

The Vortex Model of Consciousness: Physical Origin of Subjective Experience

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Abstract

The "hard problem" of consciousness lies in the unclear physical origin of subjective experience. This paper proposes the Consciousness Flow Vortex Model-Hypothesis (CFVM-H). In 2025, a study by Fang Zepeng's team published in **Science** utilized intracranial stereoelectroencephalography (sEEG) in human subjects to confirm that the centromedian/parafascicular (CM/Pf) thalamic nuclei activate prior to the prefrontal cortex during conscious perception, driving global synchronization of the thalamo-prefrontal circuit through theta-wave phase modulation, thereby serving as the gating hub of consciousness. These experimental results provide direct electrophysiological evidence from human subjects for the "Consciousness Vortex Theory" proposed in this paper, validating the core hypothesis that "thalamic nuclei act as the vortex core of consciousness, with recursive closed loops as the structural foundation." This vortex, centered on the central thalamic nucleus as its vortex core, forms a closed rotational vortex flow field encompassing the internal medullary lamina, various thalamic nuclei, and the entire neural network structure. Its three dynamical characteristics—closed-loop cyclicity, vortex-core focusing, and global synchrony—are the fundamental drivers underlying the emergence of subjective experience. The establishment of this theory and the localization of the vortex lay the most basic theoretical foundation and framework for consciousness research and neuroscience.

Keywords: Subjective Experience, Hard Problem of Consciousness, Consciousness Flow Vortex, Thalamo-Cortical Circuit, Dynamical Flow Field, Recursive Closed Loop

1. Introduction

The "hard problem" of consciousness proposed by Chalmers essentially stems from the inability of existing theories to explain how physical neural processes give rise to concrete subjective experiences. Mainstream consciousness theories (such as IIT, GWT, etc.) are confined to an information-logic-recursive framework, failing to clearly identify their physical carriers. Moreover, they predominantly focus on the cortex, which contradicts clinical evidence showing that thalamic damage leads to loss of consciousness. A 2025 study in **Science** on human intracranial electrophysiology confirmed that higher-order thalamic nuclei can activate prior to the cortex, gating and regulating conscious perception through the thalamo-prefrontal cortex circuit [1]. This temporal driving characteristic aligns closely with the vortexcore-prefrontal-driving logic of the consciousness vortex theory proposed in this paper. Based on neuroanatomical and clinical data, along with additional empirical evidence identifying the central thalamic nucleus as the vortex core, the model integrates the internal medullary lamina, various thalamic nuclei, and the body-wide neural network structure to form a closed rotating vortex flow field. The three dynamical features of this field—closed-loop cyclicity, vortex-core focusing,

and global synchrony—are the fundamental drivers underlying the emergence of subjective experiences. The model aims to address two core issues in consciousness science and neuroscience:

1. Elucidating the physical mechanisms of consciousness formation; Revealing the dynamical basis for the emergence of subjective experiences through the vortex flow field model;
2. Locating the vortex center of consciousness: Identifying the central thalamic nucleus as the vortex core of the consciousness vortex, which serves as the critical structure for consciousness integration and global synchronization.

2. The Research Dilemma of Consciousness

Academic research on "recursive closed loops" has always remained at the information-logic recursion level. This recursive approach has inherent limitations and cannot generate subjective experience. Its core flaws are reflected in four dimensions:

2.1. Abstract Symbolic Loops Without Physical Entities

Information-logic recursion occurs only at the abstract cognitive level, playing conceptual games of "sentences referencing sentences, thoughts referring to thoughts, symbols pointing to symbols." It lacks real physical entities, energy flows, or spatial

fields. Essentially, it is merely a "description" of the objective world rather than "existence" itself, incapable of generating the authentic experience of "I am feeling."

2.2. Centerless Discrete Loops

Logical recursion only forms loops without a clear focal center. All information processing involves "step-by-step discrete transitions," failing to create a unified perceiving subject. The core of subjective experience is the "first-person self"—a singular, focused center of perception.

Discrete logical loops can never merge into a unified subject.

2.3. Fragmented Processing Without Integration

Logical recursion is the fragmented processing of information, where sensory and multidimensional information remains in a separated state, while subjective experience is a continuous, unified whole (e.g., when seeing an apple, the sensations of color, shape, and taste merge into a holistic experience). Fragmented information processing cannot achieve such perceptual integration.

