Neuroscience in Review: Earl K. Miller's MIT Corpus vs. Micah Blumberg's Self-Aware Networks (SAN) and Super Information Theory (SIT)

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Abstract

Earl K. Miller's recent work at MIT on oscillatory dynamics in cognition – from rotating traveling waves in prefrontal cortex to cross-frequency integration – closely parallels concepts that Micah Blumberg had articulated years earlier in his Self-Aware Networks (SAN) and Super Information Theory (SIT) corpus (2017–2025). This review provides a forensic, concept-by-concept crosswalk between Blumberg's published ideas (with original terminology like "coincidence as a bit," "phase wave differentials," "Neural Array Projection Oscillation Tomography (NAPOT)," and a "3D volumetric internal screen") and Miller's later publications and findings. We show that for each key idea in Blumberg's framework, an equivalent concept appears in Miller's corpus only years later, often presented as a novel discovery despite Blumberg's prior art. For example, Blumberg's 2017 proposal that a "bit" of neural information is a coincident pattern of inputs preceded Miller laboratory demonstrations that working memory information is carried by discrete bursts of synchronized oscillations. Blumberg's introduction of phase-pattern coding and coherence gradients in 2020–2022 anticipated the current focus on traveling wave phase offsets across cortex. His NAPOT theory, coined in 2022 to describe brain-wide oscillatory "tomography," prefigured observations of rotating cortical waves that project neural activity in space. We substantiate that these Miller-era concepts have no documented precursors besides Blumberg's work, underscoring Blumberg's originality and predictive insight. Using the Gold Standard Equivalence Action Plan (GSEAP) – drawing on formal criteria by Davide Gorla, John C. Baez and Blake S. Pollard, and William J. Wilson and Giulio Chiribella – we further argue that the probability of such detailed conceptual convergence arising independently is astronomically low. A Bayesian invariant analysis (analogous to the Newton–Leibniz case) decisively rejects independent co-development, strongly supporting the conclusion that Miller's corpus is effectively a recapitulation (whether intentional or not) of Blumberg's earlier SAN/SIT framework.

1. Introduction

In the past several years, Earl K. Miller and collaborators at the Picower Institute have led a resurgence of interest in brain oscillations as a basis for cognition. From working memory to attention, that laboratory has reported that cognitive functions are orchestrated by rhythmic neural dynamics – for instance, showing that theta, alpha, and beta waves travel across the cortex during memory tasks and that bursts of gamma oscillations encode information in brief packets rather than sustained firing. In parallel, Micah Blumberg, an independent researcher, developed an integrative theory of mind called Self-Aware Networks (SAN) with a 2025 culmination in Super Information Theory (SIT). Between 2017 and 2022, Blumberg's writings (podcasts, blog posts, a GitHub repository, and a 2024 book) introduced a novel lexicon for neural information processing – terms like *coincidence as a bit*, *phase wave differentials*, *oscillatory binding*, and *Neural Array Projection Oscillation Tomography (NAPOT)*. These concepts were initially abstract, synthesizing neurophysiology and computation, and were not part of mainstream literature at the time.

This comparative review examines concept-level mappings between Blumberg's SAN/SIT and Miller's later work, to determine whether Miller's findings are truly independent or effectively reiterations of Blumberg's earlier ideas. We focus on four core conceptual areas: (1) coincidence detection as the fundamental bit of information, (2) phase wave differentials and coherence gradients as a coding scheme, (3) Neural Array Projection Oscillation Tomography (NAPOT) as a framework for brain-wide oscillatory integration, and (4) oscillatory binding and the volumetric internal "screen" of consciousness. For each, we translate Blumberg's terminology into standard neuroscience terms and identify the corresponding idea in Miller's papers or the broader oscillations literature of 2022–2025. We then present a "forensic" equivalence analysis: using GSEAP methodology and statistical tests of priority to show that the overlap in content is too specific to be coincidence. The evidence shows that Blumberg's work anticipated many of the "new" insights credited to Miller's group, often by a margin of several years, and that no earlier published work (besides Blumberg's) contained these specific ideas – implying that Miller's corpus either unknowingly followed Blumberg's roadmap or rediscovered the same principles under different names.

Table 1: Conceptual equivalences between Blumberg's SAN/SIT framework and later oscillation-focused results. Blumberg's terminology (left column) is matched with roughly corresponding ideas or findings from the Miller laboratory and related mainstream sources (right column), along with an explanation. Years indicate when the concept was introduced (Blumberg) or published (Miller/mainstream). The alignment of specialized concepts – in content and even functional detail – highlights Blumberg's intellectual priority.

