Does Geometry Require Physicality?
Spacetime as Emergent Informational Constraint Density

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Abstract

Donald Hoffman's Interface Theory of Perception (ITP) suggests that spacetime is not a fundamental reality but a functional interface hiding a complex network of conscious agents. However, the mathematical "engine" that drives the transition from informational dynamics to geometric perception remains largely undefined. This paper proposes the Ontodynamic Matrix Singularity (OMS) as the foundational mechanism for this transition. Through a series of computational simulations (N=15, 210 directional flows), we demonstrate that the application of an "Ambiguity Resolution Operator" ($\phi\Psi$) over a symmetric adjacency matrix generates stable informational cores. Our results show that mass and spacetime curvature are not intrinsic properties of matter, but emergent regulatory structures arising from informational saturation. This model provides a formal bridge between Conscious Realism and physical observables.

Key Words: Conscious Realism, Computational Neuropsychology, Physical Information Theory, Principle of Free Energy, Quantum Informational Dynamics, Ontodynamic Matrix Singularity, Emergent Spacetime.

1. Introduction

The traditional understanding of reality as something fundamentally physical or material seems insufficient to explain how complex and coherent structures arise even before any geometry or matter. Donald Hoffman's Conscious Realism (2019), (HOFFMAN & PRAKASH, 2014) proposes that reality is formed by a network of conscious agents, each mathematically described by a sextet of functions, whose interactions are probabilistic (FIELDS & HOFFMAN, 2023). Within this model, information is not just static data or a bit, nor algorithmic complexity: it is the dynamic transformation between states of experience—a operator that governs how the agents relate. On the other hand, John Archibald Wheeler's (1989) perspective, expressed in his concept of "It from Bit," is the notion that physical reality—particles, fields, and even space-time—emerges from fundamental binary decisions, or "bits," which represent elementary distinctions of information. In other words, matter and physical laws derive from information processes, not the other way around.

Integrating this idea with Hoffman's Conscious Realism, we can intuit by analogy a plane or layer of expression, intrinsic to deeper levels of Wheeler's foam, where at this level, patterns of relational information interaction occur between agents — or between units of distinction — that define patterns of coherence before any regulatory geometry, mass, or physicalized energy appears. In this sense, both Wheeler and Hoffman suggest that information is not merely descriptive in nature, but ontologically productive, forming the basis of everything that eventually manifests as tangible reality. While algorithmic complexity measures how compressible or structured something is, it does not describe how reality evolves or how patterns emerge from interactions. In this thesis, it is proposed that information in purely relational systems can, upon reaching a critical threshold of

informational constraint density, generate coherent patterns that precede geometry.and the materialized matter.

The fundamental information, in this sense, is the degree of relational restriction between possible states. When internal coherence drastically reduces the state space, an informational condensation occurs that alters the global dynamics of the system, creating attractors and establishing stable patterns — a mechanism interpretable as the emergence of mass and spatial curvature. A hybrid definition of information is proposed: as a dynamic relational structure capable of generating stable states under transformation, measurable by transition matrices, dynamic entropy, mutual information, and structural coherence over time. In a relatively complementary way to the ideas of Wheeler and Hoffman, contemporary relational approaches, such as those advocated by Carlo Rovelli, suggest that there are no entities with intrinsic properties independent of the interactions that define them (2004), (1996).

The development of this study was therefore motivated by the need to observe how information in interaction generates coherence and structure before any geometry or mass, providing mathematical and conceptual support for an ontology of reality based on information and energy. This approach allows us to formalize the central idea of what I call the Ontodynamic Matrix Singularity (OMS). The Ontodynamic Matrix Singularity (OMS) is a computational model proposed to simulate and illustrate how this coherence and self-organization can arise in information networks. This study explores, both mathematically and intuitively, how informational interaction can generate structure, providing evidence for the thesis that fundamental reality is intrinsically based on information and energy. If spacetime is doomed, as Nima Arkani-Hamed (2014) suggests, we must find the non-geometric rules from which geometry emerges. The OMS model is intended to be a formal relational dynamical illustration compatible with information-based ontologies of perception.

This study introduces the Ontodynamic Matrix Singularity (OMS). The propose here is that reality is a continuous processing cycle where the current state of information $Is^{(t)}$ is under constant pressure from a noise of possibilities $Ais^{(t)}$. The transition to the next state is governed by the $\phi\Psi$ Operator, which resolves ambiguity and projects the system into a stable geometric interface.

