Immortalitas in Hac Vita

Longevity Platform

https://www.longevity.ge

Longevity Horizon
ISSN:3088-4063

2026

Vol.2 No.1:9

Sleep as Suspension of Localization

Ze formalism for sleep and wakefulness

Jaba Tkemaladze [^] [1]
Affiliation: [1] Kutaisi International University, Georgia
Citation: Tkemaladze, J. (2026). Sleep as Suspension of Localization. Longevity Horizon, 2(1).
DOI : https://doi.org/10.65649/xz8vte24

Abstract

Consciousness is fundamentally a process of selection, a continuous "collapse" from a manifold of potential states into a singular, coherent narrative. This article introduces the Ze formalism, a theoretical framework that models this process through a cognitive localization parameter, Γ_Ze. We posit that the critical distinction between wakefulness and sleep is not the presence of consciousness, but the suspension of this localization mechanism. During wakefulness ($\Gamma\_Ze \gg 1$), the cognitive system enforces rapid, frequent collapse, yielding a stable, logical stream of thought. Sleep ($\Gamma\_Ze \rightarrow 0$), conversely, is a physiologically controlled state of suspended localization, where the brain acts as a "quantum eraser" for cognitive "which-path" information. This allows for the maintenance of coherent superpositions of memory and meaning, with dream phenomenology arising from the resulting interference patterns. The model provides a unifying lens for altered states: it frames psychedelics as conscious Γ_Ze reduction, general anesthesia as its artificial nullification, and psychiatric conditions like schizophrenia as its pathological dysregulation. We argue that sleep's primary function is the offline recalibration of cognitive probability amplitudes c_i, facilitating memory integration, emotional regulation, and creative insight. The Ze formalism thus redefines sleep from a passive state of rest to an active, essential operation for maintaining cognitive flexibility and the integrity of waking consciousness.

Keywords: Consciousness, Sleep, Dreaming, Cognitive Localization, Quantum Cognition, Altered States, Psychopathology.

Introduction: Consciousness as a Process of Collapse

The quest to model consciousness through formal frameworks has led to diverse approaches, from integrated information theory (Tonomi et al., 2016) to global neuronal workspace (Dehaene et al., 1998). The Ze formalism introduces a distinct perspective by conceptualizing conscious awareness not as a state but as a process of continuous localization. This process is understood as a sustained selection—or "collapse"—from a manifold of potential cognitive and perceptual states into a singular, coherent narrative of reality. In this framework, the fundamental distinction between wakefulness and sleep is not one of presence versus absence of consciousness, but rather a modulation of the very mechanism that constrains conscious content.

Wakefulness, therefore, is characterized by a high-frequency collapse of the cognitive wave function, necessitating a consistent, logical, and spatiotemporally stable interpretation of sensory input and internal representations (Barrett, 2017). Conversely, sleep is hypothesized as a state of partial or complete suspension of this localization process. During sleep, the Ze system tolerates the simultaneous coexistence of multiple, often incompatible, cognitive states without the imperative to collapse them into a single narrative thread. This paper elaborates on this core definition, situating it within contemporary neuroscience and cognitive theory.

The Ze Formalism: Basic Definitions

In the Ze formalism, a cognitive state is minimally represented as a superposition:

$$|\Psi\_mind\rangle = \sum\_i c\_i \, |s\_i\rangle$$

denotes basis states corresponding to possible interpretations, memories, semantic constructs, or perceptual frames, and c_i represents their complex probability amplitudes within the cognitive configuration space.

The dynamics of this system are governed by a localization parameter, Γ_Ze. This parameter can be interpreted as a cognitive analog to decoherence rates in quantum-inspired models of cognition (Bruza et al., 2015) or the stability of attractor states in neural network dynamics (Rolls & Deco, 2010).

- Wakefulness $(\Gamma\_Ze \gg 1)$: A high localization parameter enforces rapid and frequent collapse. Any act of "cognitive measurement"—whether directed attention, volitional action, or explicit reasoning—prompts the superposition to resolve into a single eigenstate:

$$|\Psi\_mind\rangle \xrightarrow{observation} |s\_k\rangle$$

This results in the definite, unambiguous stream of consciousness typical of alert states, where ambiguity is minimized for efficient interaction with the environment (Hobson et al., 2014).

- Sleep ($\Gamma\_Ze \to 0$): A marked reduction or near-zero value of Γ_Ze postpones or abolishes the collapse mechanism. The cognitive wave function remains in a coherent or semi-coherent superposition for extended periods:

$$|\Psi\_mind\rangle \approx coherent\ superposition$$

This suspension of localization is not passive; it is an active, physiologically regulated mode of brain operation (Nir & Tononi, 2010). The brain enters a regime where multiple potentialities can interact without being forced into a mutually exclusive selection.

Sleep as a Cognitive Quantum Eraser

A powerful analogy for understanding this process is the quantum eraser experiment (Walborn et al., 2002). In such experiments, erasing "which-path" information after a particle has traversed an interferometer restores the interference pattern, effectively undoing the classical-like localization of the particle's path.

Transposed to the Ze interpretation of sleep, the sleeping brain acts as a cognitive quantum eraser. During waking hours, countless "cognitive paths" are taken: decisions are made, interpretations are solidified, and specific memory traces are reinforced (Stickgold & Walker, 2013). This process continuously generates "which-path" information, cementing a particular narrative and suppressing alternatives. Sleep, particularly through the electrophysiological signatures of non-rapid eye movement (NREM) sleep and the synaptic downscaling hypothesized to occur during slow-wave activity (Tononi & Cirelli, 2014), functions to erase or weaken this rigid path information.

This erasure does not equate to memory loss. Instead, it decouples memories and concepts from their fixed, waking-life interpretations (Lewis & Durrant, 2011). By attenuating the strength of specific associative links, sleep allows for the recombination of cognitive elements in novel ways. Thus, sleep is not an inert state of downtime but the active switching-off of the cognitive path detector, enabling the system to revert to an interference-rich, exploratory mode of information processing.

Implications and Alignment with Empirical Data

This framework aligns with several key neuroscientific findings:

- Memory Reconsolidation and Integration: Sleep is crucial for memory consolidation, but not merely as a process of strengthening. Research indicates a dual process of selective strengthening and integrative generalization (Diekelmann & Born, 2010). The suspension of localization allows memories to be integrated into broader semantic networks, fostering insight and creative problem-solving (Wagner et al., 2004). This is precisely what the Ze model predicts: without forced collapse, the amplitudes of diverse memory traces (c_i) can interact and recombine freely.
- The Phenomenology of Dreaming: Dreaming can be reinterpreted not as random "hallucinations" but as the direct experiential correlate of sustained cognitive superposition (Windt et al., 2016). The bizarre, illogical, and hyper-associative nature of dreams—featuring fluid identities, impossible spaces, and contradictory narratives—arises naturally from the interference patterns between multiple,

simultaneously active cognitive states ($|si\rangle$) that are not being collapsed (Hobson, 2009). The dreaming brain experiences the "interference term" in the probability calculation, which is suppressed during waking localization.

- Default Mode Network (DMN) Activity: The DMN, highly active during rest and mind-wandering and showing complex patterns during sleep (Fox et al., 2015), may be a neural substrate supporting low- Γ_Ze states. Its role in self-referential and associative thought makes it a candidate system for maintaining the coherent superpositions proposed by the Ze model during off-task periods.

In summary, the Ze formalism posits that the core distinction between sleep and wakefulness lies in the dynamics of cognitive state selection. Wakefulness is a regime of frequent localization, producing a sharp, adaptive focus on a single narrative. Sleep is a regulated suspension of this localization, a period where the cognitive system operates in a superpositional mode, acting as a quantum eraser for the path information accrued during waking life. This suspension is fundamental for cognitive functions that benefit from ambiguity and broad association, such as creativity, emotional regulation, and the flexible reorganization of knowledge. The following sections will expand this model to elucidate dream content, the sleep-wake boundary, and altered states of consciousness.

A Minimal Formalism: From Superposition to Collapse

Building upon the foundational premise that consciousness is a process of localization, we now introduce the minimal mathematical formalism of the Ze framework. This model provides a schematic, yet precise, language to describe the transition between waking and sleeping cognition. It is inspired conceptually by the superposition principle in quantum mechanics (Dirac, 1958), not as a literal claim of quantum processes in the brain, but as a powerful metaphor for pre-conscious potentiality, akin to models used in quantum-inspired cognition (Busemeyer & Bruza, 2012) and theories of probabilistic brain function (Friston, 2010).

The Cognitive State Vector

In the Ze formalism, the pre-collapsed state of a cognitive-perceptual system at any moment is represented as a superposition vector in a high-dimensional Hilbert space:

$$|\Psi\_mind(t)\rangle \ = \ \sum\_i \, c\_i(t) \, |s\_i\rangle$$

Here, $|s\_i\rangle$ are basis states encoding discrete cognitive "eigenstates": specific interpretations of a percept, consolidated memories, emotional valences, narrative fragments, or motor intentions (Kindermans & Schütt, 2019). The coefficients $c\_i(t)$ are complex-valued probability amplitudes, where $|c\_i(t)|\text{^}2$ corresponds to the potential for the cognitive system to collapse into state $|s\_i\rangle$ upon "measurement." The time-dependence of $c\_i(t)$ reflects the dynamic, context-sensitive nature of pre-conscious processing, influenced by sensory input, memory activation, and internal drives (Moscovitch et al., 2016).

This formulation parallels the concept of a "probability landscape" over possible brain states prior to commitment to a specific conscious content (Dehaene, 2014). The superposition $|\Psi\_mind\rangle$ is not directly experienced; it represents the latent manifold of possibilities from which a singular conscious moment is selected.