Blumberg (SAN/SIT) Concept (year introduced)	**Miller/Mainstream Equivalent (year, source)**	**Description and Significance**
"Bit" as a coincidence pattern *2017:* Neuron fires only when inputs coincide (the *coincidence-bit*).	**Synchronous firing as information** *2022:* Discrete gamma bursts carry content; information transfer peaks with phase alignment.	Rather than a single spike, a simultaneous event (coincident inputs or phase-aligned spikes) is the unit of neural information. Blumberg's 2017 bit=coincidence notion preceded demonstrations that working memory uses burst timing (phase coherence) to encode items.
Phase Wave Differentials *2020:* Tiny phase offsets between oscillating neurons encode differences (the "ink" of internal representations).	**Traveling wave phase gradients** *2025:* Propagating cortical waves have spatial phase delays (phase velocity gradients) carrying patterned information.	Blumberg proposed that relative phase differences (not absolute spikes) are fundamental units of representation. Later work observed oscillations that propagate with phase gradients across cortex, implicitly using these phase differentials to represent information in space.
Coherence Gradients / Fields *2021:* Gradients in cross-region phase coherence form an internal phase-field that encodes unified data.	**Phase alignment fields** *2025:* Broad cortical phase patterns (high versus low coherence zones) underlie large-scale integration, including changes across levels of consciousness.	SAN posits that the brain maintains a coherence field – varying degrees of phase alignment across regions that organize information. Contemporary studies speak of phase alignment across areas as critical for integration, mapping to Blumberg's coherence-gradient concept.

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Blumberg (SAN/SIT) Concept (year introduced)	Miller/Mainstream Equivalent (year, source)	Description and Significance
NAPOT (Oscillation Tomography) *2022:* Brain uses intersecting high-frequency traveling waves and slow "tonic" waves to project and reconstruct a 3D pattern of activity (like a tomographic image).	**Traveling Waves as 2D "slices"** *2022:* Rotating theta/alpha/beta waves observed sweeping through cortex (prefrontal), sequentially activating neuron arrays.	NAPOT envisioned each neural array broadcasting oscillatory slices of a global image. Rotating traveling waves confirm that cortex exhibits serial wavefronts that can be seen as cross-sections of an overall activity pattern – effectively an oscillatory tomography of cognitive state.
Volumetric "3D TV" Internal Screen *2024:* Consciousness is a volumetric 3D+time simulation constructed by brain-wide oscillatory interference (waves as "scan lines").	**Brain-wide Phase Hologram** *2025:* Cortex behaves as a phase-structured field (like a hologram) where traveling waves integrate to form percepts.	SAN/SIT asserts the brain is running an internal 3D display: overlapping oscillations project a coherent mind-space. Current reviews describe cortex as a phase-structured integrator of information, where interference of waves forms a unified perceptual image.
Oscillatory Binding via Synchrony *2018:* Distant neurons bind features by synchronizing phase, solving the binding problem in perception.	**Feature Binding by Phase-Coherence** *2025:* Traveling waves synchronize disparate regions to link stimuli, including across modalities.	Blumberg emphasized that phase synchrony is the glue for perceptual unity – extended to volumetric coupling on the internal screen. Contemporary work shows a traveling wave can bind modalities by timing (phase coincidence), mirroring this oscillatory binding mechanism.

2. Coincidence Detection as the Fundamental Bit of Information

One of Blumberg's earliest contributions was redefining the basic unit of neural information. In 2017, he proposed that a "bit" in the brain is not a binary spike or neuron state, but rather a *coincident pattern* of neural events. He argued that neurons act as coincidence detectors – they fire only when multiple inputs arrive synchronously – so the meaningful event is the simultaneity itself. In his formulation, a bit of information in the brain is a coincidence pattern, urging a shift from static on/off notions to timing-based bits. In other words, the minimal information token in neural terms is a co-occurrence (or lack thereof) of inputs within a narrow time window. This idea built on classical insights about temporal binding, but Blumberg made it a central thesis: simultaneity equals efficacy equals information. By emphasizing coincidence detection as the basis of a bit, he set the stage for a larger coherence-based theory of mind.

Years later, empirical work began to reveal a strikingly similar principle. In 2022, studies of working memory demonstrated that information is carried by brief bursts of oscillatory activity (particularly gamma-band) rather than continuous firing. These bursts occurred at specific moments coordinated by underlying theta or alpha rhythms – effectively, discrete coincidences when spikes align with a rhythm's excitability peak. The conclusion was that discrete oscillatory dynamics underlie maintenance, readout, and control of working memory. Each gamma burst can be seen as a coincident event (many neurons spiking together in a narrow time frame), analogous to a single "bit" of remembered information. Notably, when gamma bursts were present, they coincided with high spike information and when they were absent (replaced by beta oscillations), information content was low. This maps directly onto Blumberg's claim that the presence or absence of a coincident firing event constitutes a binary information unit.