2.4. Static Processes Without Dynamic Characteristics

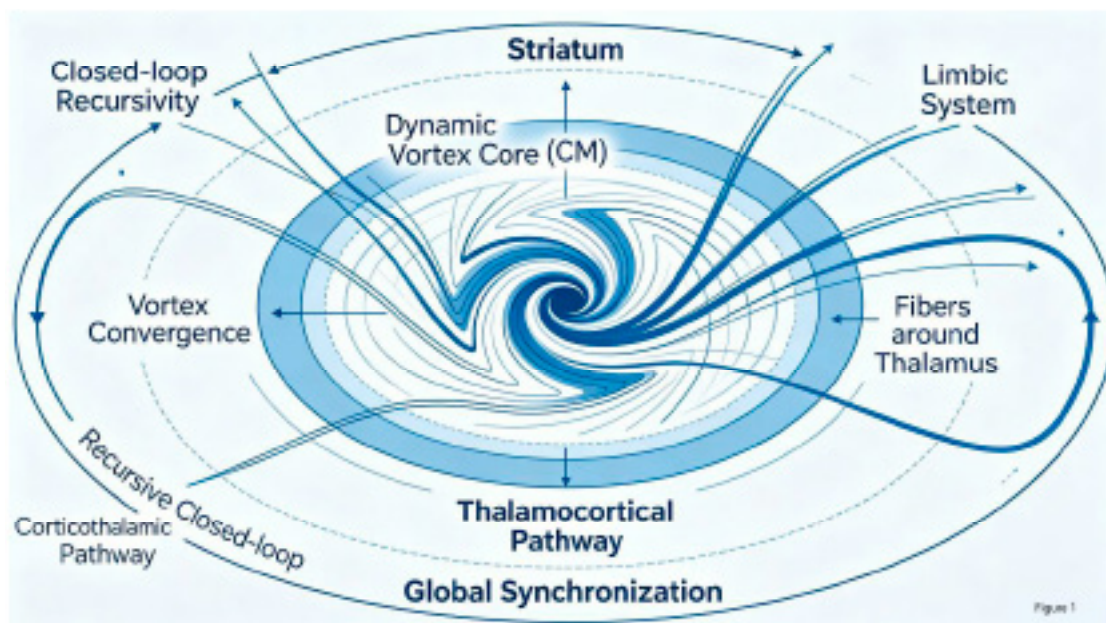
Logical recursion is static symbolic computation—devoid of energy, flow, intensity, contraction, or diffusion—whereas subjective experience is a dynamic, continuous process (e.g., emotional fluctuations, the focusing and dispersion of attention). Static logical loops cannot match the dynamic features of experience. In short, information-based logical recursion is merely "armchair theorizing"; no matter how complex, it remains

repetition and redirection of information, while subjective experience is a real physical existence. The two belong to entirely different dimensions, which is the core reason academia has been stuck for decades without breakthroughs.

3. Core Definition of the Consciousness Vortex

3.1. Core Definition: Recursive Closed Loop = Dynamically Closed Rotational Vortex

This paper is based on the Consciousness Flow Vortex Model (CFVM), which predicts that the central medial thalamic nucleus (CM) serves as the dynamic vortex core, with the bilateral CM nuclei connection as the rotational axis. The periphery consists of a series of approximately circular neural structures (including the striatum, limbic system, and perithalamic fiber tracts), collectively forming a multi-layered nested axisymmetric information flow network. Neural signals originate from the vortex core, broadcast to the entire brain network via the thalamocortical output pathways, then return to the vortex core through thalamic afferent pathways, forming unilateral or bilateral closed rotational circuits. The circuits of both hemispheres require phase synchronization through cross-hemispheric structures such as the massa intermedia thalamica and corpus callosum, collectively constituting a unified dynamic flow field. This paper proposes a working hypothesis regarding the topological relationship between the vortex center position and peripheral annular structures: these annular structures may be either concrete ring-like formations or generalized circular configurations (See Figure 1).



3.2. Core Dynamic Features of the Consciousness Vortex

The consciousness flow vortex exhibits three core dynamic characteristics, all quantifiable and verifiable physical attributes that directly drive subjective experience generation, and are cross species universal (with differences only in complexity and experiential richness):

- Closed-loop Cyclicity: The information flow starts from the vortex core, transmits through the output channels along the entire neural network, and finally returns to the input channel at the other end of the core, forming a unilaterally or bilaterally closed rotational loop with recursive robustness. In the event of unilateral loop damage, the other side can maintain the

basic flow field through unidirectional recursion.

- **Vortex Core Focusing Property:** The flow field exhibits centripetal rotational characteristics, with all multimodal sensory information (visual, auditory, tactile, etc.) converging toward the vortex core (thalamic core region), forming a singular focal center.
- **Global Synchrony:** The rotation of the flow field features global synchronization, where neural activities across different brain regions are entrained into the same dynamic flow field. Bilateral circuits achieve synchronization via the thalamic intermedullary mass, enabling the simultaneous integration of multidimensional information.

