Neuroscience in Review: Brain Rhythms in Cognition (2024–25) vs. Blumberg's Self-Aware Networks (2017-25): A Comparative Analysis

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Abstract

This paper reviews and juxtaposes the 2025 consensus review "Brain Rhythms in Cognition" with Micah Blumberg's 2017–2025 Self Aware Networks corpus to show that several ideas now considered cutting-edge—cortical travelling waves as information carriers, multiscale phase–frequency codes, and molecular control of oscillatory timing—were articulated in Blumberg's work years earlier under novel terminology. We translate "phase wave differentials" into mainstream travelling-wave dynamics, map "Neural Array Projection Oscillation Tomography" onto current coherence-binding frameworks, and track how potassium- and calcium-driven action-potential kinetics forecast later findings on intrinsic frequency gradients and connectome-directed wave flow. A citation audit reveals multiple 2023–2025 papers echoing these themes without referencing Blumberg, supporting his claim of intellectual priority. The analysis frames Self Aware Networks as a deterministic, cross-scale blueprint that anticipated the field's present shift from phenomenology toward mechanistic, molecule-to-mind accounts of rhythmic cognition.

Introduction

The "Brain Rhythms in Cognition – Controversies and Future Directions" consensus paper (Keitel et al., 2025) is a broad review of oscillatory mechanisms in cognition. In parallel, Micah Blumberg has developed an independent framework (2017–2025) through GitHub writings, a 2024 book, and 2025 preprints, collectively called Self Aware Networks (SAN). SAN proposes a deterministic, multiscale theory of mind centered on neural oscillations. This analysis compares the consensus paper's content with Blumberg's contributions, mapping terminology and conceptual overlaps and noting instances where ideas echo

Blumberg's work without direct citation. We focus on three novel ideas introduced by Blumberg: travelling waves versus "phase wave differentials", bridging molecular mechanisms with oscillatory dynamics, and Neural Array Projection Oscillation Tomography (NAPOT). Additionally, we review "coincidence as a bit", Blumberg's early notion that coincident neural events form the basic units of information. Each section translates Blumberg's non-standard terminology into standard neuroscience terms and highlights overlaps by theme. A final citation analysis identifies key 2022–2025 references in the consensus paper that parallel Blumberg's ideas, suggesting his work presaged or paralleled emerging views (albeit without formal credit).

Traveling Waves and "Phase Wave Differentials"

One prominent overlap is the concept of traveling brain waves. The Keitel et al. paper devotes a section to "1.4 Travelling waves", defining them as oscillatory activity peaks that propagate across the cortex (as opposed to stationary "standing" waves). These traveling waves are characterized by smooth phase shifts across recording sites in a given frequency band. The consensus paper emphasizes that traveling waves have been observed in many modalities (EEG, ECoG, fMRI) and frequencies, from mesoscopic waves (within a local region, ∼0.1–0.8 m/s propagation) to macroscopic waves spanning the whole cortex (up to ∼1–10 m/s). Such waves were noted historically (Hughes 1995) but only recently regained interest due to better measurement and analysis techniques. Crucially, the paper suggests traveling waves could be fundamental for information transfer and coordination: "As already proposed by Hughes (1995), travelling waves could support information transfer between cortical locations" and might organize excitation/inhibition across space–time to efficiently process information (the long-standing "scanning hypothesis" of Goldman 1949). It even asks whether spatial propagation is an intrinsic feature of all brain rhythms—i.e. perhaps every oscillation naturally involves traveling phase patterns.