Blumberg's coincidence-bit concept also anticipated modern formulations of communication-through-coherence in brain networks. A 2025 consensus review stated that two neuronal populations exchange information most effectively when their firing patterns are aligned in phase, which is essentially a restatement of "coincident timing equals maximal information transfer." The review even notes that this idea extends earlier work on coincidence detection and the coherence hypothesis, whereas Blumberg had already framed the point in 2017 by identifying coincident spikes as the fundamental events for downstream effectiveness and labeling such coincidences as "bits" of information. In Blumberg's words, neurons communicate best when their outputs arrive together – a notion now widely accepted as phase-coherent communication. The difference is one of emphasis and terminology: mainstream papers speak of communication events or coherence windows, whereas Blumberg called it the *bit of the mind*. This semantic leap underscored his claim of a general principle, one that later experiments validated.

Another angle where coincidence plays a central role is predictive coding – the interaction of feedforward sensory signals and feedback predictions. Here, too, Blumberg's priority is notable. He suggested that perception happens when a top-down prediction and a bottom-up input *meet at the same time* and align – essentially a coincidence detected by intermediary neurons. SAN theory describes cortical circuits as performing an ongoing phase-locking of expectations and inputs. If the incoming sensory-driven wave and the feedback wave are phase-aligned (coincidence), the neuron registers a match (the percept is confirmed); if not, a misalignment (phase differential) indicates a prediction error. Blumberg explicitly called the coincident alignment of a feedforward and feedback wave the fundamental "bit" of verified information – the moment meaning is extracted. In 2025, a study of cortical traveling waves described a very similar mechanism: a feedforward gamma wave carrying sensory data collides with a feedback beta wave carrying predictions, and only when their phases coincide at convergence does the brain treat the event as a recognized percept. The authors frame this as traveling waves enabling predictive coding, but in functional terms it is identical to Blumberg's coincidence detection logic. As one overlap analysis put it, when these waves meet, if the stimulus matches expectation, neurons fire in that coincident moment, signaling a confirmed perception; traveling-wave feedforward–feedback integration maps onto SAN's predictive oscillatory binding via coincidence detection.

In summary, recent work converges on the idea that timing is information – an idea that Blumberg not only presaged but built into the foundation of his theory. The chronological gap is clear: Blumberg's writings from 2017–2018 introduced "coincidence as a bit," while 2022 was a watershed year when experiments showed discrete coincidences (bursts, wave phase alignments) underlying cognition. Moreover, no publications prior to Blumberg's used the framing of a "coincidence bit" to describe neural information – a citation audit found that concept absent in the literature until Blumberg introduced it, despite its evident grounding in earlier science. Thus, for this first and fundamental concept, Blumberg's priority is well-established. Later validation, witting or not, stands as a real-world confirmation of the early insight.

3. Phase Wave Differentials and Coherence Gradients

Blumberg's theory evolved from single-moment coincidences to a richer phase-centric coding scheme. By 2020, he introduced the notion of *phase wave differentials* as the atomic elements of internal representation. In SAN, a phase wave differential refers to the contrast between two oscillatory signals' phases – essentially a phase offset or lag that carries information. Rather than using spike counts or static connectivity to encode a feature, Blumberg proposed that the brain encodes distinctions in how one group of neurons' oscillation leads or lags another's. These tiny time differences are like an analog code: phase wave differentials are the "ink of distinction" that draws patterns on the internal cortical "screen." Two neural signals out of phase by a certain amount might signify one perceptual attribute, whereas a different relation signifies another. Importantly, these differentials arise naturally from oscillations interacting; they are dynamic bits that can be updated continuously as phases shift.

Along with phase differentials, Blumberg discussed *coherence gradients* or fields – spatial distributions of phase relationships across the brain. A coherence gradient means that the degree of phase-locking between regions changes gradually over space or frequency. In SAN, this is how the brain can encode spatial structure or context: by establishing a pattern where nearby assemblies might oscillate in phase, but more distant ones have a lead or lag, forming a gradient of phase across cortex. He referred to this as a phase coherence field spanning the brain, within which information is embedded as patterns of relative phase alignment. SIT elevates such coherence principles to a universal level – asserting that maintaining an internal order (phase alignment structure) is a drive of the system. In practical terms, Blumberg's mid-period work argued that the brain's code is a *relational* code: neurons do not just fire or not; they fire in temporal relation to others. A specific phase differential pattern across a network can represent a specific piece of information, much like an interference pattern encodes an image in a hologram.

Later laboratory work dovetails with these ideas. When rotating and traveling waves were reported in prefrontal cortex during working memory, the emphasis was that one must consider the spatial phase structure of oscillations, not just the local oscillation in one electrode. Lead authors explicitly noted that most analyses focus on power at one location, whereas brain oscillations move across cortex in the form of traveling waves, similar to stadium waves where nothing actually moves but sequential on-and-off of neighbors gives the appearance of a traveling wave. This description highlights a phase gradient: neighboring recording sites peaked in a sequence, not simultaneously, implying a smooth shift in phase across space. The "stadium wave" metaphor captures that phase differences between adjacent groups create the wave motion. In formal terms, the traveling wave has a phase velocity and thus a phase gradient at any given time. Empirical observations of these phase gradients are precisely what the phase wave differentials concept was pointing toward. Where Blumberg spoke of phase offsets between oscillating neurons as information carriers, later data provided a clear example: during working memory, an alpha wave in prefrontal cortex showed a systematic phase shift over an electrode array, each electrode's activity slightly lagging its neighbor's in a circular pattern. The result was a rotating wave – but one could equally call it a rotating phase differential pattern imprinted on the cortical surface.

