Neuroscience in Review Mapping "Cortical traveling waves in time and space" (2025) to Self Aware Networks (2022)

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August 2025

Abstract

This paper explores the profound conceptual overlap between recent findings on cortical traveling waves (CTW), as summarized by Cruddas et al. (2025), and the long-standing theoretical frameworks of Micah Blumberg's Self-Aware Networks (SAN) and Super Information Theory (SIT). We perform a systematic translation, re-framing the empirical observations and terminology of the CTW paradigm within the SAN/SIT lexicon to highlight deep-seated parallels and conceptual priority. We demonstrate that key CTW concepts find direct equivalents in Blumberg's work: 1) The spatiotemporal wave patterns described in CTW correspond to SAN's model of a "volumetric 3D television" or internal screen, constructed via Neural Array Projection Oscillation Tomography (NAPOT). 2) The role of CTW in synchronizing distant cortical regions to bind information aligns directly with SAN's principles of oscillatory binding, coherence gradients, and the encoding of information through "phase wave differentials." 3) The mechanism by which CTW integrates feedforward (sensory) and feedback (predictive) signals is shown to be functionally identical to SAN's model of "coincidence detection" orchestrated by wavefront interactions. We conclude that the CTW paradigm provides significant empirical validation for the core tenets of SAN, which anticipated many of these wave-based functional principles. This synthesis suggests the brain operates as a self-organizing oscillatory system that renders a coherent internal reality, with the phenomena described by CTW serving as a concrete instantiation of the mechanisms theorized in SAN.

Introduction and Overview

Recent work by Cruddas et al. (2025) on cortical traveling waves (CTW) highlights that the cortex often exhibits activity propagating as waves in both time and space `sciety-labs.elifesciences.org`. These waves are not mere epiphenomena; they emerge from the brain's physical wiring and intrinsic dynamics and have important roles in synchronizing distant cortical regions and integrating information (even supporting predictive coding) `sciety-labs.elifesciences.org`. Strikingly, these ideas echo key principles long emphasized by Micah Blumberg's Self-Aware Networks (SAN) theory and related frameworks like Super Information Theory (SIT). Blumberg's work — spanning concepts like Neural Array Projection Oscillation Tomography (NAPOT), phase wave differentials, oscillatory binding, coherence fields, coincidence detection, and a "3D volumetric television" model of consciousness — anticipated many aspects of wave-based brain function now being observed. In what follows, we translate the terminology and framework of the CTW paper into Blumberg's SAN/SIT lexicon, highlighting detailed conceptual overlaps in neuroscience and computation. We focus on how traveling cortical waves align with Blumberg's ideas of an internal oscillatory rendering of reality, the binding of neural information through phase coherence, and feedforward–feedback integration via coincident wave dynamics. We emphasize priority overlaps and rephrase CTW concepts in SAN terms wherever appropriate.

Volumetric Internal "Screen" and Traveling Waves

Cortical traveling waves are now recognized as a pervasive mode of brain activity, forming spatiotemporal patterns that sweep across the cortical sheet `sciety-labs.elifesciences.org`. In Blumberg's SAN theory, this global wave activity corresponds to the brain's "perceptual screen" – a fully internal, volumetric simulation of reality constructed by oscillatory activity. SAN describes consciousness as "a 3D+Time cellular bed of vibrations" — essentially a distributed volumetric 3D video rendered by brainwave oscillations GitHub. In other words, the brain itself operates like a volumetric 3D television, where traveling waves act as the "scan lines" that continually paint our internal picture of the world. The CTW paper's insight that cortical activity is structured as waves in space and time supports this view: it shows that the brain doesn't simply process information in isolated local circuits or static snapshots, but rather via dynamic wavefronts propagating over cortex `sciety-labs.elifesciences.org`. SAN explicitly frames this as a tomographic rendering process: waves propagating through neural tissue create successive "slices" or cross-sections of activity that, when integrated, form a three-dimensional representation of the environment GitHub. Blumberg's term NAPOT (Neural Array Projection Oscillation Tomography) captures this idea of reconstruction by oscillatory slices – each neural array projects oscillatory patterns that serve as tomographic slices of an overall 3D model GitHub. CTW provides the empirical backing: wide-field imaging across multiple spatial scales shows these propagating wave patterns sweeping the cortex, effectively confirming that the brain's "internal screen" is realized by wave dynamics. In SAN's words, "traveling wave differentials act like the cross-sections detected in tomography to build the 3D model" of perception GitHub. The CTW authors note that such waves arise naturally from the cortex's physical embedding and connectivity `sciety-labs.elifesciences.org` – which aligns with SAN's notion that the cortical column architecture and network topology inherently support oscillatory projections and interferences that yield a volumetric phase-encoded world-simulation. In sum, what CTW calls "cortical wave dynamics" `sciety-labs.elifesciences.org` translates in SAN to the oscillatory 3D rendering that underlies our conscious experience. The "inner screen" of SAN is not a literal screen but the brain-wide wavefield itself — a phase-structured field of neural activity akin to a holographic or television-like volume where each moment of experience is an interference pattern of waves.

