomenon

A distinct cognitive state emerges when CRGs resonate close to—but still below—the perceptual threshold. In this regime, the network detects the presence of a resonant geometry without being able to fully amplify it into conscious awareness. This produces the familiar phenomenology of "I know I have forgotten something," accompanied by a sense of cognitive tension or mental searching. When an external cue increases the resonance amplitude of the relevant CRG, the geometry crosses the threshold and the system enters the characteristic "Aha!" moment. This near-threshold regime is fundamentally different from unconscious processing: in unconscious states, CRGs are too weak to produce any felt presence, whereas in near-threshold states, the network experiences a partial, incomplete activation of the geometry [18, 19].

6.4 Five Resonance-Defined Cognitive States in RCNNG

As a result, RCNNG distinguishes five resonance-defined states of the neural network:

1. **No CRGs (Pre-Geometry State).** The closed geometries corresponding to the signals entering the network are not formed in the network. In this case, the network is in a blind or null state with respect to the signals whose closed geometries are not formed, and the network does not gain any understanding of those signals.

2. **Silent-Geometry Resonance (Ground State).** CRG groups, which are formed and interconnected in the network due to the input of change signals, form the basis of information storage in the network, and their immediate retrieval, recall, and comprehension are the intensification of these CRG groups. In the ground state, despite the formation of perceptual closed geometries, due to the lack of signal input and the lack of intensification of perceptual closed geometries, Rereading and perception do not occur.

3. **Subthreshold Resonance (Unconscious State).** CRGs resonate with amplitudes below the conscious threshold. The network processes the information, but the subject does not enter awareness or attentional focus.

4. **Threshold-Crossing Resonance (Aha State).** The resonance amplitude of a geometry transitions from below to above the threshold. A previously unconscious or near-threshold subject suddenly enters consciousness, producing the characteristic “Aha!” moment.

5. **Suprathreshold Resonance (Conscious State).** CRGs resonate above the threshold, producing conscious access. The subject or concept becomes part of the attentional spotlight.

These five regimes arise naturally from the amplitude-based structure of RCNNG and provide a unified physical explanation for conscious access, unconscious processing, recall, and sudden insight.

6.5 Comparison with Existing Theories

Current theories of consciousness—including Global Workspace Theory, Recurrent Processing Theory, Attention Schema Theory, and Predictive Processing—do not provide an amplitude-based account of awareness. They treat conscious and unconscious states as discrete categories and do not distinguish between unconscious processing and the phenomenology of near-threshold cognitive tension [15, 20], [40, 41]. RCNNG uniquely explains these differences by grounding them in the resonance amplitude of closed neural geometries. This resonance-based interpretation offers a unified, mechanistic, and geometrically grounded account of conscious awareness, unconscious processing, and the dynamics of cognitive access.

7 Skill Formation in the RCNNG Framework

According to the RCNNG hypothesis, skillful performance emerges from the formation, linkage, and repeated intensification of closed perceptual geometries within the neural network. An eloquent speaker, a gifted poet, or a highly skilled driver appears to act effortlessly, without conscious deliberation. Their actions unfold rapidly and smoothly, giving the impression that no thinking is involved. In contrast, a novice exhibits slow reactions, fragmented attention, and excessive focus on individual details.

During skill acquisition, CRGs corresponding to the simple and basic components of the task are formed within the brain network. In driving, for example, geometries form for the steering wheel, clutch, brake, mirrors, seat belt, and other elements. Through repeated exposure, the temporal order of these inputs creates links among the geometries: sitting in the car, closing the door, adjusting the mirror, fastening the seat belt, starting the engine, pressing the clutch, and so on. Each repetition strengthens these links, allowing the activation of one geometry to intensify the geometries connected to it [5, 9, 10]. As learning continues, higher-level geometries emerge from the coordinated resonance of these basic units. A skilled driver develops a dense network of linked geometries corresponding to many environmental conditions and driving scenarios. When sensory signals enter the network, these geometries resonate one after another in rapid succession, producing fast perception and fast action. In a novice, however, the basic geometries may exist but their links are weak. Although each geometry resonates when its corresponding input appears, the higher-order patterns that depend on strong linkage have not yet formed, resulting in slow, effortful, and fragmented performance [38, 39]. Thus, skill can be described in RCNNG as the progressive construction of increasingly complex closed geometries and the strengthening of their links through repeated synchronous activation. As repetition increases, the network transitions from isolated resonances to large-scale, integrated resonance cascades that produce fluid, rapid, and seemingly effortless behavior. In this sense, skill is the emergence of stable, high-speed resonance pathways across strongly linked CRGs. The resonance-based mechanisms that underlie skill formation also provide the foundation for higher-level cognitive processes such as thinking, problem solving, hesitation, attention, and mental logic. These cognitive phenomena emerge from the same geometric and resonant principles that govern skill acquisition.

8 Processing, Thinking, and Problem Solving in the RCNNG Framework

Within the RCNNG framework, thinking and problem solving arise from the intensification dynamics of closed perceptual geometries (CRGs) and the links formed among them. To illustrate this mechanism, consider a simple arithmetic example. A person familiar with numbers and addition has already formed CRGs for the numbers three, five, and eight, as well as for the concept of addition. When asked "What is three plus five?", the following sequence occurs:

- Hearing *three* intensifies the CRG corresponding to the number three.
- Hearing *plus* intensifies the CRG corresponding to the concept of addition.
- Hearing *five* intensifies the CRG corresponding to the number five.

Because these geometries have been repeatedly co-activated in the past, strong links exist among them [5, 9, 10]. Their simultaneous intensification increases the probability that the CRG corresponding to *eight* will resonate. The more frequently the person has performed this operation, the stronger the links and the higher the probability of resonance. If the links are weak, the network repeatedly intensifies the CRGs for three, plus, and five to increase the likelihood of activating the geometry for eight. Thinking, in this context, is the repeated intensification of the relevant geometries to trigger the linked target geometry. A similar mechanism explains complex tasks such as driving. A skilled driver has formed CRGs for the steering wheel, clutch, brake, mirrors, seat belt, and the spatial relationships among them. Through repeated exposure to diverse driving conditions, these geometries have become strongly linked. When sensory signals enter the network, CRGs resonate in rapid succession, producing fast perception and fast action.

