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# Retinal Nano-Space and Cortical Resonance: A Default Space Framework for Visual Perception and Consciousness

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## Abstract

Feed-forward, classical theories of vision do not address how a continuous panoramic, high-def field of vision is created by 1.2 million optic fibers sent to the brain versus information received from approximately 126 million retinal photoreceptors. In addition, when nearly 80% of all inputs to the LGN are corticogeniculate feedback and blindsight, ultra-rapid object recognition and massive oscillatory synchrony are discovered, vision's top-down approach is not a universal, bottom-up process. Thus, we offer the Retinal Nano-Space Default Space Theory (DST) whereby bioelectric resonant feedback and transmission create vision; the quantum-sensitive oscillators that are the retinal photoreceptor discs are coupled by thalamo-cortical feedback resonance leading to gamma rhythms in the cortex projecting dynamic spatial and chromatic templates onto retinal nano-architecture, creating an internal default space - holographic 3D oscillatory projective reality - of what actually exists in the external world. This all-encompassing theory not only universally accounts for findings in anatomical and quantum nanoscale investigations, but it also makes the linear relationship between perception adjustable to newly defined metrics of developmental plasticity (or perversion) and intentional/goal-directed connectivity (or disconnection) as well as disorders of consciousness. Furthermore, it makes testable predictions that retinal nano-resonance stabilizes perception in an otherwise dynamically spatial world outside of cognitive engagement apart from what other elements in the visual field may be perceived, creating a quantum field of conscious perception.

## Keywords

Lateral geniculate nucleus; Microexposure; Quantum nanoscale investigations

## Introduction

Visual perception is not a passive playback of retinal pixels, but an active, recursive reconstruction that comes about through feedback - resonant loopy connections - between retina, thalamus, and cortex. Visual transduction arises from the rod and cone outer segments where photons induce G-protein cascades that turn optical energy into graded electrical signals. Yet only part of that information can be relayed via optic nerve. About 126 million photoreceptors converge onto about 1.2 million retinal ganglion cells, with a compression ratio near 100:1. Given that such a bottleneck exists, it would seem that the perceptive encoding must rely on something in addition to rate or population coding. Historically, the lateral geniculate nucleus (LGN) is considered a mere relay station between the retina and the visual cortex. Yet anatomical and physiological evidence indicates that approximately 10 % of LGN synapses derive from retinal afferents and up to 80 % derive from corticogeniculate feedback projections. Such an inversion suggests that perception is the result of top-down, dynamic exchanges that transform thalamic and retinal processing as a function of continuous predications shaped by the cortex. Within Default Space Theory, such oscillating feedback loops create an internal spatial field - a resonant "mirror" of the outside world - from coherent thalamo-cortical oscillations instead of static, feed-forward relay.

## The Paradoxes of Vision Evidence for a Retinal Nano Default Space

Despite advances over the decades, many paradoxes in visual neuroscience abound and go unanswered relative to feed-forward hierarchical models. However, when applied to the DST as the proper mechanism of perception, these paradoxes find resolve through the interplay of retinal, thalamic and cortical oscillatory dynamics. For example, the extreme mismatch between photoreceptors (~126 million), retinal ganglion cells (~1.2 million), and their resultant 100:1 compression ratio stands at paradoxical odds with center-surround encoding as a holistic means of experiencing vision subjectively as seamless and high definition (Curcio & Allen, 1990). It makes no feed-forward sense. The DST makes sense of this anomaly through the contouring structures of gamma oscillations projected back onto retinal nano-structures from the cortical macro-structures. Perception resonantly “re-expands” from its compressed state into a coherent field based upon memory reconstructions.

This relationship is complemented by the relative “modulatory” function assumed by corticothalamic feedback as it denotes about ~80 % of all synapses onto lateral geniculate neurons as opposed to information coming from the retina to the LGN. DST finds retroactive projections as part of the holographic predictive reconstruction from cortex to LGN to retina that keeps the inside world coherent with its outside spatial model.

Blindsight complicates matters for conventional accounts for visual perception as lesions in primary visual cortex (V1) result in little perceived ability when capacity retains subcortical pathways to extrastriate regions. To DST, if perception relies on resonant loops between these regions, disallowing V1 from active use does not forfeit perception; it merely complicates access to perception via a different route. Ultra-rapid visual categorization presents another paradox relative to feed-forward constraints suggesting awareness of patterns occurs in less than 150ms. Yet thalamo-cortico-retinal resonance cycles occur at even smaller intervals - near thirteen milliseconds in gamma-band oscillations - which create pre-activated spatial templates and categories rendered match almost instantaneously.