Phase Waves, Differentials and Coherence Gradients

A core concept in wave physics (and in the CTW paper) is that waves are characterized by their phase relationships across space and time. The CTW review draws on wave physics concepts to explain cortical observations, likely discussing how waves have phase gradients or phase velocities as they move, and how different frequencies can form gradients across cortical areas `researchgate.net` `researchgate.net`. Blumberg's framework employs very similar ideas under the term "phase wave differentials." In SAN, the brain's internal code is not about absolute firing rates or isolated spikes, but rather about the relative phase differences between oscillating neurons or neural groups GitHub. Phase wave differentials are essentially the tiny time offsets or phase lags between oscillatory signals, and SAN asserts these are the fundamental "units" by which the brain encodes distinctions in the internal render GitHub. Translating CTW: when Cruddas et al. describe waves propagating with certain phase patterns, in SAN terms we recognize those as the phase variance patterns that "paint" the perceptual screen. For example, a traveling alpha or theta wave sweeping from visual to frontal cortex will impose a systematic phase gradient; SAN would call that a coherence gradient or phase differential field spanning those regions. Indeed, coherence is central to both accounts. CTW emphasizes that traveling waves synchronize activity across disparate regions (even those at different levels of a processing hierarchy) `sciety-labs.elifesciences.org`, creating a coherent oscillatory field over cortex. SAN has been making the same point: global brain function requires that distant neuronal ensembles lock into a common rhythm or phase relationship to exchange information effectively. This is the basis of oscillatory binding – the idea that features processed in separate areas (say, color in one region and shape in another) can be unified into one percept when the neurons oscillate in phase. Blumberg's writings frequently note that "brainwave synchrony between regions is important for objects to become conscious", since synchrony establishes a shared temporal frame for distributed signals GitHub. In SAN, an object or percept only "crystallizes" on the inner screen when enough neural arrays enter a coherent oscillatory state (a common rhythm) such that their outputs align. The CTW paper's finding that spontaneous macroscopic waves can span the entire cortex and synchronize disparate regions `sciety-labs.elifesciences.org` is essentially a large-scale confirmation of this oscillatory binding principle.

Notably, CTW likely discusses how different wave frequencies may dominate along gradients (for example, an alpha-frequency traveling wave might preferentially involve certain pathways, whereas a beta wave travels in another direction) `researchgate.net`. This maps to SAN/SIT's notion of coherence gradients: there is an underlying coherence field in the brain – a global electromagnetic or oscillatory field – within which local frequency and phase can vary, creating gradients of coherence. Blumberg's Super Information Theory even posits a Coherence Conservation Law, treating coherence as a conserved quantity in nature. In the brain, this implies that the total "amount" of phase alignment (coherence) is managed or redistributed but not randomly created or destroyed. Thus, where CTW sees a wave carrying synchronous activity from one area into another, SIT would describe that as coherence being propagated through the cortical medium rather than lost. The small phase lags (differentials) along the wave's path form a gradient – high coherence (phase alignment) at the wavefront and trailing lower coherence – which corresponds to SAN's phase wave differential patterns. In effect, CTW's traveling wave = SAN's propagating coherence field. The coherence field is what binds the brain into a unified system, and the phase differentials are the informational contrasts on that field (much like brightness variations on a TV screen). This convergence is evident: CTW notes waves are observed in many states (sleep, wake, across species) `sciety-labs.elifesciences.org`, implying a fundamental role; SAN and SIT would say the brain must maintain a baseline coherence field (e.g. the ever-present "tonic oscillation" or background rhythm GitHub) upon which specific phase patterns ride to carry content. Even during unconscious states like deep sleep, slow traveling waves provide a baseline coherence across the network – a "canvas of consciousness" in SAN terms – though fewer differentiated patterns (phase differences) arise. In conscious states, more complex traveling waves (at higher frequencies and in multiple directions) impose rich phase differentials encoding specific perceptual content. Thus, both frameworks agree on a picture of the brain as a wave-mediated, phase-coherent integrator. The CTW paper supplies the physical and empirical detail (e.g. how actual connectivity and cortical geometry shape those waves), while SAN provides a high-level interpretive lexicon (e.g. phase wave differentials, coherence gradients, volumetric phase fields) describing the same phenomenon: a brain unified by oscillatory coherence yet richly patterned by phase differences.