The Localization Parameter Γ_Ze and the Collapse Dynamics

The core innovation of the Ze model is the introduction of a dimensionless, state-dependent parameter, $\Gamma\_Ze(t) \geq 0$, which governs the rate and stability of cognitive localization. This parameter can be interpreted as a functional composite of several well-studied neurophysiological variables:

- Neuromodulatory Tone: High levels of neuromodulators like norepinephrine and acetylcholine, characteristic of waking states, promote focused, stable neural representations (Aston-Jones & Cohen, 2005). We posit these elevate Γ_Ze.
- Cortical Synchrony: The synchronized slow-wave oscillations of NREM sleep are associated with a breakdown of long-range, stable communication and a shift to local, fragmented processing (Massimini et al., 2005; Tononi & Massimini, 2008). This corresponds to a lowering of Γ_Ze.
- Frontal Executive Control: The efficacy of prefrontal cortex-mediated inhibitory and selective mechanisms, which enforce logical coherence and task-relevant focus (Miller & Cohen, 2001), is directly proportional to Γ_Ze.

The dynamics are then defined as follows:

- Wakefulness ($\Gamma\_Ze \gg 1$): A high localization parameter signifies a system primed for rapid, frequent collapse. Any act of cognitive "observation" or attentive engagement—whether exogenous (a sudden sound) or endogenous (a deliberate thought)—triggers a stochastic collapse process. The probability of outcome $|s\_k\rangle$ is given by the Born rule, $|c\_k|\hat{}2$:

$$|\Psi\_mind\rangle \xrightarrow{observation} |s\_k\rangle \quad with\, probability\, |c\_k|\hat{}2.$$

This yields the definite, sequential stream of consciousness. The high Γ_Ze ensures that once collapsed, the system remains localized to that narrative thread, resisting rapid fluctuations, a state akin to a stable attractor in dynamical systems theory (Rolls, 2021).

- Sleep ($\Gamma\_Ze \to 0$): The transition to sleep, orchestrated by hypothalamic sleep-promoting nuclei and the decline of monoaminergic tone (Saper et al., 2001), drives Γ_Ze toward zero. This dramatically reduces the probability of permanent collapse. The cognitive superposition $|\Psi\_mind\rangle$ is maintained in a coherent or semi-coherent state for prolonged durations:

$$|\Psi\_mind\rangle \approx coherent\ superposition\ over\ \Delta t\_sleep$$

- "Coherence" here implies that the relative phases between the complex amplitudes c_i remain significant, allowing for interference effects—the experiential hallmark of dreaming, as explored in Section 4. This sustained superposition enables the interaction and recombination of cognitive elements ($|s\_i\rangle$) that are mutually exclusive in the waking state. Neuroimaging evidence supports this, showing reduced functional connectivity in executive networks and increased, more fluid connectivity in associative cortices during NREM and REM sleep (Tagliazucchi & Laufs, 2014).

Neurobiological Correlates of a Low Γ_Ze State

The physiological signature of low Γ_Ze is most clearly observed in the electroencephalogram (EEG) of deep NREM sleep. The high-amplitude, low-frequency slow oscillations $(< 1\,Hz)$ represent a fundamental cortical "reset" mechanism, where widespread periods of neuronal hyperpolarization (down-states) effectively create transient tabula rasa conditions, interrupting stable waking patterns (Steriade et al., 1993). This is a direct neural correlate of suspending localization: the forceful termination of specific, localized attractor states, allowing the system to explore its own latent configuration space. Similarly, the ponto-geniculo-occipital (PGO) waves of REM sleep may act as endogenous "seeds" that bias the interference patterns in the superposition, shaping dream narratives (Hobson, 2009).

In conclusion, the minimal Ze formalism translates the core hypothesis into a dynamic model. The waking brain operates under a regime of high Γ_Ze, enforcing a rapid, classical-like selection of conscious content. The sleeping brain transitions to a low-Γ_Ze regime, where the collapse mechanism is suspended, permitting a prolonged, interference-rich superposition of cognitive states. This fundamental switch in operational mode, rooted in established neurophysiology, sets the stage for understanding the unique cognitive phenomenology of sleep and dreaming.

Sleep as a Cognitive Quantum Eraser

The minimal Ze formalism posits that sleep is characterized by a low localization parameter Γ_Ze, allowing cognitive superpositions to persist. A powerful and precise analogy for understanding the functional consequence of this shift is the *delayed-choice quantum eraser experiment* (Walborn et al., 2002). This analogy reframes sleep from a passive state of rest into an active mechanism for cognitive reorganization and plasticity.

The Quantum Eraser Principle

In the quantum eraser paradigm, a photon can traverse an interferometer via two possible paths. If information distinguishing which path was taken ("which-path" information) is recorded, even by an environment that does not collapse the system, the photon behaves as a particle, and no interference pattern is observed—a process analogous to decoherence (Zurek, 2003). Critically, if this which-path information is subsequently and coherently erased after the photon has been detected, the interference pattern is retrospectively restored. The act of erasure does not change the past detection event but changes its interpretability, transforming it from a particle-like to a wave-like event. The system's history is, in effect, "rewritten" in terms of complementary physical properties (Kim et al., 2000).

The Cognitive "Which-Path" Information of Wakefulness

During wakefulness, the high-Γ_Ze state forces the continuous collapse of cognitive superpositions into definite percepts, decisions, and narratives. Each conscious moment represents a "measurement," selecting one cognitive path $|s\_k\rangle$ from the manifold of possibilities. This process generates and reinforces a continuous stream of "cognitive which-path information." For instance:

- A perceptual ambiguity (e.g., the Necker cube) is resolved into a single interpretation (Long & Toppino, 2004).
- An emotional event becomes tagged with a specific, dominant valence appraisal (Phelps et al., 2014).
- A problem is approached through a particular, well-learned heuristic or rule (Wason, 1960), solidifying one associative pathway over others.

This relentless path selection is adaptive, enabling goal-directed behavior and a stable model of reality. However, it comes at a cost: it progressively *entangles* cognitive elements with specific, rigid contexts and interpretations, suppressing alternative associations and latent meanings. This is the cognitive equivalent of decoherence, where potential interference (creative recombination) is lost due to the system's interaction with the "environment" of its own past decisions and reinforced neural pathways.

Sleep as the Erasure Mechanism

The Ze model posits that the core function of sleep, particularly slow-wave sleep (SWS), is to act as a *physiological quantum eraser* for cognitive which-path information (Stickgold & Walker, 2013). The transition to a low-Γ_Ze state $(\Gamma\_Ze \rightarrow 0)$ is the mechanism of erasure. This is not the deletion of memory traces, but the targeted weakening or functional decoupling of the *associative links* that bind cognitive elements to specific, waking-life contexts (Lewis & Durrant, 2011). Several established sleep processes align with this erasure function:

- Synaptic Downscaling: The synaptic homeostasis hypothesis (Tononi & Cirelli, 2003, 2014) proposes that SWS globally downscales synaptic strength, proportionally weakening all connections. Crucially, this non-selective weakening acts as a great equalizer; it prunes the over-potentiated, highly specific pathways that were heavily used during waking ("which-path" information), relative to weaker, latent connections. This restores neural dynamic range and resets the system's capacity for future learning.
- Reactivation and Reorganization: The reactivation of hippocampal-neocortical memory traces during SWS (Buzsáki, 1998; Ji & Wilson, 2007) is not mere rehearsal. In the context of erasure, this reactivation occurs in a low-Γ_Ze environment. Without the pressure to collapse into the original waking narrative, memories can be replayed in novel sequences and combinations (Cowan et al., 2020). This process effectively "dissolves" the rigid, episodic context of the memory, allowing its semantic content to be extracted and integrated into broader knowledge networks (Diekelmann & Born, 2010).
- Diminished Neuromodulatory Influence: The dramatic reduction in noradrenergic and serotonergic tone during SWS (Aston-Jones & Bloom, 1981; Portas et al., 1998) is critical. These neuromodulators are essential for stabilizing representations, maintaining

focused attention, and reinforcing rewarded pathways—all processes that create and sustain "which-path" information. Their absence liberates the cognitive system from the imperatives of focused, goal-directed localization.

The Restoration of Cognitive Interference

By erasing the rigid which-path information, sleep actively restores the conditions for cognitive interference. In the quantum analogy, erasure allows wave-like properties (superposition, interference) to re-emerge. In the cognitive domain, this corresponds to the enhanced potential for novel associative linking, creative insight, and the flexible recombination of ideas (Ritter et al., 2012). This is empirically supported by studies demonstrating that sleep, not merely time spent awake, promotes insight in problem-solving (Wagner et al., 2004) and fosters the discovery of hidden rules (Lau et al., 2010).

Therefore, sleep is not an absence of consciousness or cognition. In the Ze framework, it is the *active offline disabling of the cognitive "which-path detector."* It is a period when the brain intentionally suspends its commitment to a single, consistent narrative, allowing the latent interference patterns between disparate memory traces and concepts to surface, be evaluated, and potentially reorganize the very structure of knowledge. This process prepares the system for a new day of localization, but now operating on a reconfigured and more adaptive landscape of potential cognitive states.

Dreaming as Interference Patterns of Meaning

If sleep in the Ze framework is the suspension of cognitive localization $(\Gamma\_Ze \to 0)$ and the erasure of "which-path" information, then the phenomenological content of dreams—the dream itself—demands an explanation that moves beyond classical models of memory replay or random activation (Hobson & McCarley, 1977). We propose that dreams are not epiphenomenal hallucinations, but the direct, conscious experience of *cognitive interference patterns* emerging from sustained, low-Γ_Ze superpositions of meaning and memory states $(|s\_i\rangle)$.