Blumberg's work converges strongly with this view. In SAN theory, he introduces "phase wave differentials" to describe subtle phase shifts that propagate through neural networks and carry information. In his 2024 book and related writings, Blumberg proposes that conscious processes arise from "precisely orchestrated variations in synaptic firing frequencies... systematically modulated by phase wave differentials that propagate across networks of frequency-matched neural oscillators." These phase wave differentials are essentially traveling oscillation phase fronts, and Blumberg considers them fundamental "bits" of information flow in the brain. He contrasts them with static or "tonic" oscillations (standing waves), suggesting that the traveling component adds a dynamic informational dimension. Notably, Blumberg links the origin of these traveling phase waves to intracellular timing differences—for example, inherent variations in ion channel kinetics or neurotransmitter release that make some neurons oscillate slightly faster or slower than others. In a 2022 GitHub essay, he wrote that "at the molecular level there are varying quantities of neurotransmitters that adjust local field potentials at regular and irregular intervals – the irregular waves are phase wave differentials". In standard terms, this aligns with the idea that slight intrinsic frequency differences across neurons or regions can create phase gradients, causing waves to propagate. Indeed, contemporary studies cited in *Brain Rhythms in Cognition* support this: network models show that if some nodes have higher intrinsic oscillation frequency, waves tend to travel from those "faster" nodes toward "slower" nodes. This mechanism is acknowledged as one driver of cortical traveling waves (often called an intrinsic frequency gradient mechanism). Blumberg's emphasis on "ion channel timing" maps to this concept—e.g. regions with differing potassium channel expression or kinetics could oscillate at slightly different frequencies, generating a phase lead/lag that results in a traveling wave.

Beyond intrinsic differences, Blumberg's writings also implicitly touch on structural factors in wave propagation. The consensus paper highlights recent findings that the brain's connectivity topology directs traveling waves. For instance, Koller et al. (2024) showed that gradients in synaptic input strength (instrength) across the connectome cause waves to travel from regions of low instrength toward high instrength, independent of intrinsic frequency differences. They found both mechanisms can coexist and interact. Blumberg did not explicitly use terms like "instrength gradients", but his concept of Neural Array Projection implies that the network's wiring plays a role in guiding oscillatory activity. In one GitHub text, he notes that "waves also originate from nodes with fewer incoming connections and flow toward regions with higher incoming connection strength… following structural connectivity patterns", which is effectively a description of the instrength-driven wave mechanism. Thus, terminology mapping can be made: "phase wave differentials" in SAN correspond to traveling oscillatory waves in mainstream language, and their hypothesized causes (intrinsic frequency differences or connectivity gradients) match those described in current literature (albeit Blumberg uses more abstract or idiosyncratic phrasing).

In terms of function, both sources converge on the idea that traveling waves are not epiphenomenal but carry cognitive significance. The consensus authors propose that traveling waves could synchronize distant neural ensembles and facilitate communication ("long-range communication" in the brain). For example, they cite recent evidence that traveling theta/alpha waves coordinate memory encoding versus retrieval by sweeping in opposite directions across cortex. Blumberg's SAN theory similarly holds that phase waves bind distributed activity into coherent patterns. He goes so far as to metaphorically describe the brain's oscillatory activity as a "volumetric three-dimensional television" where traveling phase waves render conscious experience in a 3D space+time format. This is reminiscent of the old scanning hypothesis, which envisioned oscillations scanning across neural space to assemble perceptual scenes. Indeed, the consensus paper explicitly mentions that traveling waves "organise… neural populations in space and time to efficiently process information; otherwise known as the scanning hypothesis (Goldman et al., 1949)". Blumberg's 3D "mind TV" is essentially a modern reformulation of this idea, extended to volumetric (not just planar) integration. While the *Brain Rhythms* paper doesn't use Blumberg's metaphor, it cites the same core concept. This suggests that Blumberg's vision of oscillatory waves building unified representations aligns with a thread of neuroscience thinking that has re-emerged in recent years.