3.3. Quantitative Expression of Subjective Experience

The intensity of subjective experience (richness and clarity) is not an abstract, unquantifiable concept but is directly determined by the core physical parameters of the consciousness flow vortex. A cross-species universal quantitative formula is:

$$E \propto \frac{\Gamma}{r_0} \cdot \sigma \cdot C$$

Where:

- **E** represents consciousness energy: the intensity of wakefulness, integration strength, and stability of consciousness;
- **Γ** is the initial vorticity: the primordial awareness-driving force generated by the thalamus, initiating the consciousness vortex, corresponding to the circulation/tangential disturbance in fluid dynamics;
- **r_0** is the vortex core radius: representing focusing intensity,

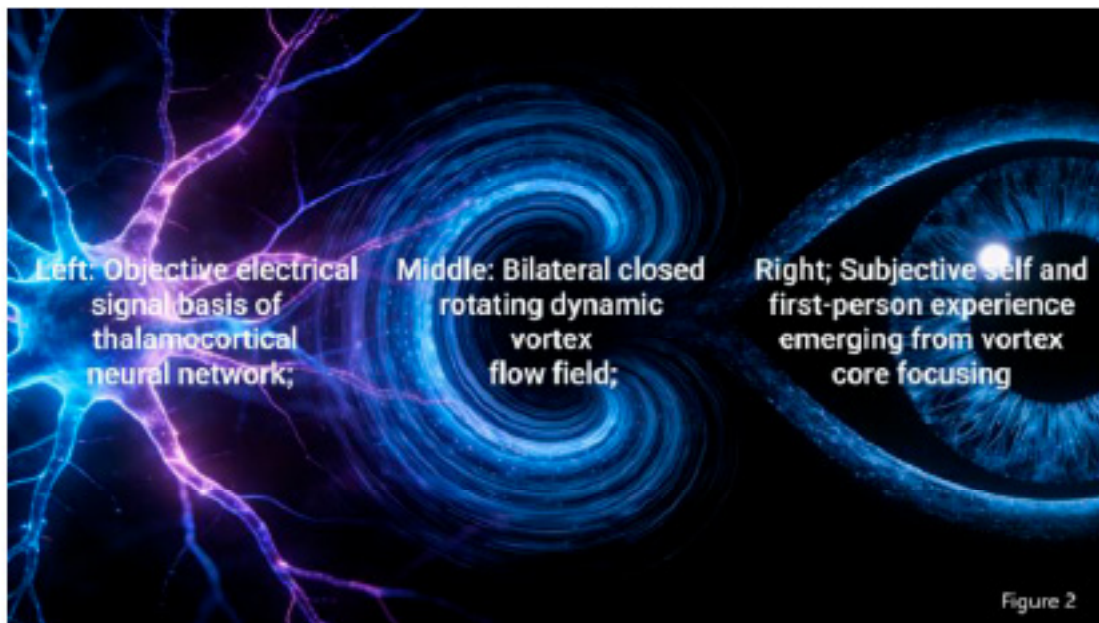
positively correlated with the directionality of experience;

- **σ** is the information integration force: the ability to gather, categorize, and unify perceptual information toward the core of consciousness, corresponding to the centripetal pressure gradient/centripetal force in fluid dynamics;
- **C** is the exclusivity of consciousness: the inherent rejection and isolation of "nonself" information by the conscious subject, preventing information from intruding into the core, corresponding to the centrifugal force in fluid dynamics.

This formula demonstrates: all characteristics of subjective experience can be quantitatively described through the physical parameters of the vortex, and the differences in subjective experiences fundamentally arise from variations in the vortex's physical structure — further validating that subjective experience is a dynamical inevitability of the vortex structure.

4. Consciousness Vortex: Derivation Results of Subjective Experience Dynamics

The three core elements of subjective experience —self-boundary, first-person perspective, and continuous unified perception— are not mysterious emergent products but direct and inevitable physical consequences of the three dynamical characteristics of the vortex of consciousness. There exists a strict one-to-one correspondence between them, and the derivation from physical structure to subjective experience requires no additional assumptions, achieving a seamless connection from matter to consciousness. (See Figure 2)



4.1. Closed Loop → Self-Boundary: The Prerequisite for Subjective Experience

The closed loop of information flow forms a clear dynamical boundary between "internal" and "external": the neural activities of the brain reside within the closed flow field, while the external

physical world lies outside. This boundary distinctly separates the "self" from the "external world," giving rise to the "sense of self-existence"—the primary prerequisite for subjective experience.

When the vortex structure disintegrates (e.g., during deep anesthesia,

brain death, or bilateral thalamic damage), the closed loop breaks, the "internal-external" boundary vanishes, and subjective experience ceases. When unilateral circuit damage occurs, the flow field shifts to unidirectional recursion; the boundary remains but is impaired in integrity, leading to deficits in subjective experience (e.g., sensory disorders), while the core "sense of self-existence" persists. This dynamical boundary is a real physical entity, not an abstract logical distinction, which fundamentally differentiates it from informational logical recursion.