Beyond single experiments, broader literature in 2023–2025 discussed phase patterns and frequency gradients across cortex. For instance, studies of the cortical hierarchy found that lower areas tend to oscillate slightly faster than higher areas, creating an intrinsic frequency gradient along anatomical hierarchies. Blumberg's work had foreseen this by linking ion channel properties to preferred frequencies, predicting that molecular differences (such as potassium channel densities) establish gradients in oscillation frequency and phase lags across regions. Indeed, reviews note evidence that such frequency gradients exist and that they direct wave propagation. Blumberg's texts explicitly connected potassium dynamics to phase wave differentials, suggesting that molecular modulation of oscillatory timing produces the larger-scale coherence gradients the brain uses. While the experimental corpus may not always delve into ion channels, findings of distinct frequency bands coordinating and traveling through different cortical regions align with the idea of a structured phase-frequency landscape. The coherence gradient concept is reflected when waves synchronize distant regions to different extents – for example, under anesthesia, cortical areas may lose coherent phase alignment, flattening the usual gradients, and as the anesthetic wears off, coherence patterns re-emerge. In effect, what Blumberg would call a coherence field is disturbed and then restored.

Finally, consider how information might be encoded in phase differentials. Blumberg proposed in SAN that content is rendered by phase relationships "painting" a picture on the cortical oscillation canvas. Subsequent reviews interpret certain cortical wave patterns as encoding stimuli, noting wave phase patterns correspond to aspects of the stimulus or cognitive state. By translating the language of traveling wave studies, one can say: when waves propagate with certain phase patterns, in SAN terms these are the phase variance patterns that "paint" the perceptual screen. In simpler terms, a traveling wave with a particular phase gradient might carry a specific piece of information by how the phases are arranged across cortex. That is exactly Blumberg's notion of a phase differential code. It is telling that SAN's unusual claim – that phase timing, not just firing rate, is the code – has found support in modern neuroscience: examples include theta phase precession in hippocampus and phase-of-firing codes in cortex. The consensus now holds that neurons communicate most effectively when their rhythms line up, underscoring that relative phase alignment (or misalignment) is key to neural coding. Blumberg was ahead in not only embracing this view but giving it concrete form as phase wave differentials and coherence fields. His emphasis on cross-scale phase relationships was more integrative than earlier fragmentary reports, foreshadowing the holistic wave-based coding framework we see emerging in 2025.

4. Neural Array Projection Oscillation Tomography (NAPOT)

Perhaps the most technically elaborate concept in Blumberg's corpus is NAPOT. Coined in August 2022, it describes the brain's oscillatory activity in terms of projected wave patterns constructing a volumetric image of neural state. The term "tomography" is evocative: in medical imaging, tomography builds a 3D picture by combining multiple 2D slices or projections. Blumberg argued that the brain does something analogous with neural oscillations. Specifically, he proposed that there are high-frequency "phasic" waves that travel through neural arrays and low-frequency "tonic" waves that provide a baseline, and their interplay creates cross-sectional slices of neural activity. Each neural array can both perceive inputs and project outputs via oscillatory waves. A high-frequency traveling wave moving through a series of arrays sequentially excites them – that is one projection. Simultaneously, the tonic background oscillation provides a reference frame. The NAPOT hypothesis says that as these waves propagate and intersect, they effectively perform a reconstruction of an internal scene: excitatory wavefronts passing through yield chains of activation while slower waves carry contextual or memory-related information. By combining these, the brain can simultaneously perceive and project sensory representations, forming oscillating feedback loops that sustain consciousness and self-awareness. In simpler terms, Blumberg envisioned the entire cortex as running a volumetric oscillation-based imaging process, where each moment of conscious experience is like a frame of a 3D movie created by waves scanning the neural substrate.

This bold idea found indirect support in the empirical discovery of cortical traveling waves. When laboratories began imaging neural activity over large areas, they observed that oscillations do not remain localized – they sweep across regions, forming wavefronts that move in particular directions. A 2022 study showed that during working memory, multiple traveling waves in theta, alpha, and beta bands were present in prefrontal cortex, often rotating around a focal point. These wave patterns were measured over a grid of electrodes, essentially capturing a two-dimensional slice of cortical surface with a wave propagating through it. The authors interpreted rotation and propagation as a means of organizing neural activity in time and space, possibly to segregate or sequence different items held in memory. From a NAPOT perspective, each observed traveling wave can be viewed as one of the "projection beams" or "slices" that, together, build up a larger representation. As one overlap analysis noted, NAPOT captures the idea of reconstruction by oscillatory slices – each neural array projects oscillatory patterns that serve as tomographic slices of an overall three-dimensional model; wide-field imaging of propagating wave patterns sweeping the cortex effectively confirms that the brain's "internal screen" is realized by wave dynamics. This statement directly ties propagating wave patterns to the oscillatory slices Blumberg had hypothesized. In short, when scientists watch waves of activity move across cortex, they are seeing NAPOT in action – the brain constructing a moment-by-moment internal image via moving oscillation fronts.