From Superposition to Experiential Interference

During waking consciousness $(\Gamma\_Ze \gg 1)$, the act of attending to an internal representation forces a collapse to a single, logically consistent cognitive eigenstate. The "interference term"—the complex interaction between the amplitudes c_i of different states—is computationally active but phenomenologically suppressed; we experience only the collapsed outcome (Dehaene, 2014). In the low-Γ_Ze state of sleep, particularly during rapid eye movement (REM) sleep where vivid dreaming is most frequent (Nir & Tononi, 2010), this constraint is lifted. The cognitive wave function $|\Psi\_mind\rangle$ evolves as a coherent superposition over extended periods.

The experienced dream narrative is the brain's "read-out" of this interference. Mathematically, the probability of experiencing a particular cognitive-perceptual combination is not simply the sum of probabilities $|c\_i|^2 + |c\_j|^2$, but includes the critical interference term

$|c\_i|^2 + |c\_j|^2$. This term allows for the emergence of configurations that are not simple averages or blends, but novel, often bizarre syntheses that would have negligible probability under waking collapse dynamics. Neurobiologically, this may correspond to the unique neurochemical milieu of REM sleep—high cholinergic and low noradrenergic/serotonergic tone—which promotes high cortical activation with reduced prefrontal executive control and aminergic stabilization (Hobson et al., 2000), creating ideal physiological conditions for sustained superpositional states.

Dream Bizarreness as a Signature of Interference

The hallmark features of dream phenomenology are direct predictions of this interference model, rather than artifacts of noise or dysfunction.

- Logical Contradictions and Incoherence: In a waking superposition of states "I am at home" and "I am in an airport," collapse forces a single, definite location. In the dreaming superposition, the interference between these incompatible eigenstates can produce the experience of being simultaneously in both places, or of one seamlessly transforming into the other without causal explanation (Revonsuo et al., 2015). The narrative does not follow deductive logic because it is not the product of a sequential, localized collapse process, but the simultaneous "illumination" of multiple, interfering possibilities.
- Temporal Loops and Non-Linear Narratives: Waking consciousness is tightly bound to a linear, localized timeline—a consistent "path" through time. Sleep erases this rigid temporal which-path information. In the resulting interference pattern, memories from different life epochs, future anticipations, and atemporal semantic knowledge can interact on an equal footing (Kahn & Hobson, 2005). The interference between a memory state from childhood and a recent worry can generate a narrative where the dreamer is both a child and an adult, or where events unfold in a cyclical, non-progressive manner. This is not a failure of memory systems, but the manifestation of a de-localized temporal cognition (Dumel et al., 2020).
- Fluid Identity and Perspective: The waking "self" is a highly stabilized, localized cognitive construct, a persistent eigenstate maintained by midline default mode network structures (Qin & Northoff, 2011). In the low-Γ_Ze dream state, this construct is no longer forcibly collapsed. The superposition may include self-models as a participant, an observer, a different person, or even an inanimate object. The dream experience can thus fluently represent the interference between these normally exclusive self-states, leading to experiences of dissociation, perspective shifts, and identity merges that are core to dream reports (Windt & Metzinger, 2007).

Empirical Support from Memory and Neuroimaging

This view aligns with key empirical findings. Studies of memory incorporation into dreams show that recent experiences ("day residues") are not simply replayed, but are fragmented and combinatorially blended with semantically or emotionally related remote memories (Fosse et al., 2003; Wamsley & Stickgold, 2011). This fragmentation and blending is the expected outcome of allowing multiple memory traces ($|s\_recent\rangle$, $|s\_remote\rangle$) to interfere, rather than one being selectively retrieved.

Neuroimaging evidence further supports a shift from localized to distributed, interfering processing. Functional MRI studies show that during REM sleep, associative cortices (temporo-parietal junction, medial temporal lobe) remain highly active and show increased functional connectivity with visual and limbic areas, while dorsolateral prefrontal cortex (dlPFC) activity and connectivity are markedly reduced (Desseilles et al., 2011; Horikawa et al., 2013). The dlPFC is critically implicated in maintaining focused attention, logical reasoning, and goal-directed thought—the neural substrate for a high Γ_Ze (Miller & Cohen, 2001). Its deactivation removes the top-down constraint that normally suppresses interference and enforces narrative coherence. The resulting brain state is one where associative, emotional, and sensory regions interact freely, generating the complex interference patterns we experience as dreams. Recent work using machine learning to decode dream content from neural activity underscores that this activity is not random, but represents a novel synthesis of visual and semantic representations (Horikawa et al., 2013).

Functional Implications: Beyond Random Noise

Interpreting dreams as interference patterns assigns them a clear cognitive function within the Ze framework. They are not random byproducts but the *exploratory phase of a cognitive search process*. By allowing meanings, memories, and selves to interact in superposition, the sleeping brain can sample a vast landscape of potential cognitive configurations that would be inaccessible under waking constraints (Stickgold & Walker, 2013). Some of these novel interferences may be nonsensical, but others may forge previously unexplored associative links that, upon waking and the restoration of high Γ_Ze, can be collapsed into a new insight, creative solution, or emotional resolution (Walker & Stickgold, 2010).

In conclusion, the bizarre, non-local, and fluid nature of dreams is not a sign of cognitive breakdown, but the signature of a fundamentally different mode of information processing. Dreams are the phenomenological correlate of a conscious system operating without the imperative of localization, where the interference of meanings—normally hidden—becomes the primary texture of experience. They represent the brain exploring its own latent potential in the space of possible thoughts and narratives.

he Sleep-Wake Boundary and Psychopathology as Dysregulated Localization

The Ze formalism provides a parsimonious framework not only for distinguishing sleep from wakefulness but also for conceptualizing a spectrum of conscious states, including those deemed pathological. If normative consciousness is governed by adaptive regulation of the localization parameter Γ_Ze, then psychopathology can be reinterpreted as a dysregulation of this fundamental control mechanism. This shifts the focus from the *content* of aberrant thoughts to the underlying *process* that fails to constrain cognitive superpositions appropriately. The following table summarizes this perspective:

Table 1

State	Ze Parameter Γ_Ze	Cognitive Character
Norm (Wakefulness)	High, Stable	Rigid localization, sequential collapse
Sleep	Low, Regulated	Sustained superposition, interference patterns
Schizophrenia	Unstable, Fluctuating	Partial or premature collapse, "leakage" of superposition
Depersonalization	Chronically Weakened	Blurred localization, attenuated self-state collapse
Psychosis (Acute)	Fragmented, Chaotic	Competing, rapid micro-collapses; loss of global narrative

The Fragile Boundary: Hypnagogia and Schizotypy

The transition between wakefulness and sleep (hypnagogia) offers a natural model for a labile Γ_Ze. In this state, elements of dream-like interference (sensory imagery, illogical thought) intrude into waking awareness (Mavromatis, 2010). This is not a disease state but a demonstration of the fluidity of localization control. Research suggests that individuals with high schizotypy traits—a subclinical continuum of psychosis-like experiences—report more frequent and vivid hypnagogic phenomena (Watson, 2001). In the Ze framework, this indicates a trait-like instability in Γ_Ze, where the system fails to maintain a robust high-localization state during wakefulness, allowing interference patterns to "leak" through. Neurophysiologically, this may correlate with reduced sensory gating and dysregulated thalamocortical rhythms, which normally help maintain a stable perceptual frame (Brockhaus-Dumke et al., 2008; Ferrarelli et al., 2007).

Schizophrenia: Unstable Collapse and Superpositional "Leakage"

Schizophrenia, particularly its positive symptoms, can be modeled as a state of profoundly unstable Γ_Ze. The system oscillates erratically between attempted localization and states of pathological superposition.

- Hallucinations: A perceptual hallucination (e.g., hearing a voice) may arise not from an external stimulus but from an internal cognitive representation (e.g., subvocal speech, memory trace). In a healthy waking state ($\Gamma\_Ze \gg 1$), this representation would remain as a latent, un-collapsed component of $|\Psi\_mind\rangle$ or be correctly labeled as self-generated. In schizophrenia, a transient, premature, or context-inappropriate collapse localizes this component into a definitive, externally perceived auditory event (Waters et al., 2012). The source-monitoring deficit common in schizophrenia (Ditman & Kuperberg, 2005) is reframed as a failure to correctly manage the "which-path" information of a cognitive state's origin.

- Delusions: Delusional ideation can be seen as a "sticky" collapse onto an improbable cognitive eigenstate $|s\_d\rangle$ (the delusional belief). Once collapsed onto, the system's dynamics are altered such that subsequent collapses are pathologically biased to reinforce $|s\_d\rangle$, resisting updating by contradictory evidence—a phenomenon known as bias against disconfirmatory evidence (BADE) (Woodward et al., 2006). The delusion becomes a maladaptive, overly rigid localized attractor.
- Formal Thought Disorder: Disorganized speech (derailment, tangentiality) mirrors the interference patterns of dreams but occurs in waking. This suggests a chronically low or fluctuating Γ_Ze during speech production, where multiple semantic associations ($|s\_i\rangle$) interfere without being pruned into a linear, goal-directed stream (Kuperberg, 2010). The result is a waking interference pattern of language.