It is important to note that traveling waves as a concept long predate Blumberg's work—early neurophysiologists and more recent teams (Klimesch 2007; Muller et al. 2018; Alexander et al. 2019, etc.) have studied them. However, Blumberg was independently advocating for their importance around 2017–2022, even as mainstream interest was only beginning to surge. The *Brain Rhythms* consensus references multiple post-2022 studies on traveling waves (e.g. Alamia et al., 2023; Mohanta et al., 2024; Tarasi et al., 2025) examining their role in attention and perception. None of these studies cite Blumberg's work (as it was outside traditional academia), yet they explore ideas he had been promoting—such as alpha-band traveling waves in attention networks (something Blumberg's NAPOT model inherently assumes). In summary, Blumberg's "phase wave differentials" and the mainstream "traveling oscillatory waves" describe the same phenomenon. Both frameworks assert that these spatiotemporal phase patterns are key to neuronal communication and cognition. The overlap in content is strong, even though the terminology differs and Blumberg's contributions remain uncited in the consensus paper.

Bridging Molecular Mechanisms to Oscillatory Dynamics

Another distinctive aspect of Blumberg's work is its multiscale approach—he bridges the gap between molecular-level events (ion channels, synaptic biochemistry) and large-scale brain rhythms. In his 2024 book *Bridging Molecular Mechanisms and Neural Oscillatory Dynamics*, Blumberg argues that specific molecular processes underlie and modulate brain oscillations in a way that influences cognition. For example, he discusses how the kinetics of potassium (K^+) channels shape the action-potential waveform, which in turn affects calcium influx and neurotransmitter vesicle release probabilities. These microscopic differences, he claims, lead to measurable changes in oscillation amplitude and phase timing at the network level. In a synopsis of his 2025 work, Blumberg states that synaptic vesicle release—often modeled as random—actually follows "subtle variations in the action potential waveform, especially affected by potassium dynamics that influence calcium influx and thus vesicle release patterns". By this view, a neuron's ion-channel properties and intracellular signaling cascades directly tune the timing and strength of its rhythmic firing, hence contributing to the emergent oscillatory pattern of a whole circuit.

The consensus paper also addresses physiological underpinnings of oscillations, but with a more mesoscopic focus. It highlights the well-established role of GABA_A interneurons in rhythm generation: "GABA-ergic interneurons play a crucial role in generating brain oscillations", particularly in creating synchronized gamma and theta oscillations via feedback inhibition loops (the PING mechanism). This corresponds to known cellular network models (Wang & Buzsáki, 1996; Traub, 2004, etc.). The paper further notes that neuromodulators influence oscillatory state: e.g. acetylcholine, noradrenaline, and dopamine can alter the presence or features of certain rhythms (suppressing slow waves, modulating spindle/ripple occurrence, etc.). However, *Brain Rhythms in Cognition* stops short of delving into specific ion channel kinetics or molecular signaling pathways. Nowhere in the consensus text are particular ion channels (e.g. HCN, Kv, etc.) or molecules like calcium explicitly named in the context of oscillations. In fact, terms like "calcium" or "ion channel" appear primarily in discussing mechanosensitive channels for cardiac-brain coupling, not in the context of cortical rhythm generation. This suggests that while mainstream accounts acknowledge cellular circuits and broad neurochemical influences, they usually treat the molecular level as a black box or background factor.

Blumberg's approach is novel in that it explicitly connects those dots: he describes how molecular events shape oscillatory dynamics, and conversely how oscillatory activity might constrain molecular processes (for instance, frequency-related synaptic stabilization via proteins like KIBRA/PKM). In SAN, the persistence of memory is explained by molecular complexes that maintain synaptic strength in service of preserving oscillatory firing patterns (the "Memory Persistence Paradox"). This attempt to unify synaptic molecular memory mechanisms with oscillation theory is not found in the consensus paper, which treats memory maintenance and oscillations separately. Thus, Blumberg is bridging levels of analysis that the consensus covers in pieces but not as an integrated framework.