Developmental retinal waves connect with this experience which have long-been noted as stochastic artifacts creating predicable maps in early life. However, they seem to be part of the scaffolding of an ultimately coherent default spatial field for life. Finally, panoramic unification throughout visual experience becomes unexplainable with saccadic interruptions that inherently sever cohesive composition for perception is based upon foveal acuities. Yet if panoramic experiences fuse through phase lock resonance across binocular and extra-foveal boundaries forming a giant coherent oscillating space, it makes sense.

Despite decades of progress, several paradoxical findings remain unresolved by feed-forward models. When reframed through DST, each finds a coherent explanation.

| Empirical Paradox | Traditional Interpretation | Unresolved Problem | Default Space Explanation |
|---|---|---|---|
| Photoreceptor–RGC ratio (~100:1) | Compression via center–surround coding | Cannot explain subjective HD perception | Cortical gamma feedback projects spatial template onto retinal nano-space, allowing resonance-based re-expansion |
| Dominant corticothalamic feedback (80%) | Modulatory or attentional gain | Why such overwhelming feedback? | Cortex injects predictive hologram into LGN and retina to maintain coherent internal space |
| Blindsight | Residual subcortical circuits | Conscious vs. unconscious vision unexplained | Resonant loops between retina, LGN, and extrastriate cortex sustain perception without V1 |
| Ultra-rapid categorization (<150 ms) | Feed-forward sweep | Latency shorter than cortical relay time | Cortical-retinal resonance pre-activates circuits within ~13 ms cycle |
| Developmental retinal waves | Developmental noise | Lack of adult function | Early waves form the initial default spatial scaffold maintained through life |
| Panoramic, unified vision | Eye movements integrate local scenes | Computationally prohibitive | Phase-locked resonance integrates binocular and wide-field inputs into continuous space |

## Nano-Architecture of the Retina The Template of Default Space

Each photoreceptor cell in the vertebrate retina contains approximately 1,000 membranous discs, each about 15–30 nm thick and stacked into outer segments up to 25 µm long. These discs provide an enormous internal surface area for phototransduction and act as nanoscale electromagnetic cavities capable of sustaining standing-wave oscillations. The periodicity and refractive index gradients within the disc stack may encode depth and focus information by establishing phase relationships with incident photons: proximal discs preferentially resonate with near-field wavelengths, whereas distal layers align with far-field components. The resulting intra-photoreceptor phase gradients could thus contribute to fine-grained spatial encoding at a sub-diffraction scale.

Within the Default Space Theory (DST) framework, cortical gamma-band feedback dynamically modulates these retinal resonances, transforming the photoreceptor lattice from a passive sensor array into an active projection surface. Through continuous thalamo-cortical coupling, spatial and chromatic templates originating in higher visual areas are imposed upon the retinal nano-architecture, maintaining alignment between internal representations and external stimuli. In this view, perception emerges not solely from feed-forward encoding of light intensity but from reciprocal resonance across hierarchical scales—from quantum-sensitive disc oscillations to cortical field dynamics. The retina therefore operates as a living holographic

interface where the cortex “writes” predictive patterns onto a nano-structured substrate, continuously reconstructing the visual world in real time.

## The 13-millisecond resonant cycle

Visual awareness emerges within a remarkably short temporal window—typically 70–100 ms following stimulus onset—yet converging evidence indicates phase coherence between the retina and visual cortex at intervals of approximately 13ms. This periodicity corresponds to a resonant loop linking the retina, lateral geniculate nucleus (LGN), and primary visual cortex (V1), followed by corticogeniculate feedback to the retina, completing a full oscillatory cycle. Within the framework of Default Space Theory (DST), each cycle serves as a temporal quantum of perceptual reconstruction, refreshing the brain’s internal holographic field with each oscillatory pass.

A 13 ms cycle (≈77 Hz) aligns with the high-gamma frequency band, widely associated with feature binding, perceptual awareness, and conscious access. Rather than sequential information transfer, perception may thus arise from continuous phase-locked resonance, in which thalamo-cortical and retinal circuits oscillate in synchrony to sustain real-time coherence between external motion and internal representation. This resonance model offers a mechanistic basis for the unity of conscious experience, implying that the “frame rate” of awareness is determined not by neuronal conduction speed but by the temporal precision of recursive feedback loops across the visual hierarchy.