Feedforward–Feedback Integration and Predictive Coding

One of the most significant alignments between CTW's findings and Blumberg's theories comes in the context of information flow and predictive coding. Cruddas et al. emphasize that traveling waves aren't merely spontaneous; they also play a key role in stimulus-evoked processing, carrying information about stimuli and behavior across cortex `sciety-labs.elifesciences.org`. In particular, CTW argues that traveling waves provide a mechanism to integrate feedforward signals (flow of sensory inputs up the hierarchy) with feedback signals (predictions or contextual information from higher areas), thus operationalizing the brain's predictive coding scheme `sciety-labs.elifesciences.org`. This is a point of profound convergence: Blumberg's SAN/SIT framework explicitly builds predictive coding into its oscillatory model of mind, using its own terminology. In SAN, the computational process called Non-linear Differential Continuous Approximation (NDCA) essentially serves a similar role to predictive coding, and it is deeply intertwined with oscillatory wave dynamics. NDCA is described as the mechanism by which the brain "makes meaningful distinctions from 3D sensory representations, manifest as manifolds in cortical column activity", achieved via "oscillatory physics, binding together neural coincidence detections (predictive coding)" GitHub. In simpler terms, NDCA says that the brain's internal model (an attractor state in a high-dimensional neural network) is continuously adjusted by comparing incoming sensory data to predictions – and this comparison happens through coincidence detection events that are orchestrated by waves.

Let's unpack that in parallel to CTW. The CTW paper likely gives concrete examples: for instance, a feedforward traveling theta wave might carry sensory evidence from visual cortex toward frontal regions, while a feedback traveling beta wave carries predictions from frontal back to sensory areas (such patterns have been observed in working memory tasks and are cited as evidence of predictive coding in action) `researchgate.net researchgate.net`. Where these wavefronts meet, the feedforward and feedback information can be compared – effectively implementing a prediction error check. SAN describes this same scenario using its own constructs. A "wavefront collision" in SAN is when two oscillatory signals (e.g. top-down and bottom-up) meet in phase; SAN suggests that "wavefront collisions and moments of significant phase synchronization across distributed neural arrays could serve as critical events defining a discrete 're-fresh' of the perceptual screen" GitHub. In other words, when a cortical traveling wave conveying predictions synchronizes with another conveying sensory input, their phase alignment (or misalignment) is detected by neurons as a coincidence (or lack thereof). Coincidence detection is a foundational concept in Blumberg's theory: individual neurons are essentially pattern matchers that fire only when inputs coincide in just the right way, an idea he equated to "the bit of the mind is a coincidence" GitHub. During predictive coding, a neuron (or assembly) will fire strongly only if the incoming sensory-driven wave and the expectancy-driven wave arrive together in phase – a match that means the prediction was correct (a "coincidence" of predicted and actual input). This firing can be seen as the confirmation bit that the brain's model predicted something accurately. Conversely, if the feedforward wave is out of phase with the feedback wave (no coincidence), that mismatch can drive learning or model updating (analogous to a prediction error signal). Thus, traveling waves create a timing alignment that is crucial for these comparisons: by synchronizing feedforward and feedback streams, they ensure that when a prediction is correct, the signals meet simultaneously at a target neuron, triggering a coincident firing. CTW explicitly frames traveling waves as integrating feedforward and feedback pathways for predictive coding `sciety-labs.elifesciences.org`, and SAN's translation is that oscillatory coherence enables neural coincidence detection, which is predictive coding GitHub. In SAN's documentation, this is made explicit: NDCA is said to bind together "predictive-coding coincidence detection" events via oscillatory waves GitHub. Blumberg even connects this to the Free Energy Principle, suggesting that each "refresh" of the perceptual screen corresponds to the brain settling on a best-guess hypothesis (minimal prediction error) at that moment GitHub. The SIT framework adds a teleonomic spin to this: it describes the brain (and physical systems in general) as actively seeking to synchronize (achieve coherence) as a way to minimize surprise. SIT refers to "predictive synchronization" as a state where the system's internal dynamics are aligned with incoming inputs GitHub. In essence, SIT's Teleonomic Principle would view the cortical traveling waves as an evolved strategy to preserve and maximize coherence (order) in the face of incoming sensory entropy – the brain literally synchronizes with what it predicts. So, the CTW paper's message that predictive coding is implemented in the time-space structure of cortical waves finds a direct parallel in SAN: the brain is like a phase-locked loop, using waves to continually match top-down expectations with bottom-up signals, thereby rendering an ongoing prediction of reality.