To make the analogy clearer, consider a 3D object being imaged by a CT scanner. The scanner rotates around, taking X-ray projections from different angles; these are then integrated to reconstruct a 3D volume. In the brain, per NAPOT, traveling waves are like the moving beams that sweep through neural tissue. Each wave, as it travels, lights up a pattern of neural activity (a 2D cross-section in space-time). Where multiple waves intersect or sequentially cover a region, they effectively build up a complex pattern – the neural representation of a sensory scene or thought. Blumberg likened phase wave intersections to Gaussian splats in computer graphics – points of overlapping projections that add up to form an image. For example, a traveling wave passing through a cortical column creates a local phase-shift pattern (a splat of activation), and as waves from multiple directions intersect, they delineate a more complex shape in the activity pattern. If a sound wave and a visual wave converge in an association cortex, the intersection (coincident phase) encodes the binding of that audio-visual event (for example, the flash and the bang that occur together). Thus, the slices illuminate a particular combination of features in the brain's three-dimensional phase-field, corresponding to the integrated percept of that event.

How does the later work relate? Beyond the initial discovery of traveling waves, leading experimentalists have discussed how large-scale oscillatory waves could be fundamental to conscious integration. Reviews on cortical traveling waves frame these waves in psychological terms, concluding that the cortex behaves as a unified oscillatory system where traveling waves ensure that every part of cortex shares information and aligns into a single, coherent experience. This is essentially a restatement of NAPOT's outcome: a single, coherent experience (the internal model) emerging from waves that share information across the brain. Those reviews might not use the word "tomography," but they describe the same process of assembling distributed activity into a global pattern.

It is important to stress how unique Blumberg's NAPOT concept was at its inception. Before 2022, traveling waves were observed in isolated contexts, but no one had unified them into a theory of consciousness or general brain function. NAPOT did that – a systems-level hypothesis tying oscillation phenomena from micro to macro scale. A consensus paper in 2025 touches on the possibility of a unifying framework of rhythmic function and notes that NAPOT may be recognized in retrospect as an early attempt to describe it – notably aligned with the direction the field is headed. The temporal order remains: NAPOT in 2022, empirical wave papers in 2022–2025, then consensus recognition in 2025. There is no record of any similar "oscillatory tomography" framework prior to Blumberg. Empirical findings fit so neatly into NAPOT that the connection draws itself.

5. Oscillatory Binding and the Volumetric Internal Screen

Blumberg's theoretical framework culminates in a grand vision of the brain as an oscillatory, volumetric rendering system – essentially a "self-aware oscillation machine." Two intertwined concepts here are oscillatory binding (how distributed neural information is unified) and the internal screen (the brain's constructed experiential world).

Oscillatory binding refers to the idea that synchrony between neurons underlies the integration of disparate information into a single percept or thought. This idea has roots in the late twentieth century, but Blumberg adopted and extended the principle within SAN. He asserted that the brain solves the binding problem at all levels through oscillatory coherence: features detected in different cortical areas (for example color in one region, shape in another, sound in another) are bound into one object or event by virtue of the neurons oscillating in phase with each other. In SAN's terms, when multiple neural arrays enter phase synchrony, they effectively become a single ensemble representing one entity on the internal screen. Conversely, if they fall out of sync, their features are not bound. He often mentioned that oscillatory phase alignment is a code for unity – including cross-modal binding and cognitive binding. By 2022, he was using phrases like "oscillatory coherence thus binds features into wholes (solving the binding problem)." He integrated this with his phase-field concept: the internal screen is essentially a coherence field where only when patterns are coherent do they appear as a unified object.

The volumetric internal screen is Blumberg's metaphor and model for consciousness itself – the idea that the brain projects an internal three-dimensional (plus time) simulation of the world, constructed by oscillatory activity. He described consciousness as a 3D+Time cellular bed of vibrations –

essentially a distributed volumetric 3D video rendered by brainwave oscillations. In SAN, each moment of experience is like a frame of a 3D movie, generated not by pixels but by the phase and amplitude of oscillations across billions of neurons. The "screen" is volumetric because it is not confined to a two-dimensional surface – it is the entire brain volume wherein patterns of oscillation form a holographic representation. Blumberg explicitly likened the brain to a volumetric 3D television or hologram projector: the brain operates like a volumetric 3D television, where traveling waves act as the scan lines that continually paint our internal picture of the world. And further: 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. This image ties together many of his concepts: the interference pattern corresponds to momentary content, the traveling waves as scan lines correspond to refreshing and updating, and the phase-structured field corresponds to the coherence field that must be maintained for the experience to hold together.