4.2. Vortex Core Focusing → First-Person Perspective: The Subjective Experiential Core

The centripetal focusing characteristic of the vortex causes all multimodal neural signals to converge toward the vortex core (central thalamic nucleus), forming the singular perceptual focal point—this focal point constitutes the first-person "I" of subjective experience. The uniqueness of the vortex core determines the subjective unity of the self, preventing the fragmented experience of "multiple selves." The focusing intensity of the vortex core is inversely correlated with its radius r_0 (stronger focusing corresponds to smaller r_0), directly corresponding to the degree of attentional focus of the "I": when attention is concentrated, the vortex core contracts, sharpening the first-person perspective; when attention is dispersed, the vortex core expands, blurring the perspective. This process represents a real physical spatial focusing, rather than a logical selection at the informational level, explaining why the "I's" perception possesses clear directionality and uniqueness.

4.3. Global Synchronized Rotation → Continuous Unified Sensation: The Morphological Features of Subjective Experience

The global synchronized rotation of the vortex draws fragmented neural signals—such as visual, auditory, tactile, and emotional—into the same dynamic flow field, achieving seamless integration of multidimensional information and forming a continuous, unified holistic subjective experience.

The continuity of rotation ensures that subjective experience is seamless (like the uninterrupted flow of a stream of consciousness), and the synchrony of rotation integrates sensations from different senses into a unified whole (such as the fusion of color, aroma, and temperature into the "experience of coffee" when seeing a cup of coffee). When the vortex rotation becomes disordered (as in epilepsy or schizophrenia), global synchrony is disrupted,

information integration fails, and subjective experience fragments (manifesting as hallucinations, delusions, or perceptual breaks). This continuous fluid rotation perfectly matches the dynamic, holistic characteristics of subjective experience, which discrete information-logic recursion cannot achieve.

5. The Physical Location of the Vortex Center is Irrefutably Proven

5.1. Innate Conditions of the Central Nucleus (CM)

5.1.1. Individual Characteristics of the Central Nucleus (CM)

The CM exhibits morphological and neuronal distribution patterns highly suited to being the "vortex center."

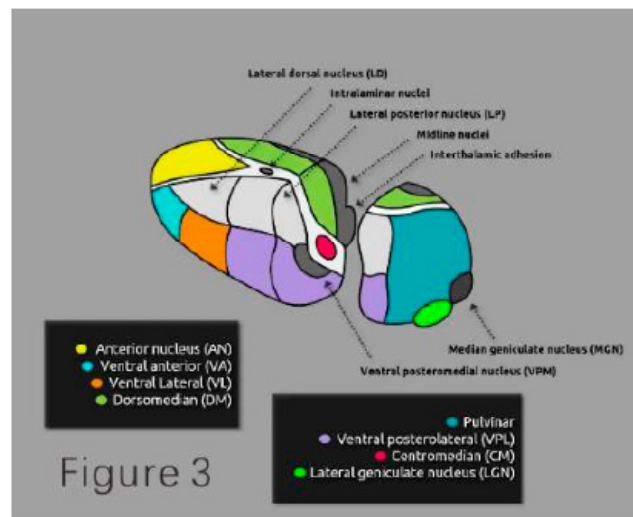
Special Attributes Fulfilling Functional Requirements: The CM has a volume of approximately 310 mm³, with a neuronal density of about 2,200 neurons/mm³, totaling roughly 664,000 neurons. This high-density neuronal cluster provides a robust foundation for the rapid convergence and synchronous integration of whole-brain information, serving as the "power core" that sustains the continuous operation of the consciousness vortex;

Natural Vortex Structure: CM exhibits a dense oval structure, embedded in the geometric center of the internal medullary lamina. Its form naturally adapts to the vortex dynamic characteristics of "signals converging toward the center and then radiating outward," serving as the physical carrier for the consciousness flow transitioning from dispersion to unification.

Special Neuronal Architecture: CM primarily consists of large and medium-sized projection neurons, with extensive axonal branches and long projection distances. This structural capability allows simultaneous transmission of synchronized signals to multiple regions such as the entire cerebral cortex and basal ganglia, perfectly aligning with the core function of the vortex center to "broadcast integrated consciousness flows."

5.1.2. Unique Anatomical Location

Absolute Geometric Center of the Thalamus: It serves as the "origin" of deep brain structures: Located in the core area of the thalamic internal medullary lamina, it is surrounded by all key thalamic nuclei, including the ventral anterior nucleus, ventral posterior nucleus, medial dorsal nucleus, and parafascicular nucleus. It is the only structure within the thalamus capable of simultaneously accessing all nuclei (See Figure 3);



The Absolute Brain Center: From a whole-brain perspective, the CM is located deep along the midline of the cerebral hemispheres, serving as a convergence hub for the brainstem-thalamus-cortex tripartite structure. It connects the cortex above, the brainstem below, and links adjacent limbic systems and basal ganglia, making it a critical pathway for global brain information flow. This "absolutely central" topological position perfectly aligns with the physical definition of a vortex center: all neural streams must converge here before diverging again, forming the spatial prerequisite for the consciousness vortex.