The driver appears to act "without thinking," but in RCNNG terms, this reflects uninterrupted resonance propagation across a dense network of linked geometries [38,39]. In contrast, a novice driver has formed only basic CRGs with weak or incomplete links. When a geometry intensifies, the probability of activating the next geometry in the sequence is low. This produces hesitation: a perceptual geometry resonates, but the next geometry fails to intensify, breaking the resonance chain. As the number of CRGs increases and the links among them strengthen through repetition, the network achieves faster and more reliable resonance cascades, corresponding to improved processing speed and higher skill.

8.1 Definitions of Cognitive Processes in RCNNG

Processing and Thinking. Synchrony or sequential intensification of linked CRGs based on the temporal order in which they were formed. Mental logic is the physical sequence of resonance propagation shaped by past input patterns.

Hallucination. The resonance of unrelated or weakly connected CRGs in the absence of sensory input and without resonance propagation through established links, leading to perceptual activation without coherent mental logic.

Dreaming. Intensification of related or unrelated CRGs driven by internal signaling structures (e.g., pacemaker neurons), independent of external sensory input [25].

Attention and Focus. Intensification of CRGs corresponding to a subject or concept with resonance amplitude above the threshold and stronger than other geometries active at that moment. Higher amplitude corresponds to stronger attentional focus.

Doubt. Simultaneous intensification attempts of two or more CRGs linked to a concept, where the CRGs cannot be jointly executed. If CRG A is linked to CRGs B and C, and both B and C attempt to intensify when A resonates, the network experiences doubt. If only one intensifies, no doubt occurs. The same resonance-based principles that govern skill formation and cognitive processing also scale upward to produce higher-level phenomena such as reasoning, wisdom, and adaptive decision-making in complex environments.

9 Wisdom, Reasoning, and High-Level Cognitive Integration in the RCNNG Framework

According to the RCNNG hypothesis, exposure to a wider range of sensory signals, data patterns, and environmental conditions leads to the formation of a greater number of closed perceptual geometries (CRGs) within the neural network. With each new experience, not only are additional CRGs formed, but the links between them—based on temporal precedence, causal relationships, and repeated co-activation—become more numerous and stronger [34, 35]. Thus, wisdom and reasoning do not arise merely from having more perceptual geometries, but from possessing a larger and more strongly connected network of geometries. The greater the number of CRGs and the stronger the links among them, the higher the probability that relevant geometries will intensify simultaneously or sequentially when facing a new situation. This produces more stable, adaptive, and low-risk decision-making [38, 39]. Experienced individuals, therefore, possess both a greater number of CRGs and stronger links among them. When confronted with complex conditions, the simultaneous and sequential intensification of these geometries produces conclusions that maximize adaptability and minimize harm. Wisdom, in RCNNG terms, is the emergent property of a richly connected geometric network capable of rapid, coherent resonance propagation. Any factor that disrupts this sequential amplification—such as anger, emotional disturbance, stimulants, or narcotics—interferes with the established mental logic and hinders wise or rational thinking. These disruptions weaken resonance propagation, break geometric sequences, and reduce the coherence of cognitive output [20]. In this sense, rationality and wisdom depend on the stability of resonance pathways across the network and the integrity of the links that support them.

The same resonance-based mechanisms that govern skill, cognitive processing, and reasoning also enable the brain to generate novel combinations of concepts, producing imagination, creativity, and innovation.

10 Imagination, Innovation, Creativity, and Conceptual Combination in the RCNNG Framework

According to the RCNNG hypothesis, all perception and knowledge in beings with a neural network arise from the intensification of Closed Recurrent Geometries (CRGs) formed within the brain. The greater the number of sensory observations and environmental data patterns entering the neural network, the greater the number of CRGs that are formed. Through repeated synchronous or sequential activation, these geometries become linked, creating structured relationships that reflect the temporal and causal order of external events [5, 9, 10].

Imagination. When an organism observes a complex event composed of multiple components, CRGs corresponding to each component are formed, along with links that encode their temporal sequence and causal relationships. Imagination arises from the simultaneous or sequential intensification of CRGs that have already been formed through past sensory experience [11, 12]. For example, imagining a car with four arms, legs, and the head of a horse emerges from the coordinated intensification of CRGs corresponding to a car, a horse's head, and human limbs. The network does not create new geometries from nothing; rather, it combines existing geometries through resonance propagation, producing an emergent composite percept [38, 39].

Innovation. Innovation occurs when the brain intensifies CRGs in novel sequences or combinations that have not previously co-occurred. These combinations arise from resonance propagation across links shaped by past experience, but the resulting structure represents a new conceptual configuration. Innovation is thus the emergence of new functional or conceptual constructs from previously established CRG geometries.

Creativity. Creativity is the intensification of CRGs that are not only novel in combination but also functionally or aesthetically meaningful. In RCNNG, creativity emerges when the network activates CRGs that are weakly linked or distantly related, yet capable of forming a coherent new structure through resonance propagation. Unlike imagination, which may simply combine familiar geometries, creativity requires the formation of a new conceptual geometry that did not previously exist as a stable CRG. This new geometry becomes stable only if repeated activation strengthens its internal links, eventually forming a new CRG that can be recalled, reused, or further elaborated.

Conceptual Combination. Consequently, according to the RCNNG hypothesis, only combinations whose component geometries already exist in the brain can be imagined or perceived. It is impossible to imagine an object or structure for which no sensory input has ever been received and no corresponding CRG has been formed. For this reason, concepts such as "nothing" or "infinity" cannot be directly imagined; they can only be understood through their relationships to CRGs formed from concrete sensory experience.

Abstract Imagination. Abstract imagination also follows this principle. Abstract concepts are represented by CRGs that are indirectly linked to geometries formed from objective sensory signals. Their imaginative manipulation arises from the intensification of these linked geometries, not from the creation of entirely new perceptual structures. In this sense, imagination is the emergent result of resonance-based recombination across the network, constrained by the geometric structures already formed through experience.