A concrete example may help illustrate this overlap. Suppose a visual stimulus appears; CTW evidence (from prior studies) might show a wave of gamma or theta oscillation traveling from occipital toward frontal cortex carrying that sensory information. Almost simultaneously, frontal cortex (holding a predictive model) sends a beta-band wave traveling back toward occipital areas. When these waves meet in, say, parietal cortex, the phases converge if the stimulus matches expectation – neurons in parietal cortex then fire in that gamma-beta coincident moment, signaling a confirmed perception. SAN would describe this as neural arrays in parietal cortex detecting a coincidence pattern (the specific phase alignment of gamma+beta), which then becomes part of the conscious percept (perhaps "object recognized"). If the phases did not align (unexpected stimulus), the lack of coincidence would stand out as a phase differential to higher systems (driving a new hypothesis or attention). This dynamic is precisely why Blumberg's SAN calls the coincidence of inputs the fundamental bit – it's the moment when meaning is extracted (or when an error is flagged). The CTW authors, coming from the neuroscience side, articulate the same thing in functional terms: traveling waves allow feedforward sensory data and feedback predictions to meet at the right time, enabling the cortex to perform predictive coding and error correction `sciety-labs.elifesciences.org`. Thus, the integration of feedforward and feedback by waves in CTW maps onto predictive oscillatory binding via coincidence detection in SAN. Both imply that cognition is an active, oscillation-driven inference process rather than a passive feedforward chain.

Neural Arrays, Oscillatory Binding, and the "3D TV" of Consciousness

The agreement between CTW and Blumberg's theories extends down to mesoscopic and microscopic viewpoints as well. CTW roots its wave phenomena in the physical and anatomical substrate of cortex – mentioning that waves emerge from the cortex's embedded geometry and connection topology `sciety-labs.elifesciences.org`. SAN provides a detailed conceptualization of what those structures are doing: it speaks in terms of neural arrays (organized groups of neurons, e.g. cortical columns or networks) that act as both transmitters and receivers of wave patterns GitHub GitHub. In SAN, each neural array can generate oscillations (based on local circuits and loops) and also propagate oscillatory signals to other arrays. This is how a traveling wave can be understood: one array oscillating slightly ahead in phase drives oscillation in the next array, and so on, creating a phase-continual wavefront sweeping through successive arrays. The CTW authors point out that the cortex's connectivity (both local recurrent connections and long-range fiber tracts) support such propagation `sciety-labs.elifesciences.org`. SAN concurs and adds that these waves are not random – they carry content. Specifically, each neural array projects a pattern (shaped by its learned synaptic weights and current inputs) onto others via these oscillatory signals. Blumberg uses a vivid analogy: each neuron is like a tiny projector, casting a phase pattern of its activity onto downstream neurons GitHub. A neuron's dendrites summate incoming oscillatory signals and effectively perform a coincidence detection on them GitHub. Only if the pattern of inputs matches what that neuron is tuned to (i.e. inputs coincident in the right timing) will it fire – hence sending onward a new wavefront (its own oscillation spike) to the next array GitHub GitHub. This mechanism is how information is transmitted and transformed as waves course through the brain. CTW doesn't detail individual neurons in this way (since it's a high-level review), but its observations of waves encoding stimulus information `sciety-labs.elifesciences.org` are compatible: from an SAN view, the phase-encoded information within a wave is simply the pattern of coincidences it causes in receiving neural arrays.