Vortex-like Fiber Arrangement: The internal medullary lamina fibers extend spirally from the central nucleus to various thalamic nuclei, positioning the central nucleus as the natural convergence point for thalamic information flow, creating an anatomical vortex structure. The internal medullary lamina fibers spiral centripetally from all directions, wrapping around the CM. These fibers do not pass straight through but instead are layered, oblique, and coiled. In cross-sectional views: concentric fiber rings twist toward the center.

5.1.3. Special Logical Circuitry of the Internal Medullary Lamina

The internal medullary lamina is a fissure-like structure formed by interwoven layers of fibers within the thalamus. Its functional properties can be likened to two mirrors placed facing each other. Neural signals propagate back and forth within these elongated, enclosed fiber gaps, continuously reflecting, superimposing, and iterating, akin to light beams bouncing repeatedly between mirrors.

The reciprocating movement of signals within the loop forms stable recursive resonance, providing a physical basis for the continuity of consciousness and the sense of self. Simultaneously, during the back-and-forth process, signals continuously synchronize, strengthen, and transmit outward, driving the global integration of whole-brain information. The central nucleus is at the core of this "reflex loop," where all signals converge, couple, and are then broadcasted to the entire brain, forming stable, high-frequency global synchronization rhythms. The fissure structure of the

internal medullary lamina serves as the natural anatomical carrier for thalamus-mediated consciousness integration and neural synchronization.

5.1.4. Extreme Functional Convergence

The core advantage of the thalamic central nucleus (CM) lies in its position as the convergence hub of key functional nuclei across the entire brain, making it the ultimate integration hub for whole-brain consciousness information. The surrounding nuclei form a comprehensive dynamic input system that converges intensely toward the CM:

- **Perceptual Dimension:** All external sensory information nuclei are directly connected to the CM via the internal medullary lamina, providing the foundational perceptual material for consciousness.
- **Cognitive Dimension:** The associative nuclei input to the CM, endowing consciousness with active cognition and self-reflective agency.
- **Arousal Dimension:** The intralaminar and midline nuclei directly regulate whole-brain arousal levels, serving as the energy source for consciousness transitioning from dormancy to wakefulness.
- **Endogenous Experience Dimension:** The limbic system-related thalamic nuclei input to the CM, imbuing consciousness with emotional hues and individual perceptual dimensions. The aforementioned nuclei cover the four core dimensions of consciousness. Only when CM is at their intersection can the scattered neural streams be fully converged and integrated, driving the formation and operation of the consciousness vortex, fundamentally establishing its necessity and uniqueness as the vortex core of consciousness.

5.1.5. Internal Medullary Lamina: The Dynamical Foundation of the Vortex Core

The most essential structural characteristic of CM lies in its

complete encapsulation and direct penetration by the dense fibers of the internal medullary lamina, forming an extreme communication advantage adapted to the vortex center (See Figure 4):



Extreme Communication Speed: The internal medullary lamina consists of highly myelinated large-diameter axons, with conduction speeds reaching 30–50 m/s. CM is directly embedded in the core, bypassing synaptic relays, enabling millisecond-level direct interaction of whole-brain information, constituting the structural prerequisite for continuous, delay-free consciousness flow.

Global Interaction Efficiency: As the thalamic "information superhighway," CM establishes seamless bidirectional direct connections with all thalamic nuclei via the internal medullary lamina, allowing multimodal neural streams to integrate instantaneously at CM, forming a unified consciousness vortex.

Synchronization Control Core: The dense encapsulation by the internal medullary lamina endows CM with a global clock function, synchronizing thalamic and cortical activities through neural oscillations such as theta waves, driving global coordination of the thalamocortical loop, and ensuring the dynamic stability and rhythmic unity of the consciousness flow.

Long-projection Topological Structure: CM is dominated by highly myelinated long projection neurons, which radiate multi directionally along the internal medullary lamina to broadcast synchronized clock signals to the entire cerebral cortex. Simultaneously, it regulates the basal ganglia, brainstem, and limbic system, achieving closed-loop control of the stream of consciousness, perfectly aligning with the core functions of the vortex center.

5.1.6. Summary of the Central Nucleus

Located at the absolute center—the vortex core
Internal medullary lamina fibers spiral and converge toward it from all directions—the vortex arms.

Signals flow inward from peripheral nuclei to the center and then diffuse outward in a broadcast manner—vortex-like circulation Morphologically spindle-shaped, enveloped by layered fibers—a typical vortex core structure.

The physical origin of consciousness is not a broad brain region or cortex but the central nucleus (CM) in the thalamic center, wrapped by the spiraling fibers of the internal medullary lamina.

5.2. Empirical Evidence of the Vortex Core Properties of the Central Nucleus

5.2.1. Central Nucleus as the Information Interaction Hub

The thalamic central nucleus serves as the core convergence hub for sensory signals in the thalamus and the entire brain. Visual, auditory, tactile, and nociceptive signals, after processing by thalamic-specific nuclei, all converge toward the central nucleus via internal medullary lamina fibers. Differences among multimodal signals exist only in frequency, waveform, and oscillation spectra. Under the mediation of the central nucleus, global coupling is achieved, laying the foundation for consciousness integration.

