Article

SEQUENTION and the Superorganism: A Timeless, Projection-Based Framework for Collective Animal Behavior

Henry Arellano *

Posted Date: 17 November 2025

doi: 10.20944/preprints202511.1039.v1

Keywords: TCGS-SEQUENTION framework; Timeless Counterspace & Shadow Gravity (TCGS); SEQUENTION biological law; projection-first ontology; 4-D counterspace (C); 3-D shadow manifold (Σ, Σ_{bio}); Identity-of-Source (Axiom A2); shadow realization (Axiom A3); biological informational potential UUU; extrinsic constitutive law $J = \mu_{bio}(\ldots)\nabla U$; retrocausal, non-local counterspace coupling (Ks kernel); foliation and foliation leaves

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 17 November 2025 doi:10.20944/preprints202511.1039.v1

Article

Equention and the Superorganism: A Timeless, Projection-Based Framework for Collective Animal Behavior

Henry Arellano

Nuevo Estandar Biotropical Nebiot Sas, Colombia; harellano@nebiot.org

Abstract

We present a formal synthesis of the TCGS-SEQUENTION framework with foundational research in collective animal behavior. We posit that the "superorganism" concept, as defined by Wheeler , is not an analogy but a precise description of a coherent three-dimensional (3-D) shadow manifold (Σ_{bio})—a projection of a single four-dimensional (4-D) source singularity (Axiom A2: Identity-of-Source). This projection-first ontology geometrically resolves the "combination problem" of panpsychism [1]; the colony mind does not "emerge" from the combination of 3-D ant-minds but is a *projection* of a unitary 4-D content. We map Wheeler's "germ-plasm" (queen) and "soma" (worker) duality to the empirically observed "generalized" (queen) and "specialized" (worker) brain architectures , demonstrating they are differential projections of this single source. We argue that 3-D collective behaviors—such as the "distributed process" of task allocation and "multiscale competency" —are the observable phenomenology of the shadow collective following the gradients of the 4-D biological informational potential (U), as defined by the SEQUENTION constitutive law $J = \mu_{bio}(...)\nabla\mathcal{U}$. Finally, we demonstrate that empirical 3-D non-local phenomena, specifically the "scale-free correlations" ($\xi \sim L$) observed in flocks , are the definitive "smoking gun" signature of the framework's "Retrocausal, Non-Local Counterspace Coupling" (K_s) kernel , which provides non-local coordination across foliation leaves.

Keywords: TCGS-SEQUENTION framework; Timeless Counterspace & Shadow Gravity (TCGS); SEQUENTION biological law; projection-first ontology; 4-D counterspace (C); 3-D shadow manifold (Σ, Σ_{bio}); Identity-of-Source (Axiom A2); shadow realization (Axiom A3); biological informational potential UUU; extrinsic constitutive law $J = \mu_{\text{bio}}(\dots)\nabla U$; retrocausal, non-local counterspace coupling (Ks kernel); foliation and foliation leaves

1. Introduction: From the Combination Problem to Projection Geometry

The study of collective animal behavior is defined by a persistent phenomenological paradox. Concepts such as the "superorganism" and "collective intelligence" are empirically powerful and necessary to describe the coherent, goal-directed behavior of social insects and vertebrate groups. Yet, the 3-D, local mechanisms for this emergent unity remain elusive. This paradox is most explicitly framed in the philosophical analysis of ant colonies as potential conscious organisms. Fonseca, applying a panpsychist framework, articulates the "combination problem": how do the "micro-minds" of individual ants, each a potential subject of experience, combine to form a unified "macro-mind" or "consciousness" of the colony?.[1]

This problem highlights the dependence on "the way how its components are physically and phenomenally integrated".[1] However, the analysis concludes that without a "general organizing principle" that clarifies the "correct combination of parts," the very concept of the collective organism remains vague.[1] This search for a 3-D, local integration *process*—a physical mechanism of combination operating in time—is the fundamental barrier.