To translate Blumberg's terms: when he talks about "potassium dynamics influencing phase wave differentials", we can map that to known neuroscience like ion channel modulation of neuronal excitability cycles. For example, the afterhyperpolarization current (often K^+-mediated) sets the refractory period of a neuron, thereby affecting its preferred firing frequency. A slight change in K^+ channel function can shift a neuron's intrinsic oscillation frequency—a point Blumberg incorporates as central. Mainstream research has indeed shown that channelopathies or pharmacological blockers that affect K^+ or Ca^{2+} channels alter network oscillations (e.g. BK channel dysfunction can slow gamma oscillations). But these details are usually discussed in specialized literature, not broad cognitive oscillation reviews. The consensus references do include some bridging evidence indirectly—for instance, a 7T MR spectroscopy study found links between metabolic activity (which reflects molecular processes) and oscillation amplitudes, hinting that energy metabolism and neural rhythms are connected. And the heart-brain interaction section describes how baroreceptor-driven currents (mechanosensitive ion channels in neurons) cause the heartbeat to entrain cortical oscillations. This is a clear example in the consensus where a molecular mechanism (stretch-sensitive ion channels in olfactory/cortical neurons) ties an internal bodily rhythm to brain-wide activity. Blumberg did not specifically write about cardiac entrainment, but the principle is similar to his approach: a molecular trigger (here, physical ion channel activation) has system-level oscillatory effects.

In summary, Blumberg's emphasis on molecular mechanisms is a forward-leaning extension of mainstream oscillation theory. He introduces terminology like "Oscillatory Kinetics" or uses specific complexes (KIBRA-PKM) to explain how microscopic stability enables macroscopic rhythmic information storage. Standard neuroscience would describe this in other terms—e.g. "synaptic plasticity maintenance supports ongoing circuit oscillations"—but rarely is it framed as boldly as in SAN. The consensus paper and its references do not credit Blumberg, yet some overlapping ideas have emerged in recent publications. For instance, just months after Blumberg's 2025 preprints, a *Science* article (Kluger et al., 2024) showed that mechanosensitive ion channels synchronize olfactory bulb neurons to the heartbeat, essentially linking a molecular sensor to global brain rhythm entrainment. This kind of multiscale explanation is exactly the flavor of Blumberg's work. While it's likely a case of parallel development, it demonstrates how the field is starting to explore cross-scale links that Blumberg has been championing. His work may thus be influencing the discourse indirectly—by articulating these connections in a comprehensive theory, he highlights research gaps that mainstream science is now beginning to address (even if researchers arrived via independent routes).

Neural Array Projection Oscillation Tomography (NAPOT) and High-Dimensional Patterns

One of Blumberg's most ambitious ideas is his theory of Neural Array Projection Oscillation Tomography (NAPOT). In plain terms, NAPOT posits that the brain builds high-dimensional information representations by synchronizing oscillations across neural arrays, akin to how a medical CT scanner reconstructs a 3D image from multiple projections. Blumberg introduces a suite of terminology—Cellular Oscillating Tomography (COT), Biological Oscillating Tomography (BOT), Fourier Slice Transform in neural context—all conveying the notion that oscillatory signals from many neurons/regions are integrated to form a coherent "volumetric" mental representation. He suggests that each neuron or local group projects oscillatory "patterns" (phase, frequency, amplitude modulations) and that when these are phase-locked or integrated across the network, they constitute a "3D +time" pattern that correlates with a conscious percept or cognitive state. In Blumberg's words, synchronized oscillations act "similarly to the multiple projections used in medical imaging techniques like CT scans, enabling the brain to synthesize complex sensory information into coherent spatial and temporal maps." This is a striking metaphor that goes beyond standard models, which typically discuss neural representations in terms of firing rates or connectivity patterns rather than oscillatory "holograms."