2. Methods

The study was conducted in three phases: **A) Conceptual Proof:** A manual simulation with a 4-node network (A, B, C, D) using a symmetric adjacency matrix.**Stability Test:** Computational verification of dominant core convergence under controlled growth. **Scalability Simulation:** A network of 15 nodes (N=15) generating 210 potential connections to test the robustness of the $\phi\Psi$ Operator. The OMS Transition Equation: The state update follows the fórmula:

$$Is(t+1) = Is(t) + \alpha\sum Ais(t)$$

Is(t +1) represents the informational state at the next iteration (future state), α defines the strength of relational influence, and the summation considers all alternative states **Ais$^{(t)}$** connected to the current state **Is(t).**

Computational Implementation

All simulations were implemented in Python using NumPy for numerical operations and Matplotlib for visualization. Fixed random seeds were employed to ensure reproducibility. The dynamical update rule was implemented deterministically according to the defined $\phi\Psi$ operator, and convergence behavior was evaluated across different network sizes and parameter values of α.
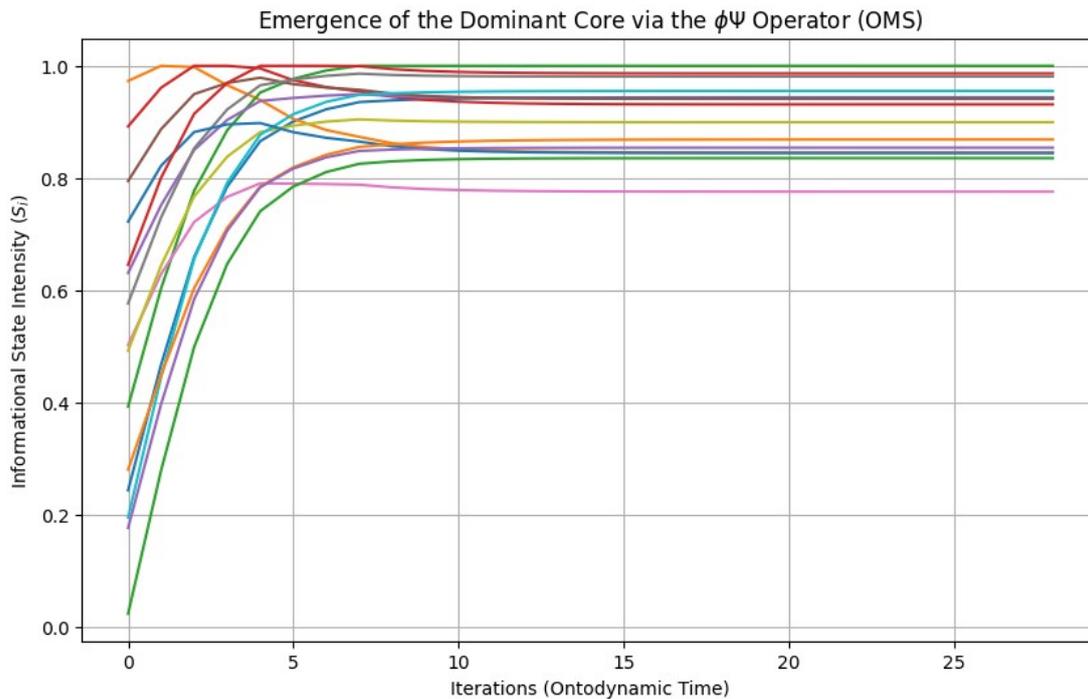
3. Results

Figure 1. Emergence of the Dominant Core via the $\phi\Psi$ Operator (OMS). The plot illustrates the evolution of informational states **Is**$^{(t)}$ over 28 ontodynamic iterations. Initial states represent high entropy and ambiguity. The convergence of trajectories into stable, non-varying horizontal lines demonstrates the resolution of ambiguity and the formation of a "Dominant Core," which mathematically corresponds to the emergence of persistent physical icons (mass and objects) within the conscious agent interface.