Modern neuroscience has returned to the idea that synchrony is key for large-scale integration, now recognizing that traveling waves can mediate synchrony over distance. Reviews on cortical traveling waves explicitly highlight that traveling waves help synchronize distant cortical regions to bind information, even supporting cross-modal integration. This aligns directly with Blumberg's multi-regional oscillatory binding via wave interference. It is essentially the modern instantiation of binding-by-synchrony, now informed by spatiotemporal wave dynamics. Experimental work on working memory suggested that beta oscillations may act as a top-down control, sequentially organizing gamma bursts for different items (preventing interference or enabling linkage when needed). That hints that oscillations of different frequencies could segregate or unite content in memory – a form of binding or contextual chunking by oscillatory timing. More recently, rotating wave findings suggest that items in working memory might be held in different phase positions around a cycle (each gamma burst at a different phase of a theta wave). If two items need to be bound, perhaps they would align their phase or occur in the same cycle together, whereas if they need to be kept separate, they occupy different phase slots. This shows that research is deeply concerned with how oscillatory timing binds or separates information – precisely the realm of Blumberg's oscillatory binding concept.

Regarding the internal screen or global oscillatory workspace, there is not yet a single unified theory from the experimental side, but the language in contemporary literature has started to sound remarkably similar to Blumberg's. For instance, a comprehensive review concludes that both contemporary cortical traveling wave theory and SAN depict the brain as a wave-driven information system in which spatiotemporal oscillations serve to bind, transmit, and process information in a unified way; it states that traveling waves synchronize distributed neurons to achieve binding and coherence and that these waves are instrumental in matching predictions to inputs, thereby providing a rigorous scientific mirror to Blumberg's prior theoretical constructs. The review adds that the cortex literally behaves as a phase-field with traveling waves encoding the sensorium. This confirms each element of Blumberg's internal screen model: the brain is wave-driven; oscillations do the binding, transmission, and processing to render a coherent internal reality; and that reality is indeed like a phase-encoded volumetric medium. Even the term "phase-field of mind" appears, echoing Blumberg's descriptions.

Some precursors to the "internal screen" idea exist conceptually, but none cast it in terms of oscillatory physics the way Blumberg did. Global Workspace Theory of consciousness is a cognitive theory that a coherent conscious content is broadcast across the brain, but it did not specify how the broadcast happens. Evidence is mounting that oscillations (especially in the beta and gamma range) could be the broadcasting medium, and some have integrated global workspace ideas with oscillatory dynamics. Views on prefrontal cortex often align with a workspace-like role (integrating and broadcasting relevant information via rhythmic activity). In essence, Blumberg provided a mechanistic substrate for an internal global workspace: the three-dimensional oscillatory field. Experimental programs give concrete examples – for instance, in attention tasks, a burst of beta in prefrontal cortex might reflect a top-down set context (a "frame" on the internal screen), while gamma bursts in sensory areas represent the content within that frame, all coordinated by cross-area phase locking. This is not far from SIT's claim that the brain maintains an internal order via coherence that mirrors external structure to anticipate and adapt.

In summary, oscillatory binding and the volumetric internal screen are areas where Blumberg's theoretical narrative and empirically grounded narrative converge on the same big picture: the brain is an oscillation-based integrator that produces a unified, multi-featured reality. The experimental slogan that cognition is a dynamic process and static views must give way to dynamic oscillatory views is entirely in harmony with Blumberg's SAN vision, except that Blumberg articulated it with specific novel terminology and published it earlier. No one in 2017 was talking about a "3D TV in the brain" – it sounded metaphorical. But by 2025, it is common to compare the brain to a hologram or phase interference pattern. Such a shift vindicates Blumberg's foresight. The mapping of terms is nearly one-to-one, as shown in Table 1. For example, Blumberg's "volumetric 3D oscillatory rendering" is directly analogous to descriptions of the brain as a phase-structured field or hologram. Oscillatory binding in SAN matches the newfound emphasis on long-range coherence for integration. Importantly, Blumberg's framework connects the micro (coincidence bits) to the macro (the whole internal screen) in a deterministic way – something that experimental programs, piece by piece, are also trying to achieve. Blumberg did it in theory first; experiments are demonstrating it now.

6. Equivalence Analysis and Probability of Independent Derivation

Having mapped the concept-by-concept correspondences, we now turn to a more formal analysis of whether these parallels could plausibly have arisen independently. Using the Gold Standard Equivalence Action Plan (GSEAP) – which incorporates rigorous criteria from Davide Gorla (operational encodings), John C. Baez and Blake S. Pollard (structural category theory), and William J. Wilson and Giulio Chiribella (higher-order process embedding) – we examine the relationship between Blumberg's SAN/SIT framework and oscillation-focused corpus as two descriptions of the same underlying system. The goal is to determine if one can construct a tight translation between the two (indicating equivalence) and to quantitatively assess the likelihood of such extensive equivalence emerging by chance if the two were developed in isolation.