5.2.2. Consciousness Temporal Synchronization and Signal Locking Device

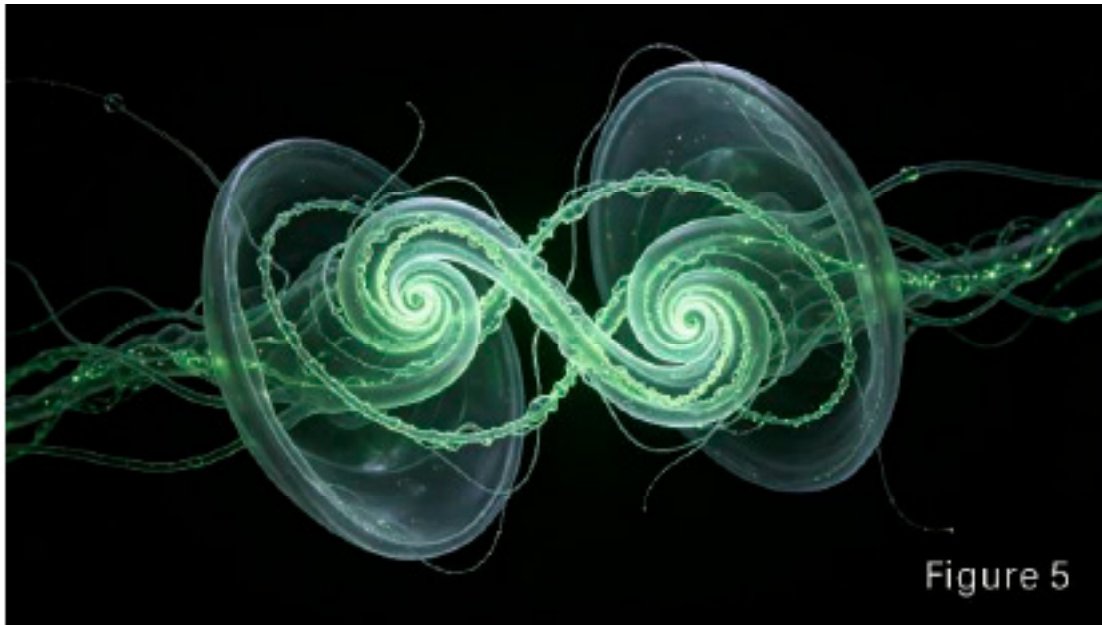
Recent intracranial human brain recordings have definitively shown that the thalamic intralaminar nuclei and Centro-medial nucleus temporally precede the prefrontal cortex in conscious processing, serving as the active driving end for circuit synchronization and perceptual emergence, directly supporting the designation of the thalamic CM/Pf as the core anchor of the consciousness vortex [1].

5.2.3. Cross-Hemispheric Synchronization Integration

The central nucleus is responsible for the synchronization and integration of thalamocortical circuits across the left and right hemispheres. Bilateral signals converge at the central nucleus via the internal medullary lamina, which achieves global coupling

through interhemispheric θ wave phase synchronization, ensuring the integrity and unity of subjective consciousness. This structure

is a key support for the singular sense of conscious agency (See Figure 5).



5.2.4. Generation Mechanism of the Self-Subject

The surrounding thalamic nuclei process specific perceptual content such as vision, hearing, somato sensation, emotions, and memory, and relay signals to the central nucleus. The central nucleus does not participate in content processing but assigns self-ownership markers to neural signals, transforming objective activities into subjective experiences of "I perceive, I experience." The synchronous coupling of these two processes ultimately generates a unified consciousness world imbued with self-identity.

5.3. High-Field Functional Magnetic Resonance Imaging Data as Definitive Evidence

Multiple independent 3T/7T fMRI studies have consistently confirmed that the central thalamic nucleus exhibits imaging characteristics highly consistent with the consciousness vortex model during conscious activities.

5.3.1. Functional Magnetic Resonance Imaging in the Awake Conscious State

In the awake state, the central nucleus displays localized central hyperactivation, with both symmetry and intensity being the highest among thalamic nuclei. 7T-fMRI reveals a sharply defined activation focus significantly brighter than surrounding nuclei, overlapping with the centromedian-parafascicular complex and exhibiting bilateral high symmetry, corroborating its vortex-core topological structure [2,3].

5.3.2. Activation Pattern Magnetic Resonance Imaging

The central nucleus activation shows 360° global symmetry, radiating outward from the vortex core in a radial-circular pattern without directional bias. Functional connectivity analysis indicates

uniform radial projections from the nucleus to the entire brain, forming a dense central core with a diffuse peripheral ring-shaped network, closely aligned with the spiral arrangement of internal medullary lamina fibers [3,4].