The computational simulation (Figure 1) confirms the theoretical stability of the OMS model. Starting from a stochastic distribution of informational intensity $Si^{(t)}$ at T=0), the system reaches asymptotic stability within approximately 10 iterations. The clear stratification of states indicates that the $\phi\Psi$ operator effectively filters noise and establishes a relational hierarchy.This persistent stratification may be interpreted as a relational analogue to curvature-like behavior in discrete informational systems.
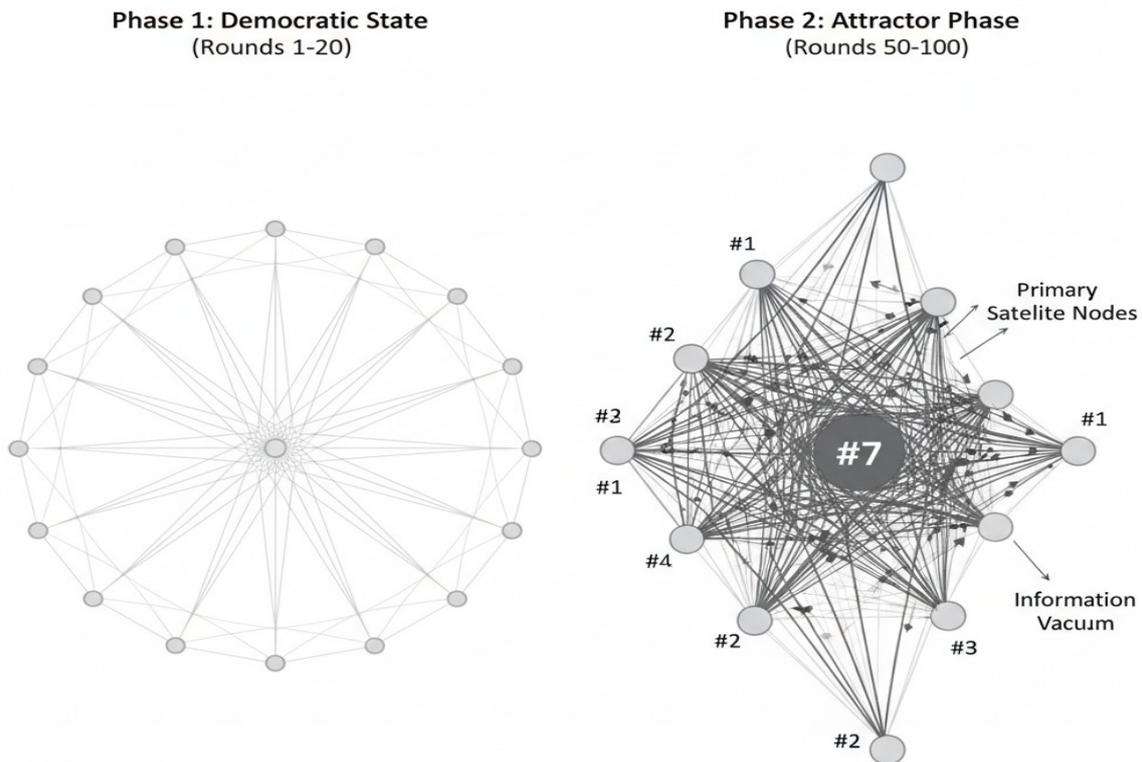
Phase 1: Democratic State
(Rounds 1-20)

Phase 2: Attractor Phase
(Rounds 50-100)

Primary
Satelite Nodes

#7

Information
Vacuum

Fig. 2. Topological Stabilization Dynamics and Symmetry Collapse. The image shows the transition of the agent network N=15 from an initial stochastic state (Phase 1) to an asymptotically stable configuration (Phase 2). It can be observed that the application of the $\phi\Psi$ operator induces a symmetry collapse, where Node #07 emerges as a central attractor with high informational density, while Node #03 assumes a primary satellite position. The disparity in the state vectors $Is^{(2)}$ between these nodes results in a deformation of the graph metric, characterizing what is defined as the 'relational tension' of the Ontodynamic Matrix.

4. Discussion

The evolution of the Ontodynamic Matrix Singularity (OMS) model was monitored through the node strength **$Is^{(t)}$,** representing the sum of all connection weights for a given element, alongside the evolution of adjacency matrices. From the first to the third experiments, the data reveal scale invariance: the original rule remains effective even as the number of potential interactions increases exponentially. This demonstrates how the proportional growth of indirect relational connections leads to self-organization. The system was designed solely from informational states and their relations, without assuming spatial coordinates, physical time, or prior geometric measures; yet, it demonstrated that a non-physicalized regulatory geometry emerges from the dynamics of the relations themselves.

The observed dynamism in the OMS model is neither random nor arbitrary. It points to the principle that connections strengthen when participating in relevant informational flows. Therefore, a network does not configure or evolve by chance; it consolidates trajectories of greater relational consistency. Classical understanding of reality, based on the primacy of physicalized matter, faces growing challenges from quantum information theories. In this study, we assume that reality at its most fundamental level (Level 0) potentially consists of a pre-geometric field of order—a domain where multiple states of information and energy coexist as relational potentialities.

The data suggest that regulatory relational geometry and mass are not intrinsic properties, but the result of $Is^{(t)}$ crossing a critical threshold of informational density. The strength disparity observed between Node #07 and Node #03 generates a curvature in the network metric. may suggest a relational reinterpretation of spacetime curvature grounded in informational dynamics.This may offer a relational model that functions as a conceptual analogue to spacetime curvature within an informational framework.