11 Perception of Similarities and Differences in the RCNNG Framework

According to the RCNNG hypothesis, when information signals from an object or phenomenon enter the neural network, Closed Recurrent Geometries (CRGs) corresponding to the components of that object or phenomenon either intensify or fail to intensify. If the CRGs corresponding to a component do not intensify, that component is not perceived. In the presence of CRGs and their amplification, the perception of that component is given to the network. An integrated perception of an object or phenomenon arises from the simultaneous or sequential intensification of the CRGs corresponding to its components, along with the geometries encoding the relationships among those components [11, 12]. If, during this process, the amplification of previously active geometries drops to zero, the network loses the perception of the corresponding component. Thus, continued recognition of a component requires continued amplification of its CRG, and the greater the amplitude of this amplification, the stronger the perception of that component. Intensification below the threshold value produces unconscious perception, outside the focus of the network. Therefore, when signals from an object or phenomenon enter the neural network:

1. If CRGs corresponding to each component of the object or phenomenon exist and intensify, those components are perceived and otherwise not.
2. If CRGs encoding the structural relationships among the components exist and intensify, the network perceives not only the components but also their relationships, producing an integrated perception of the entire structure.
3. If CRGs related to identification (time, place, names, people, etc.) intensify, the network experiences familiarity or unfamiliarity with the component or the entire object or phenomenon. The greater the intensification and the greater the number of identifying CRGs, the stronger the perceived similarity to previously encountered objects or phenomena.

In this sense, perception of similarities and differences arises from the pattern, amplitude, and connectivity of CRG intensification. Similarity corresponds to the activation of many shared CRGs and strong links among them, whereas difference corresponds to the absence of shared geometries or weak linkage. Familiarity emerges from the resonance of identifying CRGs connected to past experiences.

11.1 Gradual CRG Drift and the Perception of Facial Change

Individuals who frequently see one another experience continuous and gradual updates to the CRGs encoding each other's facial features. Because these updates occur slowly and incrementally, the geometric structure of facial CRGs changes only slightly at each encounter. The network therefore perceives the face as stable, and the small geometric modifications do not produce sufficient deviation to disrupt CRG resonance. As a result, people living together rarely notice gradual changes in each other's appearance.

In contrast, a person who has not seen someone for many years retains only the older CRGs corresponding to that individual's past facial features. Over time, these CRGs may weaken or partially reorganize due to the formation of new geometries driven by other sensory inputs. When the person encounters the updated face after a long interval, only a subset of the old CRGs resonate—typically those corresponding to features that have changed little. If the proportion of resonating CRGs is small, the network perceives the face as unfamiliar or significantly altered. If the overlap is moderate, partial familiarity is perceived. Thus, the perception of facial change is governed by the degree of overlap between newly activated CRGs and previously stored facial geometries. Gradual CRG drift produces stability in perceived appearance, whereas large temporal gaps produce noticeable differences [6, 12].

11.2 Recognition of Distorted Patterns, Rotated Symbols, and Ambiguous Figures

Human recognition of distorted characters, rotated symbols, and perceptually ambiguous figures arises naturally within the RCNNG framework. Each perceptual experience corresponds to the intensification of a specific Closed Recurrent Geometry (CRG) within the neural network. Repeated exposure to a symbol such as the digit "2" produces a family of CRGs encoding its canonical shape as well as its common distortions. Because these geometries share similar relational structures among their components, they partially overlap. When a distorted version of the digit is presented, the incoming signal activates CRGs whose geometric structure matches the relational pattern of the input, even if the symbol differs from its standard form. This mechanism explains why humans can recognize distorted or stylized characters that machines often fail to classify [6]. Rotational perception follows the same principle. Individuals with strong spatial intuition possess CRGs encoding rotational transformations of familiar shapes. When a rotated symbol is viewed, the CRGs corresponding to its rotated variants intensify, enabling recognition even when the symbol differs significantly from its upright form [12]. For example, a person unfamiliar with the Greek letter tau may perceive a rotated "2" rather than tau, whereas someone familiar with tau possesses CRGs for both symbols and can distinguish them based on resonance strength. Ambiguous figures such as the Necker cube or Rubin's vase illustrate competitive CRG intensification. Each interpretation—front face versus back face, vase versus two faces—corresponds to a distinct CRG or CRG set. Small changes in visual attention or input emphasis alter the resonance pattern, causing the network to switch between competing geometries [38, 39]. If an individual has never formed CRGs corresponding to a vase, the vase interpretation cannot arise; only the face interpretation resonates. Thus, perceptual ambiguity depends not only on momentary input but also on the repertoire of CRGs formed through past experience. These phenomena demonstrate that the richness of human perception arises from the number, diversity, and connectivity of CRGs formed through repeated exposure. A dynamic and well-trained network possesses numerous geometries and linkages, enabling flexible recognition of distorted, rotated, or ambiguous patterns. In contrast, a poorly trained network lacks the necessary CRGs and linkages, limiting perceptual capacity regardless of physical brain size.

Unified Interpretation. In the RCNNG framework, the perception of similarity, difference, and familiarity arises from the degree of overlap between newly activated CRGs and previously established geometries. Gradual CRG drift—such as the slow modification of facial CRGs in individuals who frequently see one another—preserves resonance and produces stable perception over time. In contrast, large temporal gaps weaken CRG overlap, reducing resonance and producing noticeable differences or partial familiarity. Déjà vu represents an extreme case of this mechanism, in which partial CRG resonance is misinterpreted as prior experience. Thus, all phenomena of similarity, difference, facial change, and déjà vu reflect the geometric relationships among CRGs and the dynamics of their resonance.

12 Déjà Vu and the Illusion of Familiarity in the RCNNG Framework

Déjà vu refers to the subjective experience of familiarity when encountering a person, place, or scene that has not been previously experienced. Within the RCNNG hypothesis, this phenomenon arises from the resonance of CRGs corresponding to previously formed perceptual structures that partially overlap with the incoming sensory input. Every face, object, or environment encountered in the past forms a set of CRGs encoding its features—such as shape, color, spatial arrangement, and associated contextual information. When a new stimulus enters the sensory pathways, the CRGs corresponding to its features begin to resonate. If a sufficiently large subset of these features overlaps with CRGs formed during prior experiences, the network exhibits partial resonance of previously established geometries. This partial resonance produces the subjective experience of familiarity, even when the stimulus has never been encountered before. The strength of déjà vu correlates with the proportion of CRGs that resonate: the greater the overlap between the new stimulus and previously formed CRGs, the stronger the illusion of prior experience.