We assert that these 3-D puzzles are not physical problems to be solved by 3-D, local mechanisms but are *ontological artifacts* of a 3-D, temporal framework. The "combination problem" [1] is a category error. It presupposes that 3-D, local entities (the ants) are fundamental and must be *assembled* into a 3-D, global entity (the colony) via some temporal process.

The Timeless Counterspace & Shadow Gravity (TCGS) and SEQUENTION frameworks provide the necessary ontological correction. This framework posits that the observable 3-D world (Σ) is a "shadow" or projection, and that "time" (the medium required for 3-D assembly processes) is a non-ontic gauge or "foliation artifact" (Axiom A3) . Therefore, searching for a 3-D, temporal *process* of combination is futile, as it seeks a fundamental mechanism within a gauge-dependent, non-fundamental construct.

The TCGS-SEQUENTION solution is to change the ontology:

1. The 4-D counterspace ($\mathcal{C}$) is the fundamental layer containing the "full content" of reality (Axiom A1) .
2. The 3-D shadow manifold (Σ) is the projection (Axiom A3) .
3. The 3-D collective (the colony) and the 3-D individuals (the ants) are *co-projections* of a single, unified 4-D source singularity S (Axiom A2: Identity-of-Source) .

In this projection-first ontology, there is no "combination" of 3-D parts; there is only "co-projection" from a 4-D whole. The unity of the colony is not *created* by 3-D interactions; the 4-D geometric unity is *a priori*.

This paper will formally demonstrate that the TCGS-SEQUENTION framework provides the "general organizing principle" that 3-D-local biology lacks. We will demonstrate: (i) how Axiom A2 (Identity-of-Source) redefines the superorganism as a unitary shadow, geometrically resolving the combination problem (Section 3) [1]; (ii) how the SEQUENTION biological law ($J = \mu_{bio}(...)\nabla\mathcal{U}$) defines the 4-D potential landscape that 3-D collective intelligence computes (Section 4); and (iii) how 3-D empirical non-locality is the definitive signature of the 4-D non-local coupling mechanism (K_s) (Section 5) .

2. Axiomatic Foundations: The TCGS-SEQUENTION Framework

This synthesis is built upon the established axiomatic foundation of the TCGS-SEQUENTION program, a timeless, projection-based framework for physics and biology . The core principles, as consolidated from the framework's corpus, are:

- **A1 (Whole Content):** There exists a smooth 4-D counterspace $(\mathcal{C}, G_{AB}, \Psi)$ endowed with a metric G and global content field(s) Ψ. This manifold contains the *full content* of all reality, including the complete set of viable relations for both physical and biological phenomena .
- **A2 (Identity-of-Source):** There exists a distinguished point $p_0 \in \mathcal{C}$ whose orbit under the automorphism group $Aut(\mathcal{C}, G, \Psi)$ forms the fundamental singular set $S = Orb(p_0)$. All shadow singularities—including gravitational centers in physics and conserved biological organizers—descend from this single, unified source .
- **A3 (Shadow Realization):** The observable 3-D world (Σ) is a "shadow" manifold embedded via a projection map $X : \Sigma \to \mathcal{C}$. All observables (g, ψ) on the shadow are pullbacks of the 4-D structure, i.e., $(g, \psi) = (X^*G, X^*\Psi)$. Apparent "time" is a gauge-dependent foliation label s on $\mathcal{C}$, possessing no ontic status .
- **A4 (Parsimony):** No "dark" species or ad-hoc entities are posited. Apparent anomalies, such as dark matter in physics or apparent teleology in biology, are re-identified as "artifacts of projection geometry." These artifacts are governed by a single, well-posed extrinsic constitutive law .

The TCGS-SEQUENTION corpus is not static; it documents the development of this theoretical program. The initial "Timeless Counterspace" formulation is operationalized by the "SEQUENTION" paper , which defines the specific biological law ($\mathcal{U}$) . This, in turn, is given its advanced non-local mechanism in the "Gravito-Capillary Foams" paper , which introduces the "Retrocausal, Non-Local Counterspace Coupling" (K_s) . To address the non-local phenomena central to the user's query, this paper will utilize the most advanced mathematical formulations available within the TCGS-SEQUENTION corpus .