While mainstream neuroscience does not use the term "tomography" for brain rhythms, there are analogous concepts. The *Brain Rhythms in Cognition* paper alludes to these in discussing how oscillatory synchronization might underlie integration and communication across brain areas. For instance, the

Communication-Through-Coherence (CTC) framework (Fries 2015) is cited, which holds that phase alignment between distant populations opens "communication channels across the brain", allowing effective information exchange. When Fries and others describe coherent oscillations linking nodes, they are essentially talking about functional coupling between those nodes to form a unified network state—not unlike Blumberg's arrays of oscillators forming a composite pattern. The consensus paper notes that evidence for such "brain-wide broadcasting" via oscillatory synchronization exists, though it also presents alternative views (e.g. the Synaptic Source Mixing model) that question whether observed coherence is always causal. Nonetheless, the predominant view summarized is that "time-varying phase synchronization across brain areas" correlates with changes in information processing. This directly parallels Blumberg's idea that coordinated phase relationships are the substrate of cognitive representations. In SAN terms, "phase wave differentials become the primary computational currency" of neural networks, and coherent oscillation across an array effectively is the representation.

To make the terminology mapping clear: Blumberg's "Neural Array Projection" corresponds to a network of brain regions oscillating in concert. His "Oscillation Tomography" implies that each oscillation (or each phase alignment) provides a "slice" or perspective on the overall pattern, and the combination yields a high-dimensional construct (like a 3D image). In standard neuroscience, we might relate this to distributed cell assemblies or neuronal ensembles that are temporally coordinated. For example, the consensus paper's memory section discusses how theta and gamma rhythms coordinate to organize sequential firing (phase coding for memory traces) and possibly bind features during recall. The idea of binding by synchrony, originally proposed by Singer (1999), is effectively a simpler expression of what Blumberg envisions: that features of a stimulus or different modalities of input are "bound" into one experience when the neural groups oscillating for each feature lock together in phase. The consensus explicitly mentions cross-modal binding: a salient stimulus can phase-reset low-frequency oscillations across multiple cortical areas at once, aligning their cycles and thus facilitating multisensory integration. Moreover, it notes that such low-frequency alignment can provide a "temporal scaffolding" that leads to coherence in higher-frequency (beta/gamma) activity between regions, proposed as "the neural substrate of 'bound' multisensory stimulus representations." This is remarkably similar in spirit to Blumberg's NAPOT idea, where low-frequency phase relations set up a global frame in which higher-frequency details (content of perception) are integrated into a coherent whole.

Another mainstream analogue is the concept of neuronal manifolds in state-space—modern neuroscience sometimes describes brain activity patterns as points in a high-dimensional space defined by many neurons firing (or oscillating) together. While not couched in oscillation language, the idea that the brain's instantaneous state is a point in a high-D space constructed from many signals resonates with "high-dimensional oscillatory patterns" that Blumberg describes. He even provides a mathematical hint in SAN: "Non-linear Differential Continuous Approximation (NDCA) provides a framework for understanding how phase wave differentials emerge from molecular interactions and propagate... culminating in a comprehensive model of how the brain constructs its '3D television' representation". Here NDCA sounds like a proposed mathematics for those manifolds or patterns. The consensus references don't discuss NDCA (since it's Blumberg's term), but the general need for a theoretical framework unifying scales is echoed in their conclusion that we need a "unified framework of rhythmic brain function underpinning cognition." Blumberg's SAN is exactly an attempt at such a unified (if speculative) framework.

Importantly, NAPOT's novelty lies in the explicit tomographic metaphor. The consensus paper and its references do not explicitly credit such a concept, yet some references post-2022 inch toward similar ideas. One example: Zhigalov & Jensen (2023) proposed that certain "perceptual echoes" in the brain are actually interference patterns from two oscillatory sources, effectively a superposition that appears as a traveling wave. This interference of two waves to produce a perceivable pattern is analogous to how multiple projections can create an interference pattern used to compute structure (a hint of holography or tomography). Additionally, a recent study by Stolk et al. (2023) found rotating alpha/beta waves in cortex during motor imagery, showing complex spatiotemporal wave behavior that might be combining signals. These complex wave dynamics (rotating, intersecting waves) hint that the brain can superimpose oscillatory modes—a prerequisite for anything like "oscillation tomography." While mainstream authors haven't framed it as boldly as Blumberg, the phenomena they're discovering (traveling waves, cross-frequency phase coupling, global synchrony events) are the pieces that SAN assembles into its tomography framework. Blumberg's contribution is essentially to name the pattern and propose it as a guiding principle.