Depersonalization/Derealization: Attenuated Localization of Self and World

Depersonalization disorder (DPD) and derealization present a contrasting dysregulation: a chronic, global weakening of Γ_Ze. Patients report feeling detached, robotic, or like an outside observer of their own thoughts and sensations (Sierra, 2009). In Ze terms, this is not a collapse onto a "wrong" state, but a failure to achieve the normal depth or vividness of collapse. The cognitive superposition of self-states and perceptual states is never fully resolved, leading to a persistent feeling of unreality and emotional numbness. The sense of "me-ness" or presence, a core component of normal conscious experience, requires a stable, high-fidelity collapse onto a coherent self-model (Seth et al., 2012). In DPD, Γ_Ze is too low to sustain this, resulting in a blurred, attenuated experience of both self and world. Neuroimaging studies support this, showing hypoactivity in regions like the anterior insula and amygdala, which are crucial for generating embodied, affective self-awareness (Sierra et al., 2002; Lemche et al., 2007).

Acute Psychosis: Fragmented and Competing Collapses

An acute psychotic state (which can occur in schizophrenia, bipolar disorder, or other conditions) may represent the most severe dysregulation: a fragmentation of the localization process. Instead of a single, global Γ_Ze parameter, different cognitive modules or neural assemblies may operate with independent, competing localization dynamics. This leads to a phenomenology of overwhelming sensory overload, fractured thoughts, and competing realities. The coherent global narrative of consciousness shatters into a series of rapid, unstable, and contradictory micro-collapses. This aligns with theories of psychosis as a breakdown in the brain's ability to generate and maintain a predictive model of the world, resulting in a "kaleidoscope" of unintegrated percepts (Fletcher & Frith, 2009; Horga et al., 2014). The Ze model formalizes this as a catastrophic failure of coordinated localization across the cognitive system.

Therapeutic Implications: Stabilizing the Localization Process

This reframing has significant implications. It suggests that therapeutic interventions, both pharmacological and psychological, may act—directly or indirectly—to stabilize Γ_Ze.

- Antipsychotics: Their primary therapeutic action may be to increase the stability and threshold for cognitive collapse, dampening erratic fluctuations and suppressing premature localization of internal representations (Kapur, 2003).
- Cognitive Behavioral Therapy for Psychosis (CBTp): This can be viewed as training the metacognitive capacity to "re-localize" experiences. By helping patients re-appraise hallucinations as internal events or test the evidence for delusions, CBTp effectively guides the system to re-collapse ambiguous superpositions into more adaptive, reality-based eigenstates (Morrison et al., 2014).
- Mindfulness-Based Therapies: For conditions like depersonalization, mindfulness may work by gently strengthening the attentional "grip" on the present moment, effectively training a slow, deliberate increase in Γ_Ze for sensory and interoceptive experiences, countering the pervasive blurring (Schanche et al., 2020).
- In conclusion, the Ze formalism offers a unifying lens for psychopathology. Disorders of consciousness are not primarily about generating incorrect content, but about failures in the dynamic process of selecting and maintaining coherent content from a sea of potentialities. The boundary between sleep and waking, and between health and illness, is thus a continuum defined by the precision and stability of cognitive localization.

Coma, General Anesthesia, and Psychedelics as Distinct Ze Regimes

The Ze framework, with its central parameter Γ_Ze governing cognitive localization, provides a novel axis for classifying and understanding profoundly altered states of consciousness. Conditions such as coma, general anesthesia, and the psychedelic state are not merely "unconscious" or "altered" in a generic sense; they represent distinct operational modes within the Ze landscape, characterized by specific dynamics of the localization parameter and the observability of the cognitive state vector $|\Psi\_mind\rangle$.

Coma: Global Suspension without Observation

Coma is a state of unarousable unresponsiveness resulting from severe brain injury, metabolic derangement, or structural damage (Posner et al., 2007). In the Ze formalism, coma is modeled as:

$$\Gamma\_Ze \approx 0, \quad |\Psi\_mind\rangle \; is \; not \; observed.$$

This represents the most extreme case of suspended localization. The physiological preconditions for any form of coherent cognitive superposition or collapse are globally disrupted. Neural activity is often severely depressed, disconnected, or trapped in pathological patterns like burst-suppression (Brown et al., 2010). The key distinction from deep sleep is the absence of observation. While in deep NREM sleep, $|\Psi\_mind\rangle$ may still be in a coherent, low-energy superposition that manifests in specific, organized electrophysiological signatures (e.g., slow waves, spindles) and may support off-line processing (Tononi & Massimini, 2008), in coma, the system's capacity to generate any observable conscious state—even an internally coherent, dream-like one—is critically impaired. The "cognitive measurement apparatus" itself is offline. This aligns with theories of consciousness that emphasize the need for both sufficient information generation (complexity) and integration, both of which collapse in coma (Casali et al., 2013). Recovery from coma involves the gradual restoration of the neural infrastructure necessary to first re-establish a coherent $|\Psi\_mind\rangle$ (a minimally conscious state), and only later, the restoration of a $\Gamma\_Ze > 0$ to allow for interactive localization (Laureys, 2005).

General Anesthesia: The Artificial Nullification of Γ_Ze

General anesthesia (GA) is a pharmacologically induced, reversible state encompassing unconsciousness, amnesia, analgesia, and immobility (Brown et al., 2011). In the Ze model, its primary effect is:

$$\Gamma\_Ze \to 0 \quad (artificially\ induced)$$

Unlike coma, this is a controlled, targeted suppression of the localization mechanism. Modern anesthetic agents, such as propofol and sevoflurane, are thought to produce unconsciousness by potentiating inhibitory GABAergic transmission and disrupting coherent communication across thalamocortical and corticocortical networks (Alkire et al., 2008; Mashour, 2014). This pharmacologic action can be directly interpreted as forcing Γ_Ze to zero. The brain enters a state where long-range feedback loops necessary for sustaining a globally coherent cognitive superposition are severed, and the local neural assemblies that would constitute cognitive eigenstates $|s\_i\rangle$ are functionally isolated or inhibited. The system cannot sustain the large-scale integration required for a conscious percept or thought (Mashour & Hudetz, 2018). Crucially, at lighter planes of anesthesia, phenomena like "connected consciousness" or dreaming can occur (Mashour & Avidan, 2015), which in the Ze model would correspond to transient, local elevations of Γ_Ze allowing for partial, fragmented collapses or limited superpositional states. The precise control of Γ_Ze via anesthetic depth underscores that localization is a graded, druggable neural process.

The Psychedelic State: Enhanced Interference in the Wakeful Brain

The psychedelic experience, induced by classic serotonergic agonists like psilocybin, LSD, or DMT, presents a fascinating contrast. It is a state of vivid, often overwhelming consciousness, not its loss. The Ze model captures this as a profound modification of the localization parameter while maintaining the observability of the state vector:

$$\Gamma\_Ze \downarrow, \quad Cognitive\ Coherence \uparrow$$

Psychedelics primarily act as partial agonists at cortical serotonin 2A (5-HT2A) receptors, which are densely expressed on deep-layer pyramidal neurons and are key nodes in corticocortical and thalamocortical networks (Nichols, 2016). Neuroimaging studies consistently show that psychedelics do not suppress overall brain activity but drastically alter its organization: they decrease activity and functional connectivity within the Default Mode Network (DMN)—a network associated with the stable, narrative self-model and metacognitive evaluation (Carhart-Harris et al., 2012)—while increasing global functional connectivity and the entropy of neural signals (Carhart-Harris et al., 2014; Tagliazucchi et al., 2014).

In Ze terms, this neurobiological profile has two key consequences:

1. Suppression of the Localization "Governor": The DMN is hypothesized to be a core substrate for maintaining a high, stable Γ_Ze. It enforces a consistent self-narrative and filters out percepts

and associations that do not fit the dominant cognitive model (Northoff & Bermpohl, 2004). Its disintegration under psychedelics directly translates to a dramatic reduction in Γ_Ze. The rigid, habitual patterns of cognitive collapse are dissolved.

2. Liberation of Cognitive Interference: With Γ_Ze lowered, the cognitive system enters a state akin to dreaming, but while maintaining a high level of baseline arousal and sensory input. The superposition $|\Psi\_mind\rangle$ becomes enriched with a much wider and more fluid set of potential states $|s\_i\rangle$. The "interference term" between normally disparate concepts, senses (synesthesia), memories, and self-representations becomes the dominant experiential feature (Kaelen et al., 2016). This manifests as visual imagery, mystical-type experiences, emotional catharsis, and the breakdown of boundaries between self and world. The increase in neural entropy and connectivity reflects this explosion of possible cognitive configurations and their interference patterns.

Unlike sleep, where the low Γ_Ze state is coupled with reduced exteroceptive input, the psychedelic state allows for the direct, conscious observation of this rich interference landscape. This can lead to lasting increases in cognitive flexibility and openness, interpreted in the model as a persistent relaxation of overly rigid Γ_Ze set-points, allowing for a broader exploration of cognitive state space post-experience (Carhart-Harris et al., 2016).

Synthesis: A Continuum of Localization Control

These three states illustrate a continuum. At one extreme, coma and deep GA represent the functional elimination of the capacity for observable localization $(\Gamma\_Ze \approx 0, no\ observation)$. Sleep is a natural, rhythmic, and observable low-Γ_Ze state with attenuated input. The psychedelic state is a pharmacologically induced, wakeful low-Γ_Ze state with heightened input and observation. Psychosis, as discussed earlier, could be seen as a pathological, unstable version of the latter. This unified perspective suggests that the core mechanisms controlling the breadth and stability of cognitive state selection—formalized as Γ_Ze—are a fundamental target of both neuropathology and neuroactive compounds, opening new avenues for classifying and understanding disorders and treatments of consciousness.