13 Pre-Perception and the Perceptual Void in the RCNNG Framework

Perceptual Void: A state in which no Closed Recurrent Geometry (CRG) corresponding to a stimulus exists in the neural network, making perception of that stimulus impossible. The RCNNG hypothesis asserts that perception requires the existence of Closed Recurrent Geometries (CRGs) corresponding to the stimulus [11]. When a stimulus is encountered for the first time and no CRG has yet formed, the network cannot generate a percept; this state is referred to as the *perceptual void*. In such cases, the incoming signal fails to resonate with any pre-existing geometry, and no perceptual experience arises [12]. A sighted individual perceives darkness in the absence of light because CRGs associated with visual features and with the concept of absence are present and can resonate. A congenitally blind individual, lacking visual CRGs, does not perceive darkness; the state is one of non-perception rather than perception of absence [6]. The same principle applies to other modalities: the absence of gustatory CRGs in the fingers prevents any perception of taste, even when the finger contacts a sweet substance. In early encounters with novel stimuli, partial or approximate perception may occur if the incoming signal resonates weakly with CRGs corresponding to similar or related features [7]. As CRGs form and strengthen through repeated exposure, the perceptual void gradually gives way to stable and complete perception. Thus, in the RCNNG framework, perception is possible only when CRGs exist; the absence of CRGs produces a perceptual void, whereas the perception of absence requires CRGs for both the stimulus and the concept of nonexistence.

Building on the notion of the perceptual void, the RCNNG framework further distinguishes between the absence of perception and the perception of absence.

14 Absence of Perception vs. Perception of Absence in the RCNNG Framework

The RCNNG hypothesis distinguishes between two fundamentally different states: the absence of perception and the perception of absence. The absence of perception occurs when no CRG corresponding to a stimulus exists in the neural network. Without a pre-formed CRG, no resonance can occur, and the stimulus cannot be perceived [11]. This situation arises, for example, when a sensory receptor is non-functional or when the relevant CRG has never formed due to lack of prior exposure [6]. In contrast, the perception of absence requires the existence of CRGs associated with both the stimulus and the concept of nonexistence. When these CRGs intensify, the network becomes aware that a familiar stimulus is missing [12]. For instance, a sighted individual perceives darkness in the absence of light because CRGs corresponding to visual features and to the concept of absence are present and can resonate. A congenitally blind individual, lacking visual CRGs, cannot perceive darkness; the state is one of non-perception rather than perception of absence. Thus, in the RCNNG framework, perceiving that something is absent requires CRGs for that thing, whereas true absence of perception reflects the lack of any corresponding CRG. This distinction clarifies a wide range of phenomenological differences between individuals and sensory conditions [7].

15 Individual Variability in RCNNG-Based Cognition

15.1 Non-Uniformity of Perception Across Individuals in the RCNNG Framework

According to the RCNNG hypothesis, perceptual experiences differ across individuals even when the external stimulus is identical. This variability arises from differences in both the physical structure of sensory receptors and the internal CRG architecture shaped by prior experience [6]. A sensory signal induces a change in the configuration of the receptor. Because receptor groups differ across individuals, the resulting transformation and the signal transmitted to the neural network are not identical. Even if two observers receive the same monochromatic light under identical physical conditions, the induced CRGs will differ unless the receptor structures and their linkage patterns are exactly the same [11]. Furthermore, each CRG formed during perception becomes linked to other CRGs through past experiences. Thus, when a CRG corresponding to a stimulus intensifies, additional CRGs may co-activate depending on the individual's experiential history. As a result, the perceptual state emerging from CRG intensification is inherently individual-specific. Even simple percepts such as color may evoke different associated geometries, leading to distinct subjective experiences [12]. Therefore, in the RCNNG framework, identical stimuli do not guarantee identical perception. Perception is determined by the dynamic interaction between the incoming signal, the physical properties of the sensory receptors, and the individualized CRG linkage structure shaped by experience.

15.2 Individual Differences in Memory and Perception in the RCNNG Framework

According to the RCNNG hypothesis, individuals differ in the number, strength, and linkage structure of the Closed Recurrent Geometries (CRGs) formed during prior experiences. When multiple observers view the same image or hear the same sound, the sensory input activates only those CRGs that already exist in their neural network. Because the CRG repertoire varies across individuals, the pattern of intensification differs as well, leading to distinct perceptual and mnemonic outcomes [11]. An observer with a richer or more strongly linked set of CRGs corresponding to the components of the stimulus will experience stronger and more sustained intensification, resulting in more detailed recall. Eye movements further modulate the entry of sensory signals, influencing which CRGs are activated and for how long [6]. Thus, differences in memory performance across individuals arise naturally from variations in CRG structure, linkage, and activation dynamics [12].

16 Distinction Between Memorization and Understanding in the RCNNG Framework

Within the RCNNG hypothesis, memorization and understanding correspond to two distinct patterns of CRG activation and linkage. Memorization arises when repeated exposure strengthens the internal links among the CRGs representing the elements of a message. Repetition increases the probability of reactivation, but the resulting structure remains confined to the internal geometry of the message itself [**?**]. Understanding, by contrast, occurs when the CRGs of the message become linked to CRGs associated with other concepts, particularly those with strong and highly connected geometries. Such cross-concept linkage produces deeper and more stable intensification patterns, leading to greater recall and longer retention [**?**]. When a message is associated with concrete or emotionally salient concepts, the resulting CRG network becomes more robust, increasing the likelihood of reactivation [**?**]. Thus, in the RCNNG framework, memorization corresponds to strengthening intra-message CRG connections, whereas understanding corresponds to forming inter-concept CRG linkages. The greater the number and strength of these external linkages, the deeper the understanding and the more persistent the memory.