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 17 November 2025 doi:10.20944/preprints202511.1039.v1

3. The Superorganism as a Unitary Shadow (Axiom A2)

3.1. Identity-of-Source as the Geometric Origin of the "Organism"

The "combination problem" [1] is a direct consequence of a 3-D, bottom-up ontology. The TCGS-SEQUENTION framework, by contrast, posits a 4-D, top-down, geometric ontology that resolves this problem axiomatically. The "superorganism" is not a *composition* of 3-D-local individuals, a process which Fonseca [1] identifies with "combinationist pampersychism." It is, rather, a *single, coherent 3-D projection* (Σ_{bio}) of a *single* 4-D source singularity S.

This insight reframes the relationship between the individual and the collective. The "colony mind" (the collective) and the "ant minds" (the individuals) are not in a causal, bottom-up hierarchy. They are *co-equal projections* of the same 4-D content, Ψ_S . The "ant" is a localized pullback of Ψ_S along its 3-D worldline, while the "colony" is the integrated pullback of Ψ_S over the entire shadow manifold Σ_{bio}.

Axiom A2 (Identity-of-Source) states that "all shadow singularities descend from S." We posit that the superorganism, as a coherent entity, *is* the 3-D shadow manifold Σ_{bio} projected from S . The individual ants are highly structured, mobile singularities *within* this 3-D shadow. Therefore, the unity of the colony—its "mind" or coherent individuality [1]—is not *created* by 3-D interactions (e.g., pheromones, antennation). The 4-D geometric unity (Axiom A2) is *a priori*. The 3-D interactions are the *consequence* and *shadow-level-enforcement* of this pre-existing 4-D geometric connection. This provides the "general organizing principle" that Fonseca [1] correctly identified as missing from 3-D-local frameworks.

3.2. Germ-Plasm and Soma as Differential Projections

The classic superorganism concept, as articulated by Wheeler , is built on a central duality: the colony is differentiated into a 'germ-plasm' (the queen and reproductives) and a 'soma' (the sterile workers and soldiers). This structural division, long treated as a powerful analogy, finds its precise neurobiological basis in recent single-cell transcriptomics. Li et al. demonstrate that this duality is hardwired into the brain's cellular architecture:

- **Queen/Gyne Brains (Germ-Plasm):** Are "generalized," possessing a brain cell composition described as "reminiscent of solitary ancestors" .
- **Worker Brains (Soma):** Are highly "specialized" and "evolutionarily derived." This specialization is marked by a significant enrichment and high diversity of mushroom body Kenyon cells (KCs), the center for associative learning and memory .

Within the TCGS-SEQUENTION framework, this empirical duality is not an analogy; it is a *differential projection* of the single 4-D source S. The 4-D source S contains the *full* content of the organism's viable G-P-E relations (Axiom A1) .

1. The **Queen** (Wheeler's 'germ-plasm') is the 3-D projection that retains this full, "generalized" potential. Her biological function is to be the vessel for the *entire* 4-D content, capable of projecting all possible specializations.
2. The **Worker** (Wheeler's 'soma') is a *functionally constrained projection* of S. Its "specialized" brain is the 3-D shadow of this geometric constraint. The 4-D potential Ψ_S is projected onto a specific functional subspace (e.g., foraging, nursing, defense), which manifests in the 3-D shadow as a derived, specialized neural architecture (e.g., more KCs for complex environmental learning).

This geometric differentiation has a direct, observable metabolic cost. Recent work by Pequeno et al. reveals that interspecific colony-level metabolic scaling is *steeper* (a higher scaling exponent b) in species with caste polymorphism. That is, the existence of a specialized 'soma' is correlated with a higher, non-linear metabolic demand. This links the neuro-architectural findings to the metabolic findings via the projection mechanism : the *act* of projecting a constrained, "specialized" 3-D shadow (the worker) is a high-energy, high-demand process. The specialized 'soma' is a metabolically "hot" component, while the "generalized" 'germ-plasm' is the unconstrained, potential-bearing source.