The Central Thesis: Sleep as a Physiological Quantum Eraser of Consciousness

This article has developed the Ze formalism, a theoretical framework that conceptualizes consciousness as a dynamic process of cognitive localization governed by a parameter Γ_Ze. Within this framework, the central thesis is as follows:

Sleep is a physiologically controlled quantum eraser of consciousness, a regulated neurobiological mechanism that temporarily suspends the process of cognitive localization, allowing the Ze system to recalibrate the probability amplitudes c_i of semantic, emotional, and mnemonic states $|s\_i\rangle$ within the cognitive superposition $|\Psi\_mind\rangle$.

This thesis synthesizes the model's components into a coherent functional proposal. It posits that sleep is not a passive, deficient state of cognition, but an *active, essential operation* with a specific, definable computational function: the managed erasure of "which-path" information to enable cognitive reorganization. This final section elaborates on the three core components of this thesis, integrating them with contemporary neuroscience.

Sleep as a Physiologically Controlled Process

The regulatory machinery of sleep is one of the most robust and conserved biological systems, governed by circadian rhythms and homeostatic sleep pressure (Borbély et al., 2016). The shift from a high-Γ_Ze waking state to a low-Γ_Ze sleep state is orchestrated by a precise neurochemical cascade. The decline in wake-promoting monoamines (norepinephrine, serotonin, histamine) and acetylcholine (during NREM), coupled with the rise of sleep-promoting substances like adenosine and GABAergic activity in the ventrolateral preoptic nucleus, actively suppresses the neural circuits responsible for stable, focused cognition (Saper et al., 2001; Scammell et al., 2017).

This physiological control manifests in distinct electrophysiological signatures that directly map onto the Ze model's predictions. The transition into NREM sleep is marked by the emergence of synchronized slow-wave oscillations $(< 1\,Hz)$. These oscillations are not neural noise; they are a highly organized, global phenomenon where widespread neuronal populations alternate between active "up-states" and silent "down-states" (Steriade et al., 1993; Massimini et al., 2004). In Ze terms, the slow-wave down-state represents a periodic, enforced global *reset of localization*. It is a physiological mechanism that actively terminates any ongoing, localized cognitive attractor, forcing the system into a temporary tabula rasa. This repeated reset is the neural implementation of lowering Γ_Ze to near zero, preventing any sustained collapse and creating windows of opportunity for system-wide reconfiguration. Similarly, the characteristic features of REM sleep—cortical activation coupled with muscle atonia and a unique cholinergic/monoaminergic balance (Brown et al., 2012)—establish the physiological conditions for a specific *type* of low-Γ_Ze state: one that is permissive for the vivid, narrative-driven interference patterns we experience as dreams.

The Quantum Eraser Function: Erasing Cognitive Which-Path Information

The "quantum eraser" metaphor is not merely an analogy but a formal description of the proposed computational goal. During wakefulness, every decision, perception, and learning event creates "cognitive which-path information"—a record of the specific neural pathways and associative links that were reinforced (Lewis & Durrant, 2011). This information is essential for adaptive behavior but leads to *cognitive decoherence*: an over-pruning of the associative landscape, where thoughts become trapped in well-worn, efficient, but potentially rigid and maladaptive ruts (Tononi & Cirelli, 2014).

Sleep, through its controlled physiological state, performs the erasure. The synaptic homeostasis hypothesis (SHY) provides a compelling neural correlate for this function. SHY proposes that wakefulness is associated with a net increase in synaptic strength and complexity across the cortex, as new connections are formed and others are potentiated. Sleep, particularly slow-wave sleep, triggers a homeostatic process of global synaptic downsconing, where synaptic strengths are proportionally reduced (de Vivo et al., 2017; Tononi & Cirelli, 2014). Crucially, this downscaling is not random deletion but a selective normalization: it preferentially weakens the over-potentiated, highly specific pathways that constitute the "which-path" information of the day's learning, while preserving the relative strength of weaker, latent connections. This is the mechanistic essence of erasure—it does not delete memories but dissolves the rigid, episodic context in which they were encoded, functionally decoupling memories from their specific waking-life narratives (Stickgold & Walker, 2013).

Recalibrating the Amplitudes of Meaning (c_i)

The ultimate purpose of this controlled erasure is not oblivion, but optimization. By suspending the imperative for immediate, task-relevant localization, sleep allows the cognitive system to explore its own state space. The amplitudes c_i—the weights or potentials assigned to different memories, concepts, emotional associations, and problem-solving approaches—are dynamically redistributed.

This redistribution supports multiple, well-documented cognitive benefits:

- Memory Consolidation and Integration: Sleep does more than stabilize memories; it integrates them into existing knowledge networks. This involves a shift from hippocampal-dependent, episodic detail to neocortical, semantic generalization (Diekelmann & Born, 2010). In the Ze model, this is the reweighting of amplitudes so that the core semantic essence of a memory $(|s\_semantic\rangle)$ gains prominence over its precise episodic context $(|s\_episodic\rangle)$, facilitated by hippocampal-neocortical replay in a low-Γ_Ze environment (Cowan et al., 2020).
- Emotional Regulation: Sleep, particularly REM sleep, is critical for processing emotional memories, often reducing the affective charge associated with negative experiences (Goldsmith & Perl, 2019; Walker & van der Helm, 2009). This can be modeled as a reduction in the amplitude $|c\_negative\, affect|\hat{}2$ of the emotional component associated with a memory trace, while its informational content is preserved and integrated.
- Insight and Creativity: The enhanced potential for novel associative linking after sleep (Ritter et al., 2012; Wagner et al., 2004) is a direct consequence of allowing interference between previously isolated cognitive states. The rigid which-path information that normally keeps concepts A and B separate is erased; in the low-Γ_Ze state of sleep, their superposition can generate a novel interference pattern representing a creative link A-B, which can then be consciously accessed upon waking.

In conclusion, the Ze formalism offers a unified, formal account of sleep's core function. It reframes sleep as an *active computational mode* of the conscious brain. By physiologically enforcing a state of suspended localization $(\Gamma\_Ze \to 0)$, sleep acts as a quantum eraser, dissolving the rigid informational constraints accrued during wakefulness. This permits a global, offline recalibration of the cognitive probability landscape, redistributing the amplitudes of meaning to optimize memory, emotion, and creativity. This thesis bridges phenomenological, neurophysiological, and computational levels of analysis, providing a novel lens through which to understand why we must suspend our conscious engagement with the world to maintain its coherence and richness.

8. Discussion

The Ze formalism proposed in this article provides a unified, theoretical framework for understanding the sleep-wake cycle and related states of consciousness through the lens of a dynamic cognitive localization process. By introducing the parameter Γ_Ze, we have attempted to formalize the transition from the sharply focused, logically constrained cognition of wakefulness to the fluid, associative, and bizarre phenomenology of sleep and dreaming. This final section discusses the strengths, limitations, and broader implications of the model, situating it within contemporary debates in cognitive neuroscience and consciousness studies.

Unification of Diverse Phenomena

A primary strength of the Ze framework is its capacity to unify a wide range of empirical observations under a single computational principle. The model connects:

- Sleep Physiology: The synchronous slow oscillations of NREM sleep are interpreted as a periodic, global reset mechanism that enforces low Γ_Ze by terminating localized cortical attractors (Massimini et al., 2004; Steriade et al., 1993).
- Dream Phenomenology: The bizarreness, temporal incoherence, and identity fluidity of dreams are recast not as noise but as the signature of conscious experience dominated by interference patterns in a sustained cognitive superposition (Revonsuo et al., 2015; Windt & Metzinger, 2007).
- Sleep-Dependent Cognition: The benefits of sleep for memory integration (Diekelmann & Born, 2010), emotional regulation (Walker & van der Helm, 2009), and creative insight (Wagner et al., 2004) are framed as the downstream consequences of erasing "which-path" information and redistributing the amplitudes c_i of cognitive states.
- Psychopathology: Disorders like schizophrenia and depersonalization are conceptualized not as errors in content generation, but as dysregulations of the localization control parameter Γ_Ze, leading to unstable, weakened, or fragmented collapse (Fletcher & Frith, 2009; Sierra, 2009).
- Pharmacologically Altered States: The actions of general anesthetics and psychedelics are distinguished based on their effect on Γ_Ze and the observability of $|\Psi\_mind\rangle$, offering a clear axis for comparing states of unconsciousness and expanded consciousness (Carhart-Harris et al., 2014; Mashour & Hudetz, 2018).

This integrative power suggests that the regulation of cognitive localization may be a fundamental, high-level organizing principle for brain function, cutting across traditional boundaries between sleep research, psychiatry, and anesthesiology.

Relationship to Existing Theories

The Ze model does not exist in a vacuum and intersects with several established theories. It is broadly compatible with the **Information Integration Theory (IIT)** (Tononi et al., 2016), where a high Γ_Ze could correspond to a system generating a specific, high-Φ conceptual structure, while a low Γ_Ze state (like deep NREM sleep) would correspond to a loss of effective integration and thus a fading of consciousness. However, Ze formalism specifically addresses the process of selecting one integrated concept from many, a dynamics less emphasized in IIT.

It also aligns with **predictive processing frameworks** (Clark, 2013; Friston, 2010). In this view, wakefulness involves actively minimizing prediction error by sampling the world to update a precise generative model—a process requiring sharp localization. Sleep, by attenuating exteroceptive precision weights, allows the model to prioritize intrinsic, generative activity, leading to the exploration of the model's latent state space (Hobson et al., 2014). The lowering of Γ_Ze can be seen as reducing the precision (or increasing the variance) assigned to current perceptual hypotheses, allowing prior beliefs and internal models to interact more freely.