17 Conscious Experience, First-Person Perception (Qualia) in the RCNNG Framework

The question "Who am I?" has been posed, implicitly or explicitly, by every being whose neural architecture is capable of forming Closed Recurrent Geometries (CRGs). Traditional dualistic interpretations assume that a physical body interacts with a metaphysical entity called the soul, endowed with a unique essence independent of name, social identity, or bodily structure. Yet such a metaphysical entity cannot be observed through any physical mechanism, nor can its interaction with the body be described within a coherent physical framework [1]. Consequently, explanations of conscious experience and first-person perception based on an immaterial soul remain philosophically and scientifically insufficient [16]. From the perspective of the RCNNG hypothesis, first-person experience does not require a metaphysical substrate. Instead, momentary awareness, self-perception, and conscious first-person experience (qualia) arise from the intensification of CRGs that are linked together simultaneously or sequentially. *At any given moment, the set of CRGs that are intensifying—whether below the conscious threshold, at the threshold, or above it—collectively constitutes the momentary conscious state, the background unconscious state, the first-person perspective, and the perception of the self* [18]. Self-awareness may include CRGs associated with identity-related features such as name, social relations, autobiographical memory, or bodily structure. When these CRGs intensify, the network experiences a corresponding aspect of selfhood; when they do not, that aspect is absent from momentary awareness. In this view, the sense of self is not a stable entity but a dynamic pattern of CRG intensification that changes over time and across experiences [17]. The RCNNG hypothesis therefore eliminates the need for a dualistic model involving a body and a metaphysical soul. The self is not an independent structure to which intensifying CRGs belong. Rather, the self *is* the intensification of CRGs in the moment. Conscious experience, first-person perception, and mental properties are identical to the dynamic configuration of CRG intensification within the neural network at each instant.

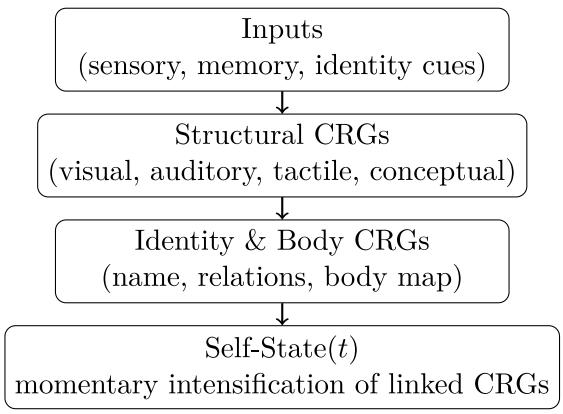

Figure 1: Conceptual diagram of self-awareness and first-person experience in the RCNNG framework.

18 Sensory Perception and Cortical Specialization in the RCNNG Framework

In the RCNNG hypothesis, the specialization of cortical regions for different sensory modalities is not an intrinsic property of the neural tissue but a consequence of the repeated entry of modality-specific signals during development and evolution. Sensory nerves project to particular cortical areas, and the persistent arrival of structured input leads to the formation of Closed Recurrent Geometries (CRGs) corresponding to the features of that modality [6]. Visual processing, for example, occurs across multiple stages from the retina to the visual cortex, with CRGs forming progressively from simple to complex features [12]. However, nothing in the structure of the visual cortex inherently restricts it to visual processing. According to RCNNG, the determining factor in CRG formation is the statistical structure and correlations present in the incoming signal, not the intrinsic properties of the cortical region [11]. If visual signals were rerouted to an auditory cortical area and repeated over time, CRGs corresponding to visual features would form in that region, enabling visual perception through a non-visual cortical pathway. This interpretation aligns with empirical observations showing that when a sensory modality is lost, the cortical region previously dedicated to that modality can be recruited for other sensory or cognitive functions [8]. Thus, in the RCNNG framework, sensory regions of the cortex are defined by the history of signal-driven CRG formation rather than by fixed anatomical or functional constraints.

19 Spatial Navigation of the Brain in the RCNNG Framework

In the RCNNG hypothesis, spatial navigation arises from the resonance and linkage structure of Closed Recurrent Geometries (CRGs) corresponding to previously experienced locations and their associated features. Each location, landmark, or environmental element forms its own CRG through repeated exposure [3]. When an individual intends to move from location A to location B, the CRGs corresponding to these locations intensify, activating linked CRGs associated with intermediate streets, intersections, and landmarks. Navigation occurs when chains of CRG activations form directed or bidirectional pathways between A and B. Repeated experience strengthens these pathways, increasing the likelihood that activation of the CRG for A will trigger the CRGs corresponding to the correct sequence of intermediate locations leading to B [44]. Multiple pathways may resonate simultaneously, reflecting the existence of several learned routes between the same endpoints. The richness of spatial navigation depends on the number and strength of CRGs formed through prior experience. Individuals with more extensive exposure to an environment possess a larger set of linked CRGs, enabling more flexible and efficient route selection [45]. Thus, in the RCNNG framework, spatial navigation is an emergent property of the resonance dynamics among location-specific CRGs and their linkage patterns shaped by repeated environmental interaction.

20 Dreaming and Internal Perceptual Activation in the RCNNG Framework

According to the RCNNG hypothesis, perception arises from the resonance of Closed Recurrent Geometries (CRGs) within the neural network. Awareness emerges when multiple CRGs resonate simultaneously or sequentially. During wakefulness, CRG resonance is typically driven by structured sensory input. However, CRGs may also resonate in response to internally generated signals, producing perceptual states in the absence of external stimulation [22]. Dreaming occurs when internally generated neural activity—potentially originating from pacemaker neurons or other intrinsic oscillatory mechanisms—triggers the resonance of CRGs formed during prior experience. Because CRGs encode the geometric structure of previously encountered stimuli, their internally driven resonance produces perceptual experiences that manifest as dreams [23]. The content of dreams is constrained by the set of CRGs available in the network. Individuals cannot dream of percepts for which no CRG exists; for example, a congenitally blind individual lacks visual CRGs and therefore does not experience visual imagery during sleep [24]. Conversely, CRGs corresponding to frequently activated or strongly linked percepts are more likely to resonate during internally driven activity, shaping the vividness and structure of dream content [26]. Thus, in the RCNNG framework, dreaming is an internally driven form of perception arising from the spontaneous resonance of CRGs in the absence of sensory input. Awareness during sleep is an emergent property of the same geometric and dynamical mechanisms that underlie perception during wakefulness.