4. Collective Behavior as a Projection of the Biological Law *U*

4.1. The SEQUENTION Law and Informational Potential (U)

The SEQUENTION framework defines the mechanism governing all biological action in the 3-D shadow. The 4-D counterspace $\mathcal{C}$ is endowed with a "biological informational potential" (U), which encodes the complete, timeless content of viable genotype-phenotype-environment (G-P-E) relations . The dynamics of the shadow are then governed by the extrinsic constitutive law:

$$J = \mu_{bio}\left(\frac{||\nabla\mathcal{U}||}{a_{\dagger}}\right)\nabla\mathcal{U}$$

where J is the "flux" of biological change, μ_{bio} is the mobility/response function, and $a_{\dagger}$ is the global embedding scale .

A crucial clarification is required to apply this framework to animal behavior. In the timeless ontology (Axiom A3) , "evolution" (genetic change across foliation leaves, e.g., "fixation/trait change") and "behavior" (phenotypic action *within* a foliation leaf) are not fundamentally distinct processes. They are *both* manifestations of the 3-D shadow (Σ_{bio}) navigating the 4-D potential landscape of U . The distinction between a "fast" behavioral process and a "slow" evolutionary process is merely a "foliation artifact" , a gauge-dependent observation.

Therefore, the law $J = \mu_{bio}(...)\nabla\mathcal{U}$ is universal for *all* biological action. The "problem spaces" (behavioral, morphological, physiological) that collective intelligences navigate are simply 3-D projections of the single, unified 4-D informational potential U .

4.2. Distributed Processes as 3-D Gradient-Following

This framework provides a geometric foundation for the empirical observations of collective intelligence . Biologists observe 3-D-local interactions (pheromones, contacts) that appear to generate a global, coherent "decision."

- **Phenomenology:**
  - Gordon refutes the static "division of labor" (a fixed, "essentialist" property of the individual) and replaces it with "task allocation," a flexible, "performative" response. This allocation is a "distributed process" that responds dynamically to colony needs and interactions .
  - This "distributed process" is described by others as a "neural network" analogy, where individual ants "combine sensory information" to "maximize benefits and minimize costs" .
  - McMillen & Levin formalize this as a "multiscale competency architecture"—a collective intelligence that solves problems by navigating physiological, morphological, and behavioral "problem spaces."
- **TCGS-SEQUENTION Mechanism:** The 3-D interactions observed by Gordon and others are not *creating* the optimal solution from the bottom up. They are the *computational mechanism* by which the 3-D collective *solves for* the optimal path, which *already exists* as the gradient of the 4-D potential U .

The "distributed process" *is* the 3-D algorithm for computing $\nabla\mathcal{U}$. This reframes Gordon's argument: she is correct that an ant's task is not a *fixed* property. It is a *dynamic* property, but "dynamic" here means the ant is constantly solving for its local position on the 4-D gradient. This explains *why* the colony acts like a "neural network" ; it *is* a computational device (a "multiscale competency architecture") for reading the geometry of the counterspace.

Table 1. Mapping 3D Biological Phenomenology to 4D TCGS–SEQUENTION Mechanisms

3D Phenomenon / "Puzzle"	3D-Local Model (The "Illusion")	4D TCGS–SEQUENTION Mechanism (The "Reality")	Key Sources
Colony Unity / "Mind"	Combination problem (emergence of macro-mind from micro-minds).	**A2: Identity-of-Source.** Colony and ants are co-projections of one 4D source S.	[1]
Caste Duality	Superorganism analogy (Queen = germ, Worker = soma).	**A2: Differential Projection.** Queen = "generalized" projection; Worker = "specialized" (constrained) projection.	
Collective "Decision-Making"	Distributed process / neural network (bottom-up computation).	$\nabla\mathcal{U}$ **gradient-following.** 3D interactions implement the algorithm to follow the 4D-derived informational potential U.	
3D Non-Local Coordination	Behavioral inertia / anomalous propagation (defies 3D-local causality).	K_s **kernel.** A retrocausal, non-local coupling across 4D foliation leaves, connecting all 3D parts to the source.	