## Quantum retinal bioelectric field

The rod photoreceptors of the retina have been shown to function at the quantum limit of detection, with quantum efficiencies on the order of 30 % for detection of single photons. Such detection means that each photoisomerization gives rise to a single hyperpolarizing current induced per activation - despite the presumed low quantum mechanical dark current noise of < 0.03 spontaneous activations $s^{-1}$ per rod. Thus, the unquantized active transduction of visual information renders a sustained oscillating potential in darkness, which fosters a self-maintained bioelectric field across the entirety of the retina. \n Relative to Default Space Theory (DST), such a retinal field represents an inherently quantum sensitive base from which communication-through-coherence coupling can occur across thalamo-cortical gamma oscillations. Such coupling occurs between spatially disparate neuronal assemblies without requiring substantially additional axonal bandwidth and links microscopic behaviors to macroscopic electrobiological fields. Thus, the retina acts as a constantly resonant bioelectric field antenna - receiving thalamic feedback from the cortex and acknowledging phase-aligned interaction as it transmits stable perceptual information - fostering equanimity of the brain's global oscillatory default space. \n Thus, this coupling occurs across the quantum level up to the integrative neurological perception, suggesting that consciousness - and visual coherence - emerges not merely from synaptic assessment but field resonance through a phasic field that transcends retinal, thalamic and cortical spaces.

## Developmental and comparative support

During mammalian development, spontaneous retinal waves - which are propagating correlated bursts of activity - occur across the retina prior to visual exposure. These patterned discharges also entrain the lateral geniculate nucleus (LGN) and visual cortex, establishing retinotopic connections and early shaping thalamo-cortical connections. When these oscillations are experimentally turned off, receptive fields and binocular alignment suffer; when returned, spatial coherence returns. \n Therefore, from a Default Space Theory

perspective, retinal waves serve as a developmental version of the self-sustaining "default spatial generator" - the resonant scaffold through which integration is able to occur throughout life. These are not random oscillations that occur for coherence during development; rather, these are preemptive waves that preorganize the architecture that will be worked upon by cortical feedback - and provide the first resonant alignment between thalamo-cortical and retinal oscillatory fields. \n This is further supported by studies in other species. In non-mammals, for example, intrinsic retinal oscillations align visuomotor engagement despite lack of cortical mapping, while cephalopods - even lacking a true visual cortex - do all edge detection and motion analysis in their retinas first- demonstrating how the spatial resonance occurs within the circuitry there as its own integrated unit. Within DST, this suggests how throughout evolution the retina was recognized as a processor in its own right which was later expanded upon by thalamo-cortical opportunities for conscious perception.

### Clinical and experimental predictions

The retinal nano-space model yields several measurable predictions testable with modern methods.

| Domain | Prediction | Methodological Test |
|---|---|---|
| Retina–Cortex Coupling | 40 Hz phase coherence between ERG and occipital EEG in healthy vision; reduced in amblyopia and schizophrenia | Simultaneous ERG–EEG/MEG recordings |
| Feedback Disruption | Optogenetic inhibition of corticogeniculate fibers reduces coherence and perceptual clarity | Animal models with reversible inactivation |
| Nano-Space Damage | Degeneration of photoreceptor discs yields disproportionate loss of gamma synchrony vs. structural damage | Human retinal imaging + EEG |
| Resonant Therapy | Dual retinal flicker + tACS entrainment restores coherence and vision | Non-invasive stimulation trials |
| Consciousness Correlate | Momentary visual disappearance during induced desynchrony | Perceptual masking experiments |

## Artificial Intelligence and Bio-Mimetic Vision

Conventional deep neural networks (DNNs) treat images as static mesh arrays with layer- by-layer transformations that fail to capture the time-based aspects of biological vision. The opposite occurs within biology, where perception emerges from a recursive, oscillatory exchange between the retina, thalamus and cortex. Artificial systems that attempt similar dynamics - oscillatory neural networks (ONNs) and phase-synchrony based architectures - dramatically outperform conventional DNNs and other system designs in robustness, efficiency and contextual awareness.

According to the Default Space Theory (DST), artificial vision could operate via resonant phase fields instead of pixel-based information derived from the retina-cortex feedback loop. Such a system would rely on holographic prediction and phase coupling instead of frame-rate sampling to anticipate shifts in the environment, operating in real-time at decreased energy levels. The lower power requirements come from digital nano-resonance mimicking retinal vibrations and thalamo-cortical coherence; ONN based architectures facilitate context-awareness through motion-colour-depth amalgamation within a single oscillatory field instead of separate sensory realms.