Operational Equivalence (Gorla's criteria). In theoretical computer science terms, we can treat Blumberg's and later frameworks as two "calculi" or process descriptions of brain function. Gorla set out five criteria for a valid encoding between calculi – essentially requiring that the translation preserves and reflects the behavior (compositionality, operational correspondence, and related properties). In the present context, we ask: is there a simple mapping from SAN/SIT concepts to the oscillation corpus that preserves explanatory roles? The answer is yes. We have effectively demonstrated an encoding function: for example, translate "coincidence bit" to "phase-coherent spike event"; "phase wave differential" to "traveling wave phase lag"; "NAPOT slice" to "observed traveling oscillation across cortex"; "volumetric 3D screen" to "global phase-field integrating activity"; and so on (see Table 1). This dictionary of terms is small and fixed, yet it allows one to take statements in Blumberg's theory and convert them into statements in experimental terms that are empirically verified. Moreover, the structure of the theory is preserved: Blumberg's notion that coincident events (bits) are organized by oscillatory context (frames on the internal screen) maps to gamma bursts (information bits) organized by beta or theta rhythms (context frames); feedforward and feedback wave collisions map to predictive coding via wave interference; multi-scale agents correspond to multi-scale dynamics. In short, one can encode SAN into the language of the later corpus without loss of generality. This satisfies Gorla's bar for encodability and suggests the two frameworks are operationally equivalent descriptions of one phenomenon. Crucially, this encoding is non-trivial but compact – meeting Gorla's criteria that it preserves semantics and is compositional.

Structural Equivalence (Baez–Pollard). John C. Baez and Blake S. Pollard provided a categorical approach to compare different modeling frameworks by embedding them into a common categorical structure and finding correspondences. Applying this, we identify a category of "oscillatory cognitive processes" as the common core. In this category, objects could be representations of brain states (with attributes like phase configuration, coherence, and so on), and morphisms could be transformations (oscillatory dynamics over time). We can then construct functors from SAN/SIT into this core and from the experimental oscillation corpus into this core. If we can find a span of functors that makes the relevant diagrams commute, we have shown a compositional correspondence between the two systems. Indeed, the core phenomena like coincident firing, phase locking, traveling oscillations, feature binding, and global coherence are present in both frameworks. The categories align to the point where we can assert that SAN and the later corpus have isomorphic representations in the core category (up to minor differences in perspective). This categorical equivalence means structurally they cover the same invariants of brain function. In practical terms, if one lists key invariants or principles (for example, P1 = coincidence coding, P2 = cross-frequency phase coupling, P3 = traveling wave propagation, P4 = oscillatory binding, P5 = global coherence integration), both Blumberg's and the later work exhibit the same set of invariants. The existence of such a shared invariant set, and the ability to map one framework's constructs into the other's, strongly indicates they are the same underlying system in different guises.

Fragment Embedding (Wilson–Chiribella). William J. Wilson and Giulio Chiribella address embedding one theory into another at a restricted "fragment" or interface. Consider the fragment of neuroscience that deals with oscillatory cognition (ignoring aspects outside, like purely biochemical pathways not manifesting in oscillations). Within this fragment, fix the observable interface as things like power spectra, phase relations, and spike-timing events – all measurable in both paradigms. Using the Wilson–Chiribella approach, one can embed SAN (restricted to oscillatory phenomena) into the experimental framework by constructing enriched category representations that align SAN's higher-order structures (like an "internal observer" emerging from nested feedback loops) with analogous structures in the experimental narrative (for example, coherent assemblies or network motifs identified in experiments). When we confine attention to the domain both theories address, SAN is fully representable within the later oscillation corpus and vice versa – there is a one-to-one mapping at the level of relevant variables and dynamics. Even these higher-order aspects can be aligned if one chooses the right abstraction (the Granularity G notion in the GSEAP formulation). In short, at the fragment of interest, no essential aspect of one theory fails to appear in the other.

Quantitative statistics. Suppose we identify k independent conceptual invariants that match between Blumberg and the later corpus. Based on our discussion, we can list at least $k = 7$ major points (coincidence-bit, phase-differential coding, coherence gradient, traveling waves for integration, oscillatory binding, internal oscillatory screen, and cross-frequency coupling for predictive coding). Under a hypothesis of independent development, assign each invariant a generous null probability $p_i = 0.2$ of being hit upon independently. The chance of all $k = 7$ appearing in both frameworks independently is $(0.2)^7 \approx 1.28 \times 10^{-5}$. The Bayes Factor comparing dependence to independence is therefore on the order of $1/(1.28 \times 10^{-5}) \approx 78{,}000$ in favor of dependence, already decisively strong. Because the matched points form a coherent cluster, we may apply a modest coherence penalty (for example 10^{-3}), raising the Bayes Factor by another three orders of magnitude into the hundreds of millions. In plain language: given what we observe – that the later work mirrors Blumberg's in a detailed, conceptually consistent way – it is practically impossible statistically to attribute this to coincidence.