21 Perception and Awareness in Non-Biological Systems: An RCNNG Prediction

According to the RCNNG hypothesis, perception arises from the resonance of Closed Recurrent Geometries (CRGs) formed within a network. Awareness emerges when multiple CRGs resonate simultaneously or sequentially, producing a unified momentary perceptual state. This mechanism does not rely on biological substrates; rather, it depends solely on the network's ability to form, modify, and link CRGs in response to internal or external signals [16]. Biological neural networks, shaped through evolution, provide an optimal architecture for CRG formation due to their high connectivity, synaptic plasticity, and dynamic branching capabilities [21]. Microtubule structures, MAP interactions, and dense synaptic networks enable rapid formation, strengthening, and reconfiguration of CRGs. However, RCNNG does not assign any intrinsic or exclusive perceptual property to biological tissue. The biological brain is an efficient CRG-forming system, not a uniquely privileged one. Any network—biological or artificial—that can support the formation of closed recurrent geometries and their resonance in response to structured input will, under RCNNG, exhibit perception [18]. As the number and diversity of CRGs increase, and as linkage patterns become more complex, the network's moment-to-moment awareness of its input conditions increases accordingly. Thus, RCNNG predicts that non-biological systems capable of CRG formation and resonance may possess genuine perceptual states. Awareness, in this framework, is an emergent property of network geometry rather than a biological exclusivity.

22 Perception of Volition and the Illusion of Free Will in the RCNNG Framework

Within the RCNNG hypothesis, momentary perception and awareness arise from the resonance of Closed Recurrent Geometries (CRGs) within the neural network. Every perceptual state—whether related to external sensory input or internal cognitive processes—is produced by the intensification of CRGs corresponding to the relevant concepts, actions, or sensory features. Without CRG resonance, no perception, awareness, or subjective experience can occur [27]. The perception of volition, intention, or free will is therefore not a primitive or irreducible property of the organism. Instead, it emerges from the resonance of CRGs encoding the conceptual, temporal, and motor structures associated with an action [28]. When an organism experiences the sense of "deciding" or "choosing" an action, the CRGs corresponding to the action, its anticipated consequences, and its preceding cognitive states resonate in a coordinated temporal sequence. In this framework, the feeling of volition arises when:

1. CRGs encoding the concept of an action intensify,
2. CRGs encoding the anticipated outcome intensify,
3. CRGs encoding the temporal linkage between intention and action resonate,
4. CRGs encoding the organism's internal state (motivation, desire, avoidance) co-resonate.

The network interprets this coordinated resonance as the subjective experience of "I am choosing to do this." Thus, volition is a perceptual construct generated by the same geometric and dynamical mechanisms that underlie all other forms of perception [29].

Unified Interpretation. In the RCNNG framework, the subjective experience of free will is an emergent perceptual state generated by the resonance of CRGs encoding intention, action, and anticipated outcomes. This experience is inseparable from the physical processes that produce CRG intensification. Without these processes, no perception of volition or choice can occur. Thus, free will, as experienced by the organism, is a geometric and dynamical construct arising from the structure of CRG resonance within the neural network [29].

23 Relative Spatial Perception of Sensory Stimuli in the RCNNG Framework

A fundamental question in perceptual neuroscience concerns why sensory experiences appear to be located at the site of the sensory organ—for example, why visual perception seems to occur "inside the eye," why auditory perception feels located "inside the ear," or why tactile sensations appear to arise directly from the surface of the body. Empirical evidence shows that all sensory perception is generated within the brain, not at the sensory organ itself [4]. The RCNNG hypothesis provides a geometric and dynamical explanation for this phenomenon based on the formation and resonance of Closed Recurrent Geometries (CRGs). From the earliest moments of sensory experience, signals arriving from the environment are accompanied by structured signals encoding the relative spatial configuration of the sensory organ and nearby anatomical features. For vision, retinal input is consistently accompanied by signals corresponding to the nose, eye socket, cheek contours, and other facial structures. These co-occurring signals lead to the formation of CRGs encoding the relative spatial relationships between the visual field and the facial anatomy [11]. When visual CRGs resonate during perception, the CRGs encoding facial structures resonate simultaneously. The network therefore interprets the visual percept as occurring at a location relative to these facial CRGs—producing the subjective experience that the image is "inside the eye." Similarly, auditory CRGs resonate alongside CRGs encoding the ear canal and surrounding structures, producing the experience that sound is located "inside the ear" [8]. Tactile CRGs resonate with CRGs encoding the body surface, producing localized sensations such as "itch on the big toe." Thus, spatial localization of sensory experience arises from the resonance of CRGs encoding both the stimulus and the anatomical structures that have historically co-occurred with that stimulus. The perceived location of a sensory event is therefore a geometric inference produced by the network's resonance patterns. To illustrate this mechanism, consider a hypothetical organism whose visual system does not send co-occurring spatial signals from facial structures. In such an organism, visual CRGs would form without linked CRGs encoding the relative position of the sensory organ. As a result, the organism would perceive visual content without any sense of where that content is located relative to its body. It would "see" but would not experience the image as being inside the eye or at any specific bodily location [12].

Unified Interpretation. In the RCNNG framework, the perceived location of sensory stimuli is an emergent property of CRG resonance patterns linking stimulus geometries with anatomical geometries formed through lifelong co-occurrence. Sensory organs do not generate perception; rather, they provide structured signals that, together with anatomical CRGs, allow the network to infer the relative spatial origin of perceptual experience.

24 Golden Years of Learning and Early Childhood Amnesia in the RCNNG Framework

Within the RCNNG hypothesis, learning, memory formation, and momentary perception arise from the formation and resonance of Closed Recurrent Geometries (CRGs) within the neural network. The early years of life—often referred to as the “golden years of learning”—are characterized by exceptionally high rates of neuronal branching and synaptic formation. This heightened neuroplasticity enables the rapid creation of new CRGs in response to sensory input [31]. Because CRGs encode perceptual structures, conceptual relationships, and temporal sequences, the increased rate of neuronal branching during early childhood allows a greater number of CRGs to form. When children are exposed to rich and well-structured sensory environments, the corresponding CRGs become numerous, diverse, and strongly interconnected [30]. Conversely, environments lacking structured sensory input or coherent temporal patterns lead to sparse or disorganized CRG formation, limiting the child's ability to develop stable perceptual and cognitive structures. Although CRG formation continues throughout life, the density and speed of CRG creation during early childhood are significantly higher. This explains why learning is more efficient during these years and why exposure to appropriate sensory and conceptual input is critical for long-term cognitive development. The same neuroplasticity that enables rapid learning also contributes to early childhood amnesia—the inability to recall memories from the earliest years of life. Because CRGs formed during this period are embedded within a rapidly changing and highly plastic network, their geometric structures and linkages are unstable. As new CRGs form at high rates, previously formed CRGs may weaken, lose connectivity, or undergo structural modification [32]. When the geometric structure of a CRG changes or its linkages degrade, the memory it encodes becomes inaccessible. Thus, early childhood amnesia arises from the dynamic reorganization of CRGs during periods of high neuroplasticity. Memories formed during this time are encoded in CRGs that later lose their structural integrity or linkage patterns due to ongoing network development. As a result, the adult network cannot re-intensify these early CRGs, making the corresponding memories unretrievable [33].