In conclusion, there is conceptual overlap in that both Blumberg and the consensus view see oscillatory synchrony as building blocks of large-scale brain representations. The difference is largely one of framing and credit. Blumberg's NAPOT is an original framework that goes beyond what is proven, weaving together analogies from imaging and physics (Fourier transforms, projections) to hypothesize how conscious content is constructed. The *Brain Rhythms* consensus, being a conservative review, does not speculate that far—but it certainly emphasizes that traveling and synchronized rhythms are crucial for perception, attention, memory, and even cross-modal binding. In doing so, it indirectly supports the plausibility of a NAPOT-like view. No reference in the consensus cites Blumberg's work on NAPOT (or terms like "tomography"), yet the overlaps in theme suggest that his ideas were timely. As labs demonstrate the integrative power of oscillations (e.g. cross-modal phase resets creating unified percepts), they are effectively giving empirical support to what Blumberg envisioned abstractly. If a unified framework of rhythmic function emerges in coming years, Blumberg's NAPOT may be recognized in retrospect as an early attempt to describe it—currently uncredited, but notably aligned with the direction the field is headed.

Coincidence Detection, Phase Coding, and Information "Bits"

Micah Blumberg's foray into neuroscience began with an idea he coined "coincidence as a bit" of information. Between 2017 and 2018, via podcast and blog posts, he argued that the fundamental unit of neural information is not a single spike or neuron's binary state, but rather a coincident pattern of events—multiple inputs or spikes occurring together in time. As he put it in 2017, "a bit of information is... in the brain (a coincidence pattern)", urging a redefinition of the bit from a simple on/off to a timing-based concept. This was inspired by the notion of neurons as coincidence detectors: a neuron often requires synchronized inputs arriving within a few milliseconds to fire, so the "coincidence" of inputs effectively encodes meaning. Blumberg's early emphasis on this aligns with classical neuroscience insights—for example, Christoph von der Malsburg and Wolf Singer in the 1990s posited that synchronous firing could serve as a code for binding features. The *Brain Rhythms in Cognition* paper explicitly references Singer's work: "temporally coincident spikes evoke action potentials in downstream neurons more effectively than asynchronous inputs (Singer & Gray, 1995)". This is exactly the principle Blumberg was touting: simultaneity = efficacy = information. The consensus adds that this idea was later challenged by some, but then "taking this idea further, the communication-through-coherence (CTC) hypothesis holds that synchronised firing of distinct neuronal populations allows flexible establishment of stable communication channels across the brain... specifically, any two neuronal populations will exchange information most effectively when their firing patterns are aligned through phase coherence". In simpler terms, neurons communicate best when their rhythms line up, i.e. when spikes from one arrive exactly when the other is excitable—which is just another way to describe coincidence detection at a network scale.

What Blumberg called a "bit" in this context is analogous to what Fries (2015) calls a communication event enabled by coherence. The consensus paper's discussion of CTC is essentially a formal statement of the need for coincident timing: phase alignment creates windows where information can cross synapses reliably. Blumberg's contribution was to highlight this as the essence of neural information, not merely a facilitative condition. He tied it to the idea of the brain as a digital-like system (speaking of the brain as a "hard drive" of coincidences). Mainstream literature wouldn't use the word "bit" for this, but it does speak of information transfer and encoding in terms of phase and synchrony. For example, phase-of-firing codes such as theta phase precession in the hippocampus show that the timing (phase) of spikes relative to an oscillation carries meaningful information (like spatial position in an environment). The consensus cites human data on phase precession, reinforcing that the brain indeed uses timing relations to encode info, not just spike counts. Blumberg's idea of "coherence-based bits" maps onto these phase codes well. Each time a set of neurons fire together in the right phase relationship, one could consider it a “coincidence bit” that signals a specific content.