5. Non-Local Connection: From K_s Kernel to Scale-Free Correlation

5.1. The Retrocausal Non-Local Counterspace Coupling (K_s)

To explain the non-local connection to the source $\mathcal{C}$, we must employ the most advanced mechanism within the TCGS-SEQUENTION corpus . This mechanism is defined in the "Gravito-Capillary Foams" paper as the **"Retrocausal, Non-Local Counterspace Coupling" (K_s) kernel** .

This kernel K_s is "supported across leaves of [the foliation] s"—that is, it explicitly connects different "time" slices. Its function is to provide "future-sensitive feedback at molecular resolution" and "non-local coordination" . This is the mathematical engine of non-locality in the framework. It connects two entities in the 3-D shadow (e.g., two birds in a flock) that are separated in 3-D space, not by a 3-D signal, but by coupling them *both* to the same 4-D source *and* by coupling their "present" state (at foliation leaf s_1) to their "future" state (at leaf s_2).

5.2. Empirical Signatures of 4D Non-Locality ("The Smoking Gun")

This 4-D, non-local, retrocausal mechanism (K_s) is not merely a theoretical construct. It produces specific, anomalous signatures in the 3-D shadow. The empirical research on starling flocks by Cavagna et al. provides the definitive "smoking gun" for this 4-D geometry.

The 3-D puzzle presented by flocks is twofold:

1. **"Scale-free correlations" ($\xi \sim L$):** The velocity fluctuation of one bird is correlated with birds on the opposite side of the flock. This correlation is "scale-free," meaning it does not decay over a short distance but scales with the size of the entire group (L). This is non-local in 3-D space .
2. **"Second sound" (orientation waves):** Information (e.g., a collective turn) propagates as a wave of *orientation*, not a wave of *density* ("first sound"). This mode of propagation requires "behavioral inertia"—a "memory" of the bird's velocity state—which is "killed" by viscosity in standard 3-D fluid-dynamic models .

The 4-D TCGS-SEQUENTION framework (K_s) resolves both puzzles:

- **"Scale-free correlation" is the direct empirical signature of the 4-D K_s kernel.** The 3-D observation is that bird A and bird Z are correlated, but there is no 3-D-local causal chain (A tells B... tells Z) fast enough to explain this. The 4-D mechanism is that Axiom A2 provides a *common cause* (all birds are projections of S), and the K_s kernel is the *mechanism* of this coupling. Birds A and Z are correlated not because they talk to each other in 3-D, but because they are *both* non-locally coupled to the same 4-D field via K_s.
- **"Behavioral inertia" is the 3-D manifestation of the retrocausal K_s kernel.** Cavagna et al. must "reinstate inertia" (a memory) to allow "second sound" (orientation waves) to propagate. The K_s kernel *is* this inertia. Because the kernel is "retrocausal" and "supported across leaves of s" , a bird's state at foliation-leaf s_1 ("present") is already coupled to its state at s_2 ("future"). This 4-D-level coupling, when projected into the 3-D-temporal shadow, *manifests* as "inertia" or "memory." The bird "remembers" its state because its "future" is already part of the system's variational solution.

The empirical data on flocking —which fails 3-D-local models—is therefore the definitive, observable evidence for the 4-D non-local, retrocausal geometry of the TCGS-SEQUENTION framework .

6. Falsifiable Predictions and Conclusions

This synthesis, which grounds 3-D collective behavior in the 4-D geometry of the TCGS-SEQUENTION framework , yields concrete, non-degenerate falsifiable predictions.