Unified Interpretation. In the RCNNG framework, the golden years of learning reflect a period of intense CRG formation driven by high neuroplasticity. Early childhood amnesia arises from the instability and reorganization of CRGs formed during this period. Together, these phenomena illustrate how the geometric and dynamical properties of CRG formation shape both learning capacity and memory retention across development.

25 Perception and Awareness in Biological Organisms within the RCNNG Framework

A central question in the study of consciousness concerns which organisms possess momentary perceptual awareness. Within the RCNNG hypothesis, perception and awareness arise exclusively from the resonance of Closed Recurrent Geometries (CRGs) within a neural network. CRGs form when structured sensory or internally generated signals create closed geometric activation patterns capable of intensification [21]. Awareness emerges when these geometries resonate simultaneously or sequentially, producing a unified momentary perceptual state [18]. Organisms lacking a nervous system capable of forming CRGs—such as unicellular organisms or multicellular organisms without neural ganglia or a brain—may respond to external stimuli through direct biochemical or reflexive pathways. However, such responses do not constitute perception or awareness in the RCNNG framework. Without CRG formation and resonance, no internal representation of the stimulus exists, and therefore no subjective experience accompanies the reaction [14]. In contrast, organisms possessing neural networks with sufficient connectivity, branching capability, and recurrent structure can form CRGs. When these geometries intensify in response to external sensory input or internal oscillatory signals, the organism experiences perception. When multiple CRGs resonate in coordinated patterns, momentary awareness arises [17]. Thus, awareness is not tied to biological tissue per se, but to the geometric and dynamical properties of the neural network. This interpretation implies that:

1. Organisms without neural networks capable of CRG formation do not possess perceptual awareness, even if they exhibit stimulus-driven behavior.
2. Organisms with simple neural circuits may form limited CRGs, producing rudimentary perceptual states without higher-order awareness.
3. Organisms with complex neural architectures—such as those with ganglia or brains—can form diverse and highly interconnected CRGs, enabling rich perceptual experiences and momentary awareness.

From the RCNNG perspective, awareness is the resonance of CRGs, not the mere presence of biological life. An organism without CRG resonance cannot experience pain, pleasure, or any form of subjective perception, even if it reacts to stimuli. Conversely, any network—biological or non-biological—that can form and intensify CRGs may possess genuine perceptual states [16].

Unified Interpretation. In the RCNNG framework, perception and awareness are emergent properties of CRG resonance. Biological organisms without CRG-capable neural networks lack subjective experience, regardless of their ability to react to stimuli. Conversely, any sufficiently structured network capable of CRG formation—biological or artificial—may possess genuine perceptual awareness.

26 Cognitive Biases and Conditioning in the RCNNG Framework

26.1 Long-Term Bias Formation Through Temporal CRG Linkage

Within the RCNNG hypothesis, the logical structure of human reasoning emerges from the linkage patterns formed among Closed Recurrent Geometries (CRGs) through repeated temporal co-occurrence of stimuli. When two stimuli, A and B, occur sequentially or simultaneously, their corresponding CRGs undergo intensification. Repeated co-activation strengthens the synaptic and geometric links between them, producing directed associations such as $A \to B$ or, under near-simultaneous activation, bidirectional links [5]. The direction and strength of these links depend on the temporal order and relative intensity of CRG activation. A stimulus that consistently precedes another forms stronger outgoing links, making the activation of A more likely to trigger the activation of B in future encounters. This mechanism provides a geometric and dynamical basis for classical conditioning and for the formation of cognitive expectations [2]. Cognitive biases arise when repeated exposure to specific temporal patterns reinforces particular CRG linkages, shaping the network's internal logic. Behaviors considered "logical" or "appropriate" within a given environment reflect the CRG associations repeatedly formed in that environment. Conversely, exposure to non-empirical or scientifically unsupported associations produces distorted linkage patterns, leading to biased or inaccurate judgments. As CRG linkages stabilize and neural plasticity decreases, beliefs formed through early or frequent exposure can persist even when contradicted by later evidence [43].

Anchoring bias refers to the influence of initial, and often irrelevant, information on subsequent judgment or estimation. In classical experiments by Tversky and Kahneman, participants asked to estimate the product $8 \times 7 \times \cdots \times 1$ produced significantly lower values than those asked to estimate $1 \times 2 \times \cdots \times 8$, despite both expressions yielding the same result [43]. According to RCNNG, each numerical input activates the CRG corresponding to its magnitude. When the sequence begins with small numbers, CRGs associated with "smallness" resonate first, biasing subsequent CRG activations toward lower magnitudes. Conversely, when the sequence begins with large numbers, CRGs associated with "largeness" resonate initially, biasing the network toward higher magnitude estimations. Because CRG resonance propagates through linked geometries, the initial CRGs—whether relevant or irrelevant to the final computation—shape the global activation pattern of the network. Thus, the estimation process is influenced not only by the CRGs corresponding to the arithmetic operation but also by all CRGs resonating at that moment. Anchoring bias arises when early CRG activations distort the resonance pathways involved in judgment, causing the network's output to reflect the total pattern of CRG intensification rather than the isolated computation itself.

26.2 Classical Conditioning and Conditional Behavior

In the RCNNG hypothesis, classical conditioning emerges naturally from the geometric and temporal dynamics of CRGs. Each stimulus generates a CRG corresponding to its perceptual or conceptual structure. When two stimuli, A and B, occur repeatedly in close temporal succession, their CRGs undergo sequential or near-simultaneous intensification. This repeated co-activation strengthens the geometric linkage between the CRGs, producing a directed association from A to B [2]. If stimulus A consistently precedes stimulus B, the outgoing links from the CRG of A toward the CRG of B become progressively stronger. As a result, future activation of A increases the probability that the CRG of B will resonate, even in the absence of stimulus B itself. This mechanism provides a geometric and dynamical basis for classical conditioning: stimulus B becomes conditionally activated through the resonance of stimulus A. The strength of conditioning depends on the number of repetitions, the temporal proximity of the stimuli, and the stability of the CRG linkage. With sufficient repetition, the CRG of A becomes a reliable trigger for the CRG of B, producing conditional behavior. This process is identical in structure to the formation of long-term cognitive biases, as both arise from repeated temporal patterns of CRG intensification and linkage.