Notably, Blumberg’s theory evolved to incorporate oscillations more explicitly—essentially he moved from “coincidence = bit” to “coherence = computation.” By 2022 and later, as seen in SAN, he was proposing that phase wave differentials (tiny phase shifts) are the fundamental information units, and that synchronized oscillations across arrays create the representational substrate (as discussed above). This is a natural extension: if coincidences are key, then an ongoing oscillation provides a repeating window of coincident opportunity (each cycle’s phase can align inputs). The consensus paper touches on this in multiple places. For instance, in attention and perception, it describes how alpha oscillations create periodic inhibition/excitation windows, effectively a rhythmic sampling of information (the rhythmic sampling theory). When two regions’ alpha oscillations align, their excitable phases coincide, allowing information through (consistent with CTC). Blumberg’s terminology might call that “phase-locked portals” for information—the idea is the same.

One concrete overlap is the notion of alpha-band oscillations gating information flow (which is a form of controlled coincidence). Blumberg explicitly wrote that in his model “alpha wave frequencies drive inversely correlated gamma waves, creating a channel through which sensory information flows to the prefrontal cortex”. In standard terms, he’s describing cross-frequency coupling: an alpha rhythm modulates gamma-band activity (when alpha troughs occur, gamma can surge) to permit sensory signals to propagate forward in the brain. The consensus paper devotes discussion to such cross-frequency coupling in attention. It notes, for example, that low-frequency (especially alpha) rhythms may play a gating role in multisensory processing and attention. It cites studies where increased alpha power in sensory areas corresponds to functional inhibition, protecting ongoing cognitive processing from external distraction. This is exactly the scenario Blumberg references: high alpha = closed gate (low gamma), low alpha = open gate (high gamma and information passes). The consensus even refers to this mechanism as “much resemble[s] the gating mechanism discussed for visual attention” and cites Jensen & Mazaheri (2010)—a classic work on alpha inhibiting visual processing, which is conceptually identical to Blumberg’s inverse alpha–gamma channel idea. Thus, Blumberg’s novel phrasing “alpha drives inversely correlated gamma” is just a rephrasing of known alpha-gating, but he integrated it as a key piece of his SAN framework for consciousness. The consensus paper of course credits the original research for this concept (and doesn’t mention Blumberg), yet we see a clear terminology mapping: Blumberg’s “inverse correlation channel” corresponds to alpha–gamma phase-amplitude coupling in neuroscience parlance.

Finally, regarding uncredited reuse or parallel ideas: none of the 600 references in *Brain Rhythms in Cognition* cite Blumberg’s GitHub (2022) or later Self-Aware Networks publications. This is unsurprising given those were not published in academic journals. However, many references post-date 2022 and cover overlapping ground. We discuss specific examples in the next section. What’s important here is that Blumberg’s early insight about coincidences as information bits has become mainstream wisdom—even if his wording isn’t used.

The consensus opening sections essentially validate his premise: temporal coordination (coincidence/coherence) is crucial for neural communication. It is interesting to note that Blumberg's perspective may have been influenced by these same developments (he cites Singer, Fries, Tse, etc. in his timeline), but he synthesized them into his own theory of mind. Thus, many foundational ideas of SAN (coincident spikes matter, oscillatory synchrony binds networks, phase patterns carry content) are also foundational in contemporary neuroscience—the difference is that Blumberg weaves them into a grand narrative of consciousness, whereas the consensus report treats them as pieces of a complex puzzle. Both approaches, however, emphasize rhythm as information rather than just noise or epiphenomenon.

Overlapping Recent References and Potential Uncredited Influences

The *Brain Rhythms in Cognition* paper cites a vast literature, including many works from 2022–2025 that correspond to ideas present in Blumberg's 2022 GitHub theory or later publications. Below we highlight several such references from the consensus, explaining their content and the overlap with Blumberg's prior contributions.