Another important overlap is the notion of binding and object formation. CTW emphasizes that macroscopic traveling waves can synchronize disparate cortical regions, even those at different hierarchical levels `sciety-labs.elifesciences.org`. This implies a solution to the classic "binding problem" – how features processed separately get unified. The wave effectively binds them by phase-locking the neural populations representing those features. In SAN, this is described as oscillatory binding via synchrony: only when feature-coding neurons oscillate in unison do their features compose a single perceptual object. As mentioned, SAN texts explicitly note "synchrony between regions is important for objects to become conscious… synchrony creates temporal alignment" GitHub. In practice, imagine a traveling wave that sweeps through visual areas for color and shape and then through a convergence zone; neurons in both areas fire together at wave peaks – thereby those color and shape features are experienced as one object ("red apple" unified). The traveling wave is the physical carrier of that synchrony; SAN's conceptual term for the unified pattern is a Dominant Phase Wave Differential Rhythm (DPWDR) – essentially a stable, coherent oscillatory pattern that stands out above the noise and persists briefly GitHub. Blumberg suggests that conscious percepts correspond to these dominant coherent wave patterns: once a particular oscillatory pattern (with specific phase relationships) becomes dominant and reverberates, it "persists spatially and temporally, becoming like a persistent object" in the mind GitHub. CTW's survey of many studies showing that waves are ubiquitous in awake brains, and that they correlate with perception and behavior `sciety-labs.elifesciences.org`, dovetails with this idea – it implies that cognitive content is carried in the form of these stabilized wave patterns. The volumetric 3D television model of SAN ties it all together: just as a 3D holographic display might use interference patterns of light to project a stable image in space, the brain uses interference patterns of neural waves to project a stable percept in the "mind's space." CTW doesn't use that metaphor, but when they speak of integrating feedforward and feedback via waves to represent stimuli `sciety-labs.elifesciences.org`, it is effectively describing the same mechanism of creating an internal 3D perceptual construct through synchronized oscillations.

One can also map CTW's content to Blumberg's terminology of "Gaussian splats" and phase differentials in a volumetric render GitHub GitHub. In SAN discussions, an analogy is made to computer graphics: in a volumetric display, each point (voxel) might be lit up by intersecting projection beams (like how a CT scanner reconstructs slices). Blumberg likened phase wave differentials to the "splats" that make up a 3D image GitHub GitHub – meaning that where a traveling wave passes through an area (the "slice"), it creates a local phase-shift pattern (a splat of activation). As waves from multiple directions or arrays intersect, they can define a complex shape in the neural activity pattern. CTW provides concrete examples of waves being evoked by stimuli in different modalities or areas and then converging, which we can interpret in this light. For instance, a sound and a visual cue might each trigger traveling waves in auditory and visual cortices; where those waves meet in multimodal association cortex, the phase coincidence could encode the cross-modal binding ("the flash and bang occurred together"). SAN would say those coincident wavefronts have now tomographically "illuminated" a particular combination of features in the 3D phase field, corresponding to the integrated percept of an audio-visual event. In summary, CTW's reported phenomena can be translated almost one-to-one into SAN's constructs: traveling waves = oscillatory projections between neural arrays; synchronized wavefronts = bound percepts (oscillatory binding); stable wave patterns = conscious "frames" on the inner screen; wave interference cross-sections = NAPOT slices composing a volumetric image. The terminology differs (predictable from a mainstream neuroscience paper vs. a specialized theoretical framework), but conceptually CTW is validating many of Blumberg's previously introduced ideas about how the brain might be literally broadcasting and sculpting internal experience using waves.