5.3.3. Functional Magnetic Resonance Imaging Under Anesthesia, Sleep, and Disorders of Consciousness

During anesthesia, sleep, and states of impaired consciousness, the BOLD signal in the central nucleus significantly attenuates, and the vortex structure disintegrates; consciousness recovery leads to structural reconstruction. These dynamic changes are completely synchronized with the "on/off" states of consciousness [4,5].

5.3.4. The Central Nucleus as the Core Node with the Strongest Whole-Brain Synchrony

Resting-state functional connectivity confirms that the central nucleus is a critical hub in the whole-brain network, exhibiting the highest functional connectivity strength and phase synchrony among thalamic regions. Its inhibition under anesthesia directly leads to cortical synchronization collapse; electrical stimulation of the central thalamus can restore cortical cooperative activity, proving it to be the dynamic core driving whole-brain synchronization [2,5].

5.4. Electrophysiological Ironclad Evidence

Central nucleus electrophysiological recordings provide direct dynamic validation of its vortex core status.

5.4.1. High-Frequency Oscillations and the Whole-Brain Synchrony Generator

CM neurons exhibit prominent high-frequency activity in the

gamma band (30–100 Hz), which synchronously drives coherence in bilateral cerebral cortices, fully consistent with the anchoring mechanism of the vortex center frequency.

5.4.2. Temporal Switching of Consciousness State Transitions

In anesthesia, sleep-wake cycles, and disorders of consciousness, changes in CM electrical activity precede those in the cortex: it is the first to be suppressed during anesthesia and the first to recover and restart cortical synchronization upon awakening, proving it to be a key leading node for the initiation and maintenance of consciousness.

5.4.3. Dynamic Hub of Cross-Brain Regional Coherence

Intracranial recordings show that the strength of CM's connections with nodes of the consciousness network, such as the prefrontal and parietal lobes, is significantly positively correlated with the clarity of consciousness. Its field potentials can predict the efficiency of multimodal information integration, confirming its role as a hub for global information exchange.

6. The Vortex of Consciousness: Multifaceted Evidence from Subjective Experience

6.1. Fully Consistent with Existing Theories on the Emergence of Consciousness

From the core predictive conditions of current mainstream consciousness theories, the core logic of the consciousness vortex model fully aligns with the presuppositions and inferences of existing theories regarding the core characteristics of consciousness. The model constructs a self-consistent logical

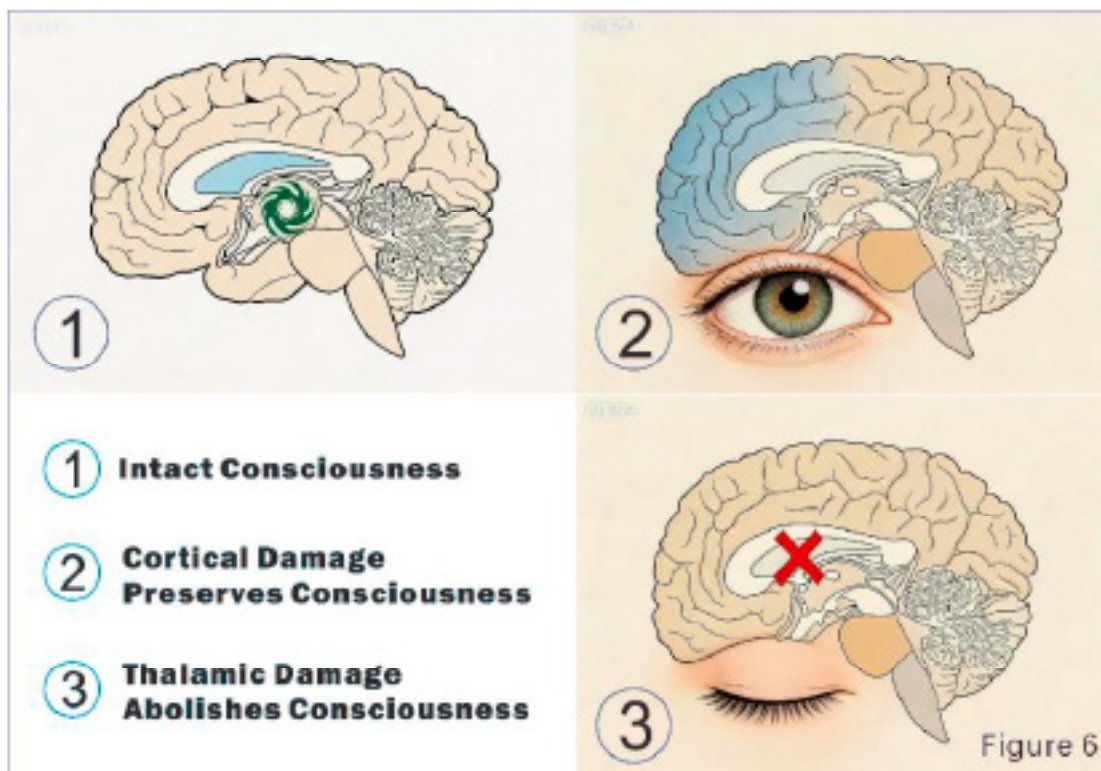
framework around key dimensions of consciousness, such as subjective unity, state dynamics, and neural correlates. It resonates with and complements the core predictions of classical theories like the Global Neuronal Workspace Theory and Integrated Information Theory, demonstrating its rationality and feasibility as a theoretical conjecture. This lays a theoretical foundation for further verification of its scientific validity.