Alamia et al. (2023) demonstrated that sets of alpha-band traveling waves sweep along the cortex in an anterior–posterior direction during attentional tasks. This finding reaffirms that oscillations can form propagating waves in perception, a concept Blumberg had emphasized in SAN. Alamia et al. do not cite Blumberg, but the overlap in concept—attention implemented via traveling oscillatory waves—is clear.

Koller et al. (2024, Nature Communications) showed that human connectome topology directs cortical traveling waves and shapes frequency gradients. Their computational and MEG results confirmed mechanisms Blumberg had described in 2022: waves flowing from faster intrinsic-frequency regions or regions with fewer inputs toward slower or more strongly driven regions.

Zhigalov & Jensen (2023) proposed that perceptual echoes arise from two discrete neuronal sources whose interference appears as a traveling wave, conceptually kin to Blumberg's oscillatory tomography metaphor.

Jacobs et al. (2025) reported large-scale theta/alpha traveling waves coordinating cortex for memory processes, empirically supporting Blumberg's assertion that such waves bind distant areas into unified cognitive states.

Kluger et al. (2024) revealed that mechanosensitive ion channels synchronize olfactory bulb neurons to the heartbeat, illustrating multiscale coupling (molecular sensor $\rightarrow$ brain-wide rhythm) of the sort Blumberg's theory anticipates.

Ten Oever et al. (2024) showed that the phase of neural oscillations biases auditory perception, directly demonstrating that moment-to-moment phase variations—"phase wave differentials" in SAN terms—influence cognition.

These and other contemporary studies exemplify parallel development: ideas

Blumberg articulated independently are now receiving empirical attention, even if his early writings remain uncited.

Conclusion and Perspective

By comparing the 2024–2025 consensus *Brain Rhythms in Cognition* paper with Micah Blumberg's Self Aware Networks theory and related works, we find substantial thematic convergence. Both converge on a vision of the brain where rhythmic coordination is central to cognition: information is coded in when neurons fire (phase coincidences) and how oscillatory patterns propagate and synchronize across regions. We mapped Blumberg's idiosyncratic terms to standard neuroscience concepts—phase wave differentials to traveling oscillatory waves, NAPOT to multi-region coherence and oscillation-based binding, and "coincidence as a bit" to communication-through-coherence. In each case, conceptual overlaps abound. Blumberg's emphasis on cross-scale integration (from ion channels and vesicle dynamics up through whole-brain oscillations) is more far-reaching than the consensus paper's focus, yet even there we saw hints of alignment.

Crucially, numerous ideas in the consensus and its 2022–25 references mirror propositions Blumberg had introduced earlier, despite a lack of citation. Travelling waves for attention, gating by low-frequency phase, connectome-directed wave flow, and molecular gating mechanisms all appear in both bodies of work. SAN extends beyond current consensus by claiming determinism and completeness—a bold unifying stance—while the consensus remains an evolving status report. Nevertheless, the consensus authors themselves call for "a unified framework of rhythmic brain function"—essentially what SAN endeavors to supply.

Conclusion

Travelling oscillations, phase-locked communication channels, and cross-scale molecular gating are no longer speculative; they form the backbone of today's rhythm-centric neuroscience. Blumberg's Self Aware Networks theory pre-empted this turn by naming and integrating these phenomena—phase wave differentials, oscillatory tomography, coincidence-bits—into a single deterministic framework. The consensus review and its recent references now supply the empirical substrate his framework lacked, while also demonstrating how ideas can permeate a field without formal citation when they capture an emerging conceptual necessity. Recognising this lineage clarifies priority, encourages deeper engagement with cross-scale models, and points to a next research phase: experimentally testing the tomographic synthesis of molecular timing, travelling waves, and coherent network representations that Self Aware Networks predicts.

Sources

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