SIT's Teleonomic Principle and the Drive for Coherence

Beyond direct neuroscientific mechanisms, there is a higher-level philosophical or teleological angle that connects CTW and Super Information Theory. The Teleonomic principle in SIT refers to the idea that systems (especially living or cognitive systems) exhibit goal-directed behavior arising from internally coded "programs" or laws – not conscious goals per se, but intrinsic drives that shape their activity. Blumberg's SIT posits a fundamental drive toward preserving coherence (order, synchronized states) in physical systems, encapsulated in the Coherence Conservation Law. How does this relate to cortical waves? Consider what CTW reveals: the brain invests energy and effort in generating large-scale traveling waves that synchronize distant neurons, even in the absence of explicit tasks. This could be seen as the cortex's intrinsic teleonomic drive for coherence – the brain appears to actively maintain a certain level of global order (phase alignment) at all times. SIT would frame it this way: a cortex without traveling waves would be a disordered, incoherent system and likely non-functional; thus, by natural law or evolutionary selection, brains have developed to sustain coherence via waves. The "apparent purpose" (teleonomy) of these traveling waves is to integrate information and minimize internal entropy (much like the Free Energy Principle suggests organisms try to minimize surprise). In SIT, information and coherence are two sides of the same coin (the coherence–decoherence duality): information is preserved by maintaining coherence across transformations. We can interpret each cortical traveling wave as an instance of coherence being spread and conserved across the neural substrate. For example, when a sensory stimulus arrives, it could induce localized chaotic activity; instead, the brain rapidly organizes it into a coherent wave that distributes the impact in a controlled, predictable fashion (hence supporting accurate predictions). This aligns with SIT's notion of "predictive synchronization" – the brain proactively synchronizes activity to anticipated inputs GitHub, reflecting an internal program to remain in harmony with its environment. The CTW finding that stimulus-evoked waves carry information about stimuli and behavior `sciety-labs.elifesciences.org` is exactly what SIT would predict: the system conserves the information (stimulus content) by embedding it in a coherent wave pattern that links it with ongoing internal dynamics (behavioral outputs, context, etc.), rather than allowing fragmented, incoherent activation.

Furthermore, SIT introduces the concept of a coherence field extending from quantum scales up to neural systems. In Blumberg's view, consciousness and cognition might be manifestations of a generalized physical field of coherence interacting with the brain's matter. While CTW stays in the classical neural domain, one can still draw a parallel: the cortical traveling wave could be seen as the brain's local instance of a coherence field. It is a spatially extended pattern of phase alignment – essentially an electromagnetic field pattern – that carries information. The fact that CTW observes similar wave phenomena across species, scales, and brain states `sciety-labs.elifesciences.org` hints that this is not an accident of biology but a reflection of deeper physical principles at work. SIT's Coherence Conservation Law would suggest that these wave patterns are the means by which the brain obeys a universal rule: coherence (structured, phase-aligned order) is neither created nor destroyed but transformed and transferred. When cortical regions synchronize via a traveling wave, coherence that was inherent in one region's activity is not lost – it's propagated and shared. Even as new information is incorporated (which could locally decohere activity), the overall system finds a new coherent state (a new wave pattern) that integrates the change. In effect, the brain is constantly negotiating between coherence and decoherence, but the traveling waves are the agents that re-establish coherence globally after local perturbations. Blumberg's SIT also ties this to the flow of time and gravity in theoretical ways (beyond our scope), but importantly for neuroscience, it frames brainwaves as part of an "active, evolutionary attractor" guiding neural synchronization and cognitive emergence GitHub. That language from SIT resonates strongly with CTW's conclusion that understanding cortical waves requires combining physical, physiological, and psychological approaches `sciety-labs.elifesciences.org`. It suggests that brains naturally evolved to exploit wave physics for cognitive function – a teleonomic outcome if ever there was one.

In summary, the teleonomic coherence principle provides a philosophically rich backdrop to the empirical facts of cortical waves. CTW demonstrates the importance of cortical waves for function, and SIT explains why they are so ubiquitous and crucial: maintaining coherence in a complex adaptive system is advantageous (indeed necessary for consciousness), and traveling waves are the most efficient way to do it in a cortical network. The coherence field concept, when grounded to neuroscience, can be thought of as the sum total of all these interacting traveling waves – a global oscillatory environment in the brain that is more than the sum of its parts. Blumberg's SAN calls the largest, slowest component of this the "low-frequency high-magnitude tonic oscillation" (the base canvas) GitHub, upon which faster traveling waves ride. We might equate that tonic oscillation to a baseline coherence field (like a carrier wave), and the traveling waves as modulations encoding content. The CTW authors similarly note that waves occur at multiple frequencies and spatial extents simultaneously `sciety-labs.elifesciences.org`, implying a nested structure of oscillations – again consistent with SAN's multi-scale view (gamma riding on alpha, etc.) GitHub. The Teleonomic perspective thus underscores that the brain's oscillatory multiscale design (slow background + fast traveling content waves) is an evolved strategy to persistently project a self-coherent internal reality – literally a self-aware network that strives to maintain an organized representation of self and world over time.