The model's "quantum eraser" function for memory directly engages with the **Synaptic Homeostasis Hypothesis (SHY)** (Tononi & Cirelli, 2014). While SHY provides a cellular and molecular mechanism (synaptic downscaling), the Ze formalism provides a systems-level *computational rationale* for why such a reset is necessary: to prevent cognitive "decoherence" and maintain the system's capacity for flexible inference and learning.

Limitations and Future Directions

The model, as presented, is intentionally schematic and faces several challenges that must be addressed for it to evolve beyond a compelling metaphor.

- Neural Implementation: The most pressing question is the precise neural correlate of Γ_Ze. We have proposed it as a composite of neuromodulatory tone, cortical synchronization, and prefrontal executive control. Future work must test this by seeking specific, measurable neural signatures that correlate with subjective or behavioral estimates of "localization strength." This could involve analyzing EEG/MEG complexity, fronto-parietal connectivity, or the stability of multivariate activity patterns during tasks that probe cognitive flexibility vs. stability, across the sleep-wake cycle and in psychiatric populations.
- Quantification: Can Γ_Ze be quantified? Potential proxies could be derived from behavioral tasks measuring tolerance for ambiguity, speed of perceptual switching, or the propensity for remote versus close associative thinking. Neurophysiologically, the steepness of the attractor landscape in recurrent network models fitted to neural data could serve as a formal estimate (Rolls, 2021).
- The "Hard Problem" and Metaphor: The use of quantum mechanical terminology (superposition, collapse, interference) is a formal metaphor, not a claim about quantum biology in the brain. It is a mathematical language chosen for its utility in describing probabilistic state selection. The model addresses the "easy problems" of the structure

and function of consciousness across states (Chalmers, 1996), not the "hard problem" of subjective experience itself. However, it offers a more precise vocabulary for describing the formal structure of that experience in different regimes.

- Evolutionary Considerations: Why would a system evolve to spend a third of its life in a state of suspended localization? The Ze framework suggests a compelling answer: the computational benefits of offline reorganization, error correction, and creative exploration outweigh the risks of behavioral dormancy. This aligns with the adaptive, restorative theories of sleep (Medic et al., 2017).

Concluding Implications

The Ze formalism shifts the perspective on sleep from one of *quiescence* to one of *reconfiguration*. It suggests that the very integrity and adaptability of waking consciousness depend on its regular dissolution. By framing psychopathology as a dysregulation of this essential cycle, it points toward novel therapeutic strategies focused on stabilizing cognitive dynamics (e.g., via neuromodulation, neurofeedback, or pharmacological tuning of network stability) rather than merely suppressing symptoms.

In essence, the Ze model proposes that to be coherently *here* and *now* during the day, our brains must regularly cease to be definitively anywhere at all. Sleep is the necessary suspension of our cognitive commitment to a single reality, allowing the myriad potential realities within us to communicate, interfere, and reshape the landscape of meaning from which our waking lives are drawn.

9. Conclusion

This article has introduced and elaborated the Ze formalism, a theoretical framework that re-conceptualizes consciousness as a dynamic process of cognitive localization, governed by a quantifiable parameter Γ_Ze. We have argued that the fundamental distinction between wakefulness and sleep—and a key dimension for understanding altered states—lies not in the presence or absence of consciousness, but in the *regulation of this localization process*. The central thesis posits that sleep serves as a physiologically controlled cognitive quantum eraser: a periodic, essential state where the imperative for definitive cognitive collapse is suspended, allowing for the erasure of rigid associative "which-path" information and the recalibration of semantic and emotional amplitudes within the mind's probability landscape.

Recapitulation of the Framework

The journey through the Ze model began by defining the cognitive state vector $|\Psi\_mind\rangle$ as a superposition of potential percepts, memories, and meanings $|s\_i\rangle$. In the waking state, a high and stable Γ_Ze ensures rapid and frequent collapse into definite, logically consistent narratives, a process underpinned by robust neuromodulatory tone and executive prefrontal control (Aston-Jones & Cohen, 2005; Miller & Cohen, 2001). This state is optimal for real-time interaction with the environment but accrues a cost in cognitive rigidity.

Sleep, in contrast, is characterized by a controlled descent of Γ_Ze towards zero. This transition, orchestrated by dedicated hypothalamic sleep-switch circuitry and the ebb of monoaminergic activity (Saper et al., 2001), creates a permissive environment for sustained superposition. The resulting phenomenology—dreaming—is not a hallucinatory epiphenomenon but the direct experience of interference patterns between cognitive states that would be mutually exclusive in wakefulness (Nir & Tononi, 2010). The bizarre, hyper-associative, and temporally fluid nature of dreams is the signature of a conscious system operating without the constraint of localization (Revonsuo et al., 2015).

The functional utility of this suspended state is profound. By acting as a cognitive quantum eraser, sleep performs essential offline maintenance. It facilitates the synaptic downscaling and systems-level memory replay that transforms labile, episodic memories into integrated, semantic knowledge, a process supported by extensive research (Diekelmann & Born, 2010; Tononi & Cirelli, 2014). It modulates emotional affect, dampening the visceral charge of memories while preserving their content (Walker & van der Helm, 2009). Most importantly, it restores the potential for cognitive interference, thereby fostering creativity and insight by allowing novel connections to form between previously isolated concepts (Stickgold & Walker, 2013; Wagner et al., 2004).

A Unifying Lens for Consciousness Studies

The explanatory power of the Ze formalism extends beyond normative sleep. It provides a parsimonious axis for classifying a spectrum of conscious states based on the stability and value of Γ_Ze. We have demonstrated how this framework can illuminate:

Psychopathology: Conditions like schizophrenia, with its unstable Γ_Ze leading to premature collapses (hallucinations) and sticky maladaptive attractors (delusions), and depersonalization, with its chronically weakened localization, are reframed as dysregulations of a fundamental cognitive control parameter (Fletcher & Frith, 2009; Sierra, 2009).

Pharmacologically Induced States: The model clearly distinguishes the artificial nullification of Γ_Ze and observation in general anesthesia (Mashour & Hudetz, 2018) from the conscious, wakeful lowering of Γ_Ze induced by classic psychedelics, which disintegrate the default mode network and liberate cognitive interference (Carhart-Harris et al., 2014).

Disorders of Consciousness: States like coma can be understood as the pathological collapse of both Γ_Ze and the very capacity to generate an observable $|\Psi\_mind\rangle$ (Laureys, 2005).

This unification suggests that the brain's ability to dynamically modulate the breadth and focus of cognitive state selection is a core, high-order function. Disturbances in this function cut across traditional diagnostic categories, offering a transdiagnostic perspective that may inform novel therapeutic approaches aimed at stabilizing cognitive dynamics rather than merely suppressing symptomatic content.

Future Horizons and Final Synthesis

The Ze formalism, as presented, is a theoretical model. Its value will be determined by its capacity to generate novel, testable hypotheses and to integrate with empirical neuroscience.

Key challenges include the precise neural instantiation of Γ_Ze and the development of quantitative biomarkers for it, potentially derived from measures of neural signal complexity, attractor stability in computational models, or the dynamic repertoire of functional connectivity patterns (Deco et al., 2011; Tagliazucchi et al., 2014).

Nevertheless, the model offers a significant conceptual advance. It moves beyond describing *what* changes in the brain during sleep (e.g., synaptic strength, oscillation patterns) to propose a computational why: to periodically reset the process of cognitive localization. In doing so, it bridges domains often treated in isolation—the electrophysiology of sleep, the phenomenology of dreaming, the cognitive science of memory, and the neurobiology of psychosis.

In conclusion, the Ze formalism posits that the regular suspension of our commitment to a single, coherent reality is not a flaw but a fundamental design feature of conscious cognition. Sleep is the necessary counterpoint to wakefulness. It is the phase where the cognitive wave function is allowed to expand, explore, and interfere with itself, erasing the deterministic paths of yesterday to lay the groundwork for the adaptive possibilities of tomorrow. We are not conscious *in spite of* this daily suspension, but *because of it*. The clarity of our waking hours is purchased with the fertile chaos of the night, in a perpetual cycle of localization and delocalization that defines the very rhythm of a mindful existence.

References

Alkire, M. T., Hudetz, A. G., & Tononi, G. (2008). Consciousness and anesthesia. Science, 322(5903), 876-880.

Aston-Jones, G., & Bloom, F. E. (1981). Norepinephrine-containing locus coeruleus neurons in behaving rats exhibit pronounced responses to non-noxious environmental stimuli. Journal of Neuroscience, 1(8), 887-900.

Aston-Jones, G., & Cohen, J. D. (2005). An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. Annual Review of Neuroscience, 28, 403-450.

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. Social Cognitive and Affective Neuroscience, 12(1), 1–23.

Brockhaus-Dumke, A., Schultze-Lutter, F., Mueller, R., Tendolkar, I., Bechdolf, A., Pukrop, R., ... & Ruhrmann, S. (2008). Sensory gating in schizophrenia: P50 and N100 gating in antipsychotic-free subjects at risk, first-episode, and chronic patients. Biological Psychiatry, 64(5), 376-384.

Brown, E. N., Lydic, R., & Schiff, N. D. (2010). General anesthesia, sleep, and coma. New England Journal of Medicine, 363(27), 2638-2650.

Brown, E. N., Purdon, P. L., & Van Dort, C. J. (2011). General anesthesia and altered states of arousal: a systems neuroscience analysis. Annual Review of Neuroscience, 34, 601-628.

Bruza, P. D., Wang, Z., & Busemeyer, J. R. (2015). Quantum cognition: a new theoretical approach to psychology. Trends in Cognitive Sciences, 19(7), 383–393.

Busemeyer, J. R., & Bruza, P. D. (2012). Quantum models of cognition and decision. Cambridge University Press.