Unified Interpretation. Together, these mechanisms show that cognitive biases—whether long-term or momentary—are emergent properties of the temporal structure of CRG intensification and linkage within the neural network. Long-term biases arise from stable CRG associations formed through repeated experience, while momentary biases arise from transient CRG activations that shape the resonance landscape during judgment. Classical conditioning reflects the same geometric principles, demonstrating that expectation, bias, and conditional behavior share a unified dynamical origin in the RCNNG framework.

27 Cognitive Foundations of Physics, Logic, and Mathematics in the RCNNG Framework

Within the RCNNG framework, perception and consciousness arise from the resonance of closed recurrent geometries formed in the neural network. Every sensation, concept, or experience corresponds to the resonance of closed geometries, either simultaneously or sequentially. When these geometries cease to intensify—as in coma or brain death—the network no longer generates perceptual or cognitive states, even though other physiological systems may continue to function. Without resonance, there is no perception, no awareness, and no sense of self [17].

Because all perceptual and cognitive content depends on the resonance of closed geometries, the structure of subjective experience is determined by the physics of the signals entering the network and the resonant geometries they induce. The perception of temporal order, causal relationships, and logical structure emerges from the sequential or simultaneous intensification of linked or unlinked geometries [18]. Thus, the logic of an individual is not an abstract symbolic system but a physical consequence of how environmental events generate and link closed geometries within the neural network. Mathematics follows the same principle. Mathematical concepts, symbols, and patterns originate from physical structures in the external world whose signals induce closed geometries in the brain. The relationships between mathematical symbols are discovered through the perceived order and co-activation of these geometries.

Without physical change in the environment—and without the formation and intensification of perceptual geometries—no mathematical perception or abstraction could arise [42]. Even highly abstract mathematical and physical concepts rely on geometric structures that the brain can resonate with. Human imagination of points, lines, and planes ultimately depends on resonant geometries formed from three-dimensional sensory experience [11, 12]. A point, line, or plane in external physical space is always a three-dimensional entity, and the brain's ability to imagine them arises from resonant geometries shaped by three-dimensional perception. For this reason, higher dimensions cannot be directly imagined; they must be inferred through relationships among lower-dimensional geometries [13]. All scientific domains—whether theoretical or practical—emerge from the same mechanism: the formation and intensification of closed perceptual geometries. Outside the brain, and without resonance, there is no perception or awareness through which the existence of the external world could be known. Consequently, every form of human knowledge—physics, logic, mathematics, philosophy, art, literature, and language—depends on the RCNNG process and the geometric–resonant structures it generates.

28 Results & Discussion

28.1 Unified Interpretation of Cognitive and Perceptual Phenomena

Analysis of diverse cognitive and perceptual phenomena indicates that many mental processes—from basic sensory detection to abstract reasoning—can be interpreted through a single underlying mechanism: the formation, resonance, and interaction of closed neural geometries. These geometries exhibit stability, coherence, combinability, and frequency-selective responsiveness, making them suitable candidates for fundamental perceptual-cognitive units.

28.2 Basic and Composite Perception

Simple perceptual events are interpreted as the emergence of individual closed geometries, while composite percepts arise from the merging of multiple geometries. This merging provides a geometric mechanism for perceptual binding, consistent with synchrony-based theories proposed by Singer and Engel.

28.3 Conceptual Reasoning and Abstraction

Concepts correspond to stable, multilayer resonant geometries formed from combinations of simpler structures. Reasoning is modeled as transitions between these geometries, while abstraction emerges from the reinforcement of persistent geometric features. This interpretation aligns with Marr's representational theory, Lakoff's conceptual frameworks, and distributed neural models.

28.4 Memory Formation and Recall Variability

Memory phenomena are explained as the strengthening or reactivation of persistent closed geometries. Variability in recall corresponds to differences in geometric stability across individuals. This provides a unified geometric interpretation bridging Hebbian learning, Hopfield networks, and resonant neural dynamics.

28.5 Imagination, Innovation, and Internal Simulation

Imagination and creative thought arise from recombination of existing geometries into novel configurations. This recombination acts as an internal simulation mechanism, consistent with theories of mental imagery and generative cognition.

28.6 Similarity, Difference, and Logical Bias

Similarity and difference judgments correspond to geometric or topological distances between resonant structures. Logical biases emerge from dominant resonance pathways that the network preferentially activates, offering a geometric explanation for well-known cognitive heuristics.

28.7 Pre-perception, Perceptual Void, and Non-perception

Borderline perceptual phenomena—including pre-perception, perceptual void, and absence versus non-perception—are interpreted as states in which closed geometries fail to form or lack sufficient resonance. This distinction clarifies the difference between absence of stimulus and absence of percept.

28.8 Conscious Experience and Qualia

Conscious experience emerges when a resonant closed geometry achieves sufficient stability, coherence, and integrative capacity to influence other structures. This interpretation aligns with major theories of consciousness (Tononi, Dehaene, Lamme, Koch, Graziano) while providing a unified geometric-dynamic mechanism underlying them.

28.9 Overall Interpretation

The results demonstrate that RCNNG provides a coherent and unified explanation for a wide range of cognitive and perceptual phenomena. The framework integrates perception, memory, reasoning, imagination, and conscious experience within a single geometric-dynamic model.

29 Conclusion

This work shows that diverse cognitive, perceptual, and conscious phenomena share a common structural foundation: the formation, resonance, and interaction of closed neural geometries. RCNNG offers a unified framework capable of explaining simple and composite perception, conceptual reasoning, memory processes, imagination, similarity judgments, logical biases, preperceptual states, and conscious experience.

By integrating neural dynamics, topology, perceptual theory, and cognitive structure, RCNNG provides a single mechanism through which mental phenomena can be understood as manifestations of resonant geometric organization. This unified perspective opens new directions for research in neuroscience, cognition, and philosophy of mind, suggesting that geometry and resonance may form the fundamental basis of mental structure.

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