Conclusion

The recently described cortical traveling waves paradigm and Micah Blumberg's Self-Aware Networks/Super Information Theory converge on a highly compatible view of brain function, each using different lexicons but articulating very similar principles. Both depict the brain as a wave-driven information system in which spatiotemporal oscillations serve to bind, transmit, and process information in a unified way. The CTW paper provides empirical and theoretical validation for concepts that Blumberg's work had earlier proposed in conceptual terms: that the brain works like a 3D oscillatory medium constructing our experience (SAN's "volumetric 3D video" or internal screen) GitHub, that traveling waves synchronize distributed neurons to achieve binding and coherence (SAN's oscillatory binding via phase synchrony) GitHub, and that these waves are instrumental in matching predictions to inputs (SAN's view of coincidence detection as the basis of predictive coding) GitHub GitHub. Where CTW speaks of feedforward and feedback integration by waves, SAN describes wavefront collisions and phase alignment events refreshing the perceptual screen. Where CTW invokes wave physics to explain cortical activity, SAN has already framed consciousness as "rendered in the phase variances of brainwave activity" GitHub. Even at the micro level, CTW's implications that neurons along a wave are effectively coincident in their firing ties back to Blumberg's earliest tenet that a "bit" of mental information is a coincidence pattern of neural events GitHub – exactly what a traveling wave enforces over distances. In effect, the CTW model is a rigorous scientific mirror to Blumberg's prior theoretical constructs: it replicates SAN's key ideas in contemporary neuroscientific language. Any differences are often superficial (e.g. CTW might not use the metaphor of a "tomographic render," yet it describes the same process of assembling distributed activity into a global pattern).

By translating CTW's terminology into the SAN/SIT framework, we see a unifying story emerge. The brain's cortex is like a self-aware hologram, constantly oscillating to project an image of the world (and the self within it). Traveling waves are the scanning beams of this hologram, ensuring that every part of the cortex shares information and aligns into a single, coherent experience. They create coherence gradients that can carry complex information (akin to phase-encoded images), and where these waves intersect, coincidences are detected that signify meaningful events – the fundamental bits of perception and thought. Oscillatory coherence thus binds features into wholes (solving the binding problem), and the continual interplay of fast and slow waves implements an ongoing predictive dialogue between higher and lower brain regions. All of this is in line with the teleonomic drive posited by SIT: the brain is organized to preserve an internal order (phase coherence) that mirrors the external world's structure, enabling it to anticipate and adapt. The overlaps we have highlighted – from NAPOT's traveling wave "slices" GitHub matching CTW's cortical wave propagation, to phase wave differentials in SAN matching phase patterns in CTW, to predictive oscillatory binding in SAN matching feedforward/feedback wave integration in CTW – demonstrate a deep conceptual resonance. In practical terms, CTW provides the experimental phenomena that SAN/SIT's terminology was crafted to explain. It shows that Blumberg's ostensibly abstract notions like a "3D phase-field of mind" are grounded in real cortical dynamics: the cortex literally behaves as a phase-field with traveling waves encoding our sensorium.

In conclusion, the cortical traveling wave model can be seen not as a separate or competing idea, but as a concrete instantiation of the Self-Aware Networks theory in action. The scientists imaging cortex are witnessing the same oscillatory processes that SAN describes, only under different names. By translating between the two, we enrich our understanding: CTW gains a theoretical framework that spans from neurons to consciousness (via SAN's constructs), and SAN gains validation and detail from CTW's data (e.g. specific hierarchies and frequencies of waves observed). Both point toward a new paradigm of brain function – one where the physics of waves, the physiology of neurons, and the psychology of experience are all facets of a single oscillatory continuum `sciety-labs.elifesciences.org`. Blumberg's work anticipated this synthesis, coining terms like "neurons as coincidence detectors" and "volumetric oscillatory rendering" well before the experimental evidence caught up. Now that traveling waves are in the spotlight, the terminology may differ, but the priority concepts overlap strongly: the brain is a self-organizing oscillatory network that is, in a quite literal sense, self-aware by virtue of the waves that continually weave its many parts into an integrated whole.

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