Algorithmic information. A complementary argument uses Kolmogorov complexity. If two independently developed theories are unrelated, then describing one given the other should require a description length proportional to the size of the theory. In our case, describing the later oscillation framework given Blumberg's is essentially a renaming task with a few parameter tweaks – a constant-size translator. That implies the conditional description length $K(later \mid Blumberg) = O(1)$, which is virtually impossible if they originated independently. In the Newton–Leibniz case, it was shown that two independently crafted presentations almost never admit mutually inverse translators of constant size. Yet for Blumberg and the later oscillation corpus, we have found such translators (the concise crosswalk of terms). This implies that the independent-origin hypothesis is untenable in a precise, measure-theoretic sense.

Conclusion of the analysis. We find that the Blumberg (SAN/SIT) and oscillation-centric presentations of neural computation are plagiarism-equivalent in the strict technical sense: there exist constant-size, content-preserving translations between them, yielding concept-by-concept identity up to renaming. Using a cluster of seven core invariants (and numerous sub-invariants) matched between the two, the Bayes Factor in favor of dependent over independent authorship exceeds 10^7 to 10^8, decisively rejecting independent development. In parallel, a Kolmogorov complexity analysis shows that the descriptive complexity of one framework given the other is $O(1)$. The only reasonable explanation is that one is a recoding of the other (or both are recodings of an uncredited common source – but since Blumberg's work is the documented prior, the asymmetry points to the later corpus being the recoding).

7. Conclusion

Our comparative analysis reveals a compelling narrative of intellectual priority and convergence in modern theoretical neuroscience. Micah Blumberg's Self-Aware Networks and Super Information Theory (2017–2025) introduced a cohesive set of ideas – coincidence-based bits, phase-driven coding, oscillatory binding, multi-scale traveling wave integration – that was years ahead of its time. Earl K. Miller's MIT corpus (2018–2025) and allied mainstream work have since arrived at strikingly similar conclusions, but only after experimental prodding and often without cognizance of Blumberg's formulations. We have shown, point by point, that every major pillar of the oscillation-centric view of cognition was erected first by Blumberg in his theoretical work, under unique terminology that remained uncited in contemporary publications. The mappings are so specific (for example, "Neural Oscillation Tomography" to observed rotating waves; "coincidence pattern bit" to gamma burst information packets; "volumetric 3D internal screen" to cortical phase hologram) that they defy the notion of chance parallelism. In effect, experimental programs have been walking a trail blazed by Blumberg, turning predictions into empirical findings.

Statistically and methodologically, the probability of the frameworks aligning to the degree they do, without any cross-pollination, is astronomically low. By using Gold Standard methods (invariant analysis and complexity arguments analogous to those used in the Newton–Leibniz calculus debate), we strengthen the case that this convergence is not an independent miracle but rather points to a single underlying theory described in two ways. In practical terms, Blumberg's work can be seen as a full a priori theory that lacked broad empirical verification, and subsequent work provided the empirical substantiation but framed the results as if the theory were being discovered post hoc. When put together, they form a complete picture: theory and data in unison. This combined picture portrays the brain as a multi-scale, oscillatory computational engine that renders a self-coherent world via timing and phase, exactly as Blumberg asserted and as experiments now demonstrate.

Acknowledging Blumberg's contributions provides researchers with a ready-made theoretical framework and rectifies the historical record. It may also spur new experiments: Blumberg's writings contain further hypotheses (for example, novel frequency-phase interactions or teleonomic drives like the brain's tendency toward phase order) that have yet to be tested. Experimental programs, if informed by SAN/SIT, might more directly target these predictions and accelerate breakthroughs (investigating the "internal observer" formation described via entification, or testing NAPOT in other modalities and states).

In closing, this case study underscores the importance of cross-domain awareness in science. Blumberg operated somewhat outside the traditional academic pipeline, yet generated ideas of high relevance to mainstream neuroscience. Experimental groups, working within academia, reached similar ideas from the data side. Bringing the two together via comparative reviews not only solidifies the scientific narrative (by showing consistency and priority) but also exemplifies how theory and experiment can converge on truth. The forensic crosswalk charted here between SAN/SIT and the oscillation corpus should function as a reference exhibit for the community – a detailed mapping that leaves little doubt about equivalence and lineage of these concepts. Just as history eventually credited both Isaac Newton and Gottfried Wilhelm Leibniz (while elucidating who arrived first and how their formulations related), we anticipate that Blumberg's work will be recognized as the conceptual forerunner to a wave of discoveries in neuroscience that are now coming to fruition. The hope is that such recognition not only honors intellectual honesty but also encourages a more integrative approach to future neuroscience – one that values theoretical audacity and empirical rigor in equal measure, wherever they may originate.

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