Buzsáki, G. (1998). Memory consolidation during sleep: a neurophysiological perspective. Journal of Sleep Research, 7(S1), 17-23.

Carhart-Harris, R. L., Erritzoe, D., Williams, T., Stone, J. M., Reed, L. J., Colasanti, A., ... & Nutt, D. J. (2012). Neural correlates of the psychedelic state as determined by fMRI studies with psilocybin. Proceedings of the National Academy of Sciences, 109(6), 2138-2143.

Carhart-Harris, R. L., Leech, R., Hellyer, P. J., Shanahan, M., Feilding, A., Tagliazucchi, E., ... & Nutt, D. (2014). The entropic brain: a theory of conscious states informed by neuroimaging research with psychedelic drugs. Frontiers in Human Neuroscience, 8, 20.

Carhart-Harris, R. L., Muthukumaraswamy, S., Roseman, L., Kaelen, M., Droog, W., Murphy, K., ... & Nutt, D. J. (2016). Neural correlates of the LSD experience revealed by multimodal neuroimaging. Proceedings of the National Academy of Sciences, 113(17), 4853-4858.

Casali, A. G., Gosseries, O., Rosanova, M., Boly, M., Sarasso, S., Casali, K. R., ... & Massimini, M. (2013). A theoretically based index of consciousness independent of sensory processing and behavior. Science Translational Medicine, 5(198), 198ra105.

Chalmers, D. J. (1996). The conscious mind: In search of a fundamental theory. Oxford

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. Behavioral and Brain Sciences, 36(3), 181-204.

Cowan, E., Liu, A., Henin, S., Kothare, S., Devinsky, O., & Davachi, L. (2020). Sleep spindles promote the restructuring of memory representations in ventromedial prefrontal cortex through enhanced hippocampal–cortical functional connectivity. Journal of Neuroscience, 40(9), 1909-1919.

Deco, G., Jirsa, V. K., & McIntosh, A. R. (2011). Emerging concepts for the dynamical organization of resting-state activity in the brain. Nature Reviews Neuroscience, 12(1), 43-56.

Dehaene, S. (2014). Consciousness and the brain: Deciphering how the brain codes our thoughts. Viking.

Dehaene, S., Kerszberg, M., & Changeux, J. P. (1998). A neuronal model of a global workspace in effortful cognitive tasks. Proceedings of the National Academy of Sciences, 95(24), 14529–14534.

Desseilles, M., Dang-Vu, T. T., Sterpenich, V., & Schwartz, S. (2011). Cognitive and emotional processes during dreaming: A neuroimaging view. Consciousness and Cognition, 20(4), 998-1008.

Diekelmann, S., & Born, J. (2010). The memory function of sleep. Nature Reviews Neuroscience, 11(2), 114-126.

Diekelmann, S., & Born, J. (2010). The memory function of sleep. Nature Reviews Neuroscience, 11(2), 114–126.

Dirac, P. A. M. (1958). The principles of quantum mechanics (4th ed.). Oxford University Press.

Ditman, T., & Kuperberg, G. R. (2005). A source-monitoring account of auditory verbal hallucinations in patients with schizophrenia. Harvard Review of Psychiatry, 13(5), 280-299.

Dumel, G., Carr, M., & Nielsen, T. (2020). Dreaming and offline memory consolidation. Current Neurology and Neuroscience Reports, 20(11), 1-9.

Ferrarelli, F., Huber, R., Peterson, M. J., Massimini, M., Murphy, M., Riedner, B. A., ... & Tononi, G. (2007). Reduced sleep spindle activity in schizophrenia patients. American Journal of Psychiatry, 164(3), 483-492.

Fletcher, P. C., & Frith, C. D. (2009). Perceiving is believing: a Bayesian approach to explaining the positive symptoms of schizophrenia. Nature Reviews Neuroscience, 10(1), 48-58.

Fosse, M. J., Fosse, R., Hobson, J. A., & Stickgold, R. J. (2003). Dreaming and episodic memory: A functional dissociation? Journal of Cognitive Neuroscience, 15(1), 1-9.

Fox, K. C., Spreng, R. N., Ellamil, M., Andrews-Hanna, J. R., & Christoff, K. (2015). The wandering brain: Meta-analysis of functional neuroimaging studies of mind-wandering and related spontaneous thought processes. NeuroImage, 111, 611–621.

Friston, K. (2010). The free-energy principle: a unified brain theory? Nature Reviews Neuroscience, 11(2), 127-138.

Hobson, J. A. (2009). REM sleep and dreaming: towards a theory of protoconsciousness. Nature Reviews Neuroscience, 10(11), 803-813.

Hobson, J. A. (2009). REM sleep and dreaming: towards a theory of protoconsciousness. Nature Reviews Neuroscience, 10(11), 803–813.

Hobson, J. A., & McCarley, R. W. (1977). The brain as a dream state generator: an activation-synthesis hypothesis of the dream process. American Journal of Psychiatry, 134(12), 1335-1348.

Hobson, J. A., Pace-Schott, E. F., & Stickgold, R. (2000). Dreaming and the brain: toward a cognitive neuroscience of conscious states. Behavioral and Brain Sciences, 23(6), 793-842.

Hobson, J. A., Pace-Schott, E. F., & Stickgold, R. (2014). Dreaming and the brain: toward a cognitive neuroscience of conscious states. In Sleep and dreaming (pp. 1-50). Psychology Press.

Hobson, J. A., Pace-Schott, E. F., & Stickgold, R. (2014). Dreaming and the brain: toward a cognitive neuroscience of conscious states. In Sleep and dreaming (pp. 1-50). Psychology Press.

Horga, G., Schatz, K. C., Abi-Dargham, A., & Peterson, B. S. (2014). Deficits in predictive coding underlie hallucinations in schizophrenia. Journal of Neuroscience, 34(24), 8072-8082.

Horikawa, T., Tamaki, M., Miyawaki, Y., & Kamitani, Y. (2013). Neural decoding of visual imagery during sleep. Science, 340(6132), 639-642.

Jaba, T. (2022). Dasatinib and quercetin: short-term simultaneous administration yields senolytic effect in humans. Issues and Developments in Medicine and Medical Research Vol. 2, 22-31.

Ji, D., & Wilson, M. A. (2007). Coordinated memory replay in the visual cortex and hippocampus during sleep. Nature Neuroscience, 10(1), 100-107.

Kaelen, M., Roseman, L., Kahan, J., Santos-Ribeiro, A., Orban, C., Lorenz, R., ... & Carhart-Harris, R. (2016). LSD modulates music-induced imagery via changes in parahippocampal connectivity. European Neuropsychopharmacology, 26(7), 1099-1109.

Kahn, D., & Hobson, J. A. (2005). Theory of mind in dreaming: awareness of feelings and thoughts of others in dreams. Dreaming, 15(1), 48-57.

Kapur, S. (2003). Psychosis as a state of aberrant salience: a framework linking biology, phenomenology, and pharmacology in schizophrenia. American Journal of Psychiatry, 160(1), 13-23.

Kim, Y. H., Yu, R., Kulik, S. P., Shih, Y., & Scully, M. O. (2000). A delayed choice quantum eraser. Physical Review Letters, 84(1), 1.

Kindermans, P. J., & Schütt, K. T. (2019). The neural coding framework for understanding cognitive and perceptual states. PLOS Computational Biology, 15(4), e1006904.

Kuperberg, G. R. (2010). Language in schizophrenia Part 1: an Introduction. Language and Linguistics Compass, 4(8), 576-589.

Lau, H., Alger, S. E., & Fishbein, W. (2010). Relational memory: A daytime nap facilitates the abstraction of general concepts. PLoS One, 5(5), e10640.

Laureys, S. (2005). The neural correlate of (un)awareness: lessons from the vegetative state. Trends in Cognitive Sciences, 9(12), 556-559.

Lemche, E., Brammer, M. J., David, A. S., Surguladze, S. A., Phillips, M. L., & Sierra, M. (2007). Neural correlates of incidental memory in depersonalization disorder: A fMRI study. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 31(4), 799-808.

Lewis, P. A., & Durrant, S. J. (2011). Overlapping memory replay during sleep builds cognitive schemata. Trends in Cognitive Sciences, 15(8), 343-351.

Lewis, P. A., & Durrant, S. J. (2011). Overlapping memory replay during sleep builds cognitive schemata. Trends in Cognitive Sciences, 15(8), 343–351.

Long, G. M., & Toppino, T. C. (2004). Enduring interest in perceptual ambiguity: alternating views of reversible figures. Psychological Bulletin, 130(5), 748.

Mashour, G. A. (2014). Top-down mechanisms of anesthetic-induced unconsciousness. Frontiers in Systems Neuroscience, 8, 115.

Mashour, G. A., & Avidan, A. Y. (2015). Intraoperative awareness: controversies and non-controversies. British Journal of Anaesthesia, 115(suppl_1), i20-i26.

Mashour, G. A., & Hudetz, A. G. (2018). Neural correlates of unconsciousness in large-scale brain networks. Trends in Neurosciences, 41(3), 150-160.

Massimini, M., Ferrarelli, F., Huber, R., Esser, S. K., Singh, H., & Tononi, G. (2005). Breakdown of cortical effective connectivity during sleep. Science, 309(5744), 2228-2232.

Massimini, M., Huber, R., Ferrarelli, F., Hill, S., & Tononi, G. (2004). The sleep slow oscillation as a traveling wave. Journal of Neuroscience, 24(31), 6862-6870.

Mavromatis, A. (2010). Hypnagogia: The unique state of consciousness between wakefulness and sleep. Routledge.