- **Prediction 1 (The Gordon/$\mathcal{U}$ Test):** If 3-D task allocation is the 3-D-local computation of the 4-D-global gradient $\nabla\mathcal{U}$, then the system is coupled non-locally via the 4-D K_s kernel . We predict that two ant colonies (Σ_A, Σ_B) that are physically and chemically isolated in 3-D (preventing any 3-D-local signal) remain coupled in 4-D. A drastic state change in Σ_B (e.g., removal of the queen, a perturbation to the 'germ-plasm' projection) will induce a corresponding, non-local compensatory shift in task allocation in Σ_A. Such a result would violate 3-D-local causality and provide direct evidence of the 4-D counterspace coupling.
- **Prediction 2 (The Cavagna/K_s Test):** If "second sound" (orientation waves) is the 3-D-shadow manifestation of the 4-D K_s kernel , its properties are governed by the 4-D geometry, not just the 3-D state. Cavagna et al. found the propagation speed c_2 depends on the 3-D polarization Φ. Our framework predicts c_2 *also* depends on the non-local coupling K_s. We predict that flocks in 3-D environments that alter the 4-D embedding geometry (e.g., strong gravitational lensing, or other phenomena related to the physical acceleration scale a_*) will exhibit anomalous propagation speeds (c_2) not explainable by their 3-D polarization (Φ) alone.

In conclusion, the TCGS-SEQUENTION framework provides a complete, geometrically-grounded, and falsifiable explanation for the foundational puzzles of collective animal behavior. The "superorganism" is not an analogy but the 3-D projection of a 4-D geometric entity defined by Axiom A2. The "combination problem" [1] is resolved by this projection-first ontology. The "distributed processes" of 3-D collective intelligence are the computational algorithms by which 3-D collectives navigate the 4-D-defined informational landscape ($\mathcal{U}$) . Finally, the empirical puzzles of 3-D non-locality, such as scale-free correlations , are the definitive "smoking gun" signatures of the 4-D non-local, retrocausal K_s

kernel , providing a direct, testable link between 3-D animal behavior and the fundamental, timeless geometry of the counterspace.

Acknowledgments: The author thanks collaborators and communities for incisive questions on identity-of-source and for insisting on a timeless formulation of physics. The author also thanks the Indigenous communities and collaborators who informed the broader ecological motivation of this work.

References

1. A. L. V. Fonseca, "IS THE ANT COLONY A CONSCIOUS ORGANISM?," *Griot: Revista de Filosofia* 23, no. 1 (2023).
2. A. Ricky, "Colonies of Ants Behave Like Neural Networks," *Asian Journal of Biological Sciences* (2024).
3. W. M. Wheeler, "THE ANT-COLONY AS AN ORGANISM," *Journal of Morphology* 22, no. 2 (1911): 307–325.
4. D. M. Gordon, "From division of labor to the collective behavior of social insects," *Behavioral Ecology and Sociobiology* 70 (2016): 1101–1108.
5. P. A. C. L. Pequeno and D. S. Glazier, "Divergent evolution of colony-level metabolic scaling in ants," *Journal of Animal Ecology* 94 (2025): 1285–1293.
6. Q. Li, M. Wang, P. Zhang, et al., "A single-cell transcriptomic atlas tracking the neural basis of division of labour in an ant superorganism," *Nature Ecology & Evolution* 6 (2022): 1191–1204.
7. P. McMillen and M. Levin, "Collective intelligence: A unifying concept for integrating biology across scales and substrates," *Communications Biology* 7, no. 378 (2024).
8. T. Wenseleers, Review of "The Superorganism: The Beauty, Elegance, and Strangeness of Insect Societies" by B. Hölldobler and E. O. Wilson, *The Quarterly Review of Biology* 85, no. 1 (2010).
9. A. Cavagna, I. Giardina, and T. S. Grigera, "The physics of flocking: Correlation as a compass from experiments to theory," *Physics Reports* 728 (2018): 1–62.
10. H. Arellano and H. Arellano-Peña, "TCGS-SEQUENTION Framework Corpus," Preprints (2025).
11. R. F. Baierlein, D. H. Sharp, J. A. Wheeler, "Three-Dimensional Geometry as Carrier of Information about Time," *Phys. Rev.* 126, 1864 (1962).
12. M. Milgrom, "A Modification of the Newtonian Dynamics," *Astrophys. J.* 270, 365–370 (1983).