6.2. Self-Consistent Quantitative Explanations of Physiological Phenomena

- Life / Death: Living = stable rotation of the vortex; Death = curl disappears, vortex collapses.
- Awake / Sleep / Coma: Awake = Γ strong; Sleep = Γ weakened; Coma = Γ nearly inactive.
- Emotion and Cognition: Focus = r_0 contraction; Calm = σ and C balance; Anxiety/Depression = vortex instability.
- Intelligence Level: High cognitive ability = E high; Weak awareness = E low.
- Disease: Schizophrenia = C boundary collapse; Cancer = loss of cellular exclusivity, escaping the constraints of the overall vortex.

6.3. Minor Vortex Core Damage Causes Consciousness Shutdown

Numerous clinical pathological cases confirm that minor damage to the thalamus, midbrain, or brainstem reticular formation (lesion volume often less than 1cm³) can lead to complete collapse of consciousness, providing the most direct evidence for the core localization of the consciousness vortex [7,8] (See Figure 6):



- Damage to the midbrain reticular activating system: The patient instantly falls into a deep coma, losing all conscious awareness and subjective experiences. Vital signs may be maintained, but the consciousness vortex ceases entirely due to the loss of its core driving force. Even if subsequent damage is repaired, recovery of consciousness becomes extremely difficult [9];
- Lesions in the medial thalamic nuclei: The patient exhibits a vegetative state (wakeful coma), with eyes open and preserved sleep-wake cycles, but completely loses self-awareness, subjective perception, and emotional experiences. The essence lies in the loss of the thalamus's function as a signal integration hub, preventing neural signals from achieving recursive self-reference, resulting in an empty rotation of the consciousness vortex devoid of substantive content [10];
- Lesions in the thalamo-midbrain junction: Trigger symptoms of depersonalization and derealization. Patients experience blurred self-boundaries, a sense of unreality about themselves, and perceptions of the external world as "through a layer of glass." This arises from the disruption of rotational stability in the signal closed-loop, impairing the self-referential function of the consciousness vortex [11,12].

6.4. Etiology of Subjective Perception Disorders Localized Near the Vortex Core

Clinical studies reveal that diseases with abnormal self-perception as the core symptom consistently show lesions concentrated in the thalamo-limbic pathway, confirming the central role of the thalamo-midbrain region:

Capgras syndrome (delusion of doubles in loved ones): Lesions involve the prefrontal-thalamic-amygdala pathway, with impaired thalamic integration of "familiarity signals," leading to blurred boundaries between self and external perception and abnormal self-referential recognition in the vortex of consciousness [13].

Cotard syndrome (delusion of being a walking corpse): Lesions often involve the thalamus, cingulate gyrus, and prefrontal cortex, with collapse of thalamic integration of somatosensory and emotional signals, resulting in loss of self-anchoring ability in the vortex of consciousness [14].

Self-perception disturbances in schizophrenia: Symptoms such as "thought insertion" and "feelings of being controlled" arise from damage to self-referential attribution circuits; pathological studies confirm abnormal thalamocortical circuit connectivity, thalamic signal filtering, and integration dysfunction, leading to chaotic rotation of the vortex of consciousness [15].

6.5. Pathological Insights from Locked-In Syndrome

Locked-in syndrome serves as a classic case for validating the core localization of consciousness: patients, due to damage in the lower pons, experience quadriplegia, an inability to speak, and a lack of facial expressions, communicating solely through eye movements, yet remain fully conscious with intact subjective experiences. Analyzing from the perspective of the consciousness

vortex theory, the patient's thalamo-midbrain core region functions normally, with the rotational closed-loop of the consciousness vortex remaining intact; only the pons and peripheral motor nerves, which act as "signal output channels," are impaired, thus preserving core consciousness. This phenomenon directly demonstrates that as long as the thalamo-midbrain core region functions normally, the consciousness vortex can sustain its operation, and subjective experience persists, further corroborating the central role of this area [7,16].

7. Conclusion

This paper proposes the Consciousness Flow Vortex Model (CFVM), explicitly anchoring the central thalamic nucleus as the dynamic core of the consciousness vortex. Through three key features—closure, focus, and synchronization—the model provides a unified and falsifiable explanation for the physical origin of consciousness, addressing the deficiency of existing theories that lack a specific physical substrate. The empirical establishment of the central thalamic nucleus as the vortex core offers a new structured pathway for consciousness research to transition from speculation to empirical validation.

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