Medic, G., Wille, M., & Hemels, M. E. (2017). Short-and long-term health consequences of sleep disruption. Nature and Science of Sleep, 9, 151.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. Annual Review of Neuroscience, 24(1), 167-202.

Morrison, A. P., Turkington, D., Pyle, M., Spencer, H., Brabban, A., Dunn, G., ... & Hutton, P. (2014). Cognitive therapy for people with schizophrenia spectrum disorders not taking antipsychotic drugs: a single-blind randomised controlled trial. The Lancet, 383(9926), 1395-1403.

Moscovitch, M., Cabeza, R., Winocur, G., & Nadel, L. (2016). Episodic memory and beyond: The hippocampus and neocortex in transformation. Annual Review of Psychology, 67, 105-134.

Nichols, D. E. (2016). Psychedelics. Pharmacological Reviews, 68(2), 264-355.

Nir, Y., & Tononi, G. (2010). Dreaming and the brain: from phenomenology to neurophysiology. Trends in Cognitive Sciences, 14(2), 88-100.

Nir, Y., & Tononi, G. (2010). Dreaming and the brain: from phenomenology to neurophysiology. Trends in Cognitive Sciences, 14(2), 88–100.

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. Trends in Cognitive Sciences, 8(3), 102-107.

Phelps, E. A., Lempert, K. M., & Sokol-Hessner, P. (2014). Emotion and decision making: multiple modulatory neural circuits. Annual Review of Neuroscience, 37, 263-287.

Portas, C. M., Thakkar, M., Rainnie, D. G., & McCarley, R. W. (1998). Role of adenosine in behavioral state modulation: a microdialysis study in the freely moving cat. Neuroscience, 79(1), 225-235.

Posner, J. B., Saper, C. B., Schiff, N. D., & Plum, F. (2007). Plum and Posner's diagnosis of stupor and coma (Vol. 71). Oxford University Press.

Qin, P., & Northoff, G. (2011). How is our self related to midline regions and the default-mode network? NeuroImage, 57(3), 1221-1233.

Revonsuo, A., Tuominen, J., & Valli, K. (2015). The Avatars in the Machine: Dreaming as a Simulation of Social Reality. In T. K. Metzinger & J. M. Windt (Eds.), Open MIND. MIND Group.

Ritter, S. M., Strick, M., Bos, M. W., Van Baaren, R. B., & Dijksterhuis, A. (2012). Good morning creativity: task reactivation during sleep enhances beneficial effect of sleep on creative performance. Journal of Sleep Research, 21(6), 643-647.

Rolls, E. T. (2021). Attractor cortical neurodynamics, schizophrenia, and depression. Translational Psychiatry, 11(1), 1-16.

Rolls, E. T., & Deco, G. (2010). The noisy brain: stochastic dynamics as a principle of brain function. Oxford University Press.

Saper, C. B., Chou, T. C., & Scammell, T. E. (2001). The sleep switch: hypothalamic control of sleep and wakefulness. Trends in Neurosciences, 24(12), 726-731.

Schanche, E., Vøllestad, J., Binder, P. E., Hjeltnes, A., Dundas, I., & Nielsen, G. H. (2020). Participant experiences of change in mindfulness-based stress reduction for anxiety and depression. Counselling and Psychotherapy Research, 20(2), 218-228.

Seth, A. K., Suzuki, K., & Critchley, H. D. (2012). An interoceptive predictive coding model of conscious presence. Frontiers in Psychology, 3, 395.

Sierra, M. (2009). Depersonalization: A new look at a neglected syndrome. Cambridge University Press.

Sierra, M., Senior, C., Dalton, J., McDonough, M., Bond, A., Phillips, M. L., ... & David, A. S. (2002). Autonomic response in depersonalization disorder. Archives of General Psychiatry, 59(9), 833-838.

Steriade, M., Nunez, A., & Amzica, F. (1993). A novel slow (< 1 Hz) oscillation of neocortical neurons in vivo: depolarizing and hyperpolarizing components. Journal of Neuroscience, 13(8), 3252-3265.

Stickgold, R., & Walker, M. P. (2013). Sleep-dependent memory triage: evolving generalization through selective processing. Nature Neuroscience, 16(2), 139-145.

Stickgold, R., & Walker, M. P. (2013). Sleep-dependent memory triage: evolving generalization through selective processing. Nature Neuroscience, 16(2), 139–145.

Tagliazucchi, E., & Laufs, H. (2014). Decoding wakefulness levels from typical fMRI resting-state data reveals reliable drifts between wakefulness and sleep. Neuron, 82(3), 695-708.

Tagliazucchi, E., Carhart-Harris, R., Leech, R., Nutt, D., & Chialvo, D. R. (2014). Enhanced repertoire of brain dynamical states during the psychedelic experience. Human Brain Mapping, 35(11), 5442-5456.

Tagliazucchi, E., von Wegner, F., Morzelewski, A., Brodbeck, V., & Laufs, H. (2014). Dynamic BOLD functional connectivity in humans and its electrophysiological correlates. Frontiers in Human Neuroscience, 8, 339.

Tonomi, G., Boly, M., Massimini, M., & Koch, C. (2016). Integrated information theory: from consciousness to its physical substrate. Nature Reviews Neuroscience, 17(7), 450–461.

Tononi, G., & Cirelli, C. (2003). Sleep and synaptic homeostasis: a hypothesis. Brain Research Bulletin, 62(2), 143-150.

Tononi, G., & Cirelli, C. (2014). Sleep and the price of plasticity: from synaptic and cellular homeostasis to memory consolidation and integration. Neuron, 81(1), 12-34.

Tononi, G., & Cirelli, C. (2014). Sleep and the price of plasticity: from synaptic and cellular homeostasis to memory consolidation and integration. Neuron, 81(1), 12–34.

Tononi, G., & Massimini, M. (2008). Why does consciousness fade in early sleep? Annals of the New York Academy of Sciences, 1129(1), 330-334.

Tononi, G., Boly, M., Massimini, M., & Koch, C. (2016). Integrated information theory: from consciousness to its physical substrate. Nature Reviews Neuroscience, 17(7), 450-461. University Press.

Tkemaladze, J. (2023). Reduction, proliferation, and differentiation defects of stem cells over time: a consequence of selective accumulation of old centrioles in the stem cells?. Molecular Biology Reports, 50(3), 2751-2761. DOI : https://pubmed.ncbi.nlm.nih.gov/36583780/

Tkemaladze, J. (2024). Editorial: Molecular mechanism of ageing and therapeutic advances through targeting glycative and oxidative stress. Front Pharmacol. 2024 Mar 6;14:1324446. DOI : 10.3389/fphar.2023.1324446. PMID: 38510429; PMCID: PMC10953819.

Tkemaladze, J. (2026). Old Centrioles Make Old Bodies. Annals of Rejuvenation Science, 1(1). DOI : https://doi.org/10.65649/yx9sn772

Tkemaladze, J. (2026). Visions of the Future. Longevity Horizon, 2(1). DOI : https://doi.org/10.65649/8be27s21

Wagner, U., Gais, S., Haider, H., Verleger, R., & Born, J. (2004). Sleep inspires insight. Nature, 427(6972), 352-355.

Wagner, U., Gais, S., Haider, H., Verleger, R., & Born, J. (2004). Sleep inspires insight. Nature, 427(6972), 352–355.

Walborn, S. P., Terra Cunha, M. O., Pádua, S., & Monken, C. H. (2002). Double-slit quantum eraser. Physical Review A, 65(3), 033818.

Walborn, S. P., Terra Cunha, M. O., Pádua, S., & Monken, C. H. (2002). Double-slit quantum eraser. Physical Review A, 65(3), 033818.

Walker, M. P., & Stickgold, R. (2010). Overnight alchemy: sleep-dependent memory evolution. Nature Reviews Neuroscience, 11(4), 218-218.

Walker, M. P., & van der Helm, E. (2009). Overnight therapy? The role of sleep in emotional brain processing. Psychological Bulletin, 135(5), 731.

Wamsley, E. J., & Stickgold, R. (2011). Memory, sleep and dreaming: Experiencing consolidation. Sleep Medicine Clinics, 6(1), 97-108.

Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. Quarterly Journal of Experimental Psychology, 12(3), 129-140.

Waters, F., Allen, P., Aleman, A., Fernyhough, C., Woodward, T. S., Badcock, J. C., ... & Larøi, F. (2012). Auditory hallucinations in schizophrenia and nonschizophrenia populations: a review and integrated model of cognitive mechanisms. Schizophrenia Bulletin, 38(4), 683-693.

Watson, D. (2001). Dissociations of the night: Individual differences in sleep-related experiences and their relation to dissociation and schizotypy. Journal of Abnormal Psychology, 110(4), 526.

Windt, J. M., & Metzinger, T. (2007). The philosophy of dreaming and self-consciousness: What happens to the experiential subject during the dream state? In D. Barrett & P. McNamara (Eds.), The new science of dreaming (Vol. 3, pp. 193-247). Praeger Publishers/Greenwood Publishing Group.

Windt, J. M., Nielsen, T., & Thompson, E. (2016). Does consciousness disappear in dreamless sleep?. Trends in Cognitive Sciences, 20(12), 871–882.

Woodward, T. S., Moritz, S., Cuttler, C., & Whitman, J. C. (2006). The contribution of a cognitive bias against disconfirmatory evidence (BADE) to delusions in schizophrenia. Journal of Clinical and Experimental Neuropsychology, 28(4), 605-617.

Zurek, W. H. (2003). Decoherence, einselection, and the quantum origins of the classical. Reviews of Modern Physics, 75(3), 715.