The same applies to neuro-prosthetics. Brain-machine interfaces that incorporate resonant retinal patterns

might complement human cortical gamma rhythms in prosthetic transmission by creating a perceptual experience that feels integrated within existing mental frameworks. Ultimately, the link between DST-influenced neuroscience and oscillatory AI suggests that bio-mimetic vision will operate through synchrony instead of sequential computation.

### Perceptual and conscious foundations

The tenets of Default Space Theory extend from the biophysics of nano-architecture within the retina to the phenomenology of perceptual awareness. Here, coherent oscillatory fields that form distributed across sensory, thalamic, and visceral systems are the source of perception and consciousness. Within the visual hierarchy, the retinal nano-space serves as a spatial point, an origin of sorts, where quantum photo-transduction operates in concert with cortical predictive feedback to create a unified oscillatory field.

Gamma-band synchrony (30-100 Hz) serves as the ultimate mechanism for binding colour, motion and form - visible aspects - into coherent perceptual experiences. This synchrony is organized dynamically by theta-gamma coupling (~4-8 Hz × 40-80 Hz), which binds perceptual experiences into perceptual moments. Furthermore, beta oscillations (15-30 Hz) - particularly in magnocellular pathways - appear most associated with preconscious visual processing and feedforward predictive capacities.

Oscillatory coherence itself fluctuates during binocular rivalry and perceptual transitions with a theta frequency rhythm tightly linked to subjective awareness transitions. Together, this evidence suggests that what we perceive in our “inner scene” does not stem from static maps across the cortex but from recursive resonance among the retinal-thalamic-cortical oscillators - a hierarchical synchronization from distributed fields transformed into the unified experience of conscious awareness. DST provides a biophysical link between matter and phenomenology for this reason, grounding awareness in the interconnected rhythms of the default space.

## Conclusion

Retinal Nano-Space Default Space Theory (DST) integrates quantum phototransduction, thalamo-cortical oscillations and predictive feedback into the biophysical design of percept. By making vision a resonant reconstitution instead of a sequential communication, DST renders mechanical responsibility for a countless number of long-existing paradoxical correlates of visual neuroscience - the optic nerve compression bottleneck and optic nerve neutrality, blindsight due to corticogeniculate signaling and superhuman categorical velocity of object recognition yet universal microexposure. Therefore, DST operates as a follow-up to relative theories from bottom-up creation to causative default mediation. The assumption is that conscious percept is produced as an outcome of recursive oscillatory resonance extending from retinal, thalamic and cortical ensembles and therefore the retina never serves as a passive sensory appreciative part, instead, contributing integrative with brain waves to make spatial coherence constructor binding all together. Observable determinations are (1) 40 hz coherence transcendentally meets up for retinal and cortical potentials observed across all relevant neurons, (2) experience-dependent plasticity is relative to the magnitude and strength of dynamics of retinal waves prior to sound counterparts (3) it can use external stimulation at certain frequencies to use in correlation to excitation signals to make up for any deficit from lack of spacing together at all. Ideationally, the retina becomes the default space of the brain itself - the spatial surface met up by nano-architectural events transpiring at quantum levels of functioning within

photoreceptors and a predictive scribe to create a spatialized intentional field of vision. This can be further validated through explorations into electrophysiology of multiple sites, optogenetics, high-def retinal imaging and neuroimaging with consciousness-relative angles. Thus, the gap between physiology and phenomenology is bridged as DST operates as more than a how-the-brain-does-it vision perceivable construct but a why-it-comes-out-as-seeing reality. The transformation of transcoding elements may change like how the physical constitution of DNA became the metafor for genetic coding - as making sense of what's going on beyond the percept is what makes reality founded by brain creating it sensible.

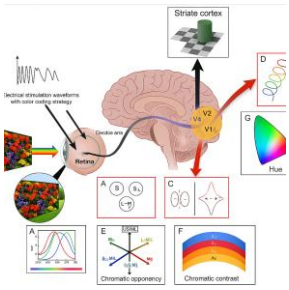


**Figure 1:**

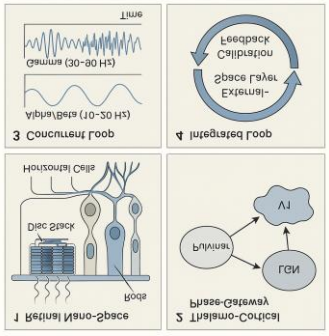

**Figure 2:**

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