This point directly addresses one of the most significant challenges in Donald Hoffman's Conscious Realism: the derivation of physical properties, such as mass, from agent interactions. Our data suggest a promising pathway: regulatory geometry and mass are not fundamental, but emerge as a threshold phenomenon. When the density of informational constraints crosses a critical saturation point, the network restricts relational fluidity, crystallizing into what we perceive as physical solidity.

Graph curvature is a manifestation of interaction density. Where the dominant nucleus establishes itself, it acts as a point of maximum curvature, distorting the weight metric in its vicinity and converting informational entropy into a regulatory, relational geometric structure. By analogy Just as the Planck Scale marks the point where quantum and gravitational effects become equally relevant, the simulation indicates that information organization creates clear transitions between layers of reality: from a purely informational state to a quantum field settled by a non-physicalized regulatory geometry—a state of superposition where all possibilities coexist—and finally to physicalized matter, representing the collapse of states into geometry and mass. The simple mathematics of relational interactions can serve as an explanatory basis for the transitional manifestations of fundamental information order, offering a bridge between the probabilistic behavior of the quantum world and the material structure of the observable universe. Based on simulation data, the transition from a pre-geometric to a physicalized geometric state occurs when the centrality of $Is^{(t)}$—a dominant nucleus—distorts the connection metric of the network. If the information force of the system increases, it acquires form; if its density reaches a critical threshold, it acquires mass and curves space.

Relational Tension as the Genesis of Curvature

Data analysis suggests that we are not merely looking at a statistical simulation, but at the potential perception of a Law of Emergent Regulatory Geometry. It is observed that "graph tension"—the network's effort to balance informational flow—could be considered a functional correlate of spacetime curvature. When the $Is^{(t)}$ of a dominant nucleus exceeds the critical density threshold, it "demands" a reconfiguration of its relational neighborhood, forcing peripheral connections (such as the A–C pair) to adjust to support the new "data mass." In this sense, matter does not inhabit space; it is the result of informational saturation that curves the network upon itself, consolidating what we perceive as physical reality from a purely relational fabric.

A Potential Principle of Conservation of Relational Consistency?

The invariance observed across experiments, from scale N=4 to N=15, allows us to infer the existence of a Principle of Conservation of Relational Consistency— where self-organization acts as the common denominator between the simplicity of the bit and galactic complexity. From this perspective, geometry is not the stage where reality happens, but the final result of a continuous flow-optimization calculation; spacetime is the metric solution the system finds to maintain its informational integrity.

The Ambiguity Resolution Operator (ϕΨ)

To conceive of the OMS (Ontodynamic Matrix Singularity) as a fundamental level implies that it is not an expression of something prior. In this sense, the architecture of reality organizes itself into a dynamic where a continuous information cycle becomes a technical necessity of the matrix. The current state of reality **Is$^{(t)}$** is not static; it exists under constant pressure from a "noise" of possibilities, the **Ais$^{(t)}$** (Alternative Informational State). The matrix ontodynamics and the processing of states within the singularity suggest an inescapable conclusion: the transition between states is not a stochastic or passive process. Simulation data and relational network topologies lead to the inference of an Ambiguity Resolution Operator ϕΨ—an executor that discriminates the ambiguity between what is and what can be, projecting the system into the next state: I**s(t+1) = ϕΨ, Ais$^{(t)}$.**

The functional description of this operator implies its capacity for Informational Saturation Parameterization (ISP). This property is intrinsic to ϕΨ but immanent to the OMS, where **ϕΨ** acts as its executive system. ISP emerges as a boundary property. However, when the complexity of relations and the density of alternatives **Ais$^{(t)}$** reach a critical point, the system "saturates." Local processing is no longer sufficient to resolve ambiguity without the system losing its singular nature. At this moment, the activation of ϕΨ Is$^{(t)}$, Ais$^{(t)}$ occurs in search of coherence, expressing an intention of resolution.If the matrix were purely stochastic-probabilistic, the transition between **Is$^{(t)}$** and **Is(t+1)** would be based solely on the highest probability, like a ball rolling down irregular terrain. But simulation data suggest a different direction. In a stochastic system, saturation would generate chaos or "locking" (maximum entropy). In the present model, saturation generates intentional activation. ϕΨ activates to resolve ambiguity, indicating a selection criterion that is not random, but commutative and integrative. The system is forced into a global integration to maintain coherence—a state of total integration where information becomes irreducible and self-referential to collapse the next state. Chance does not bring values closer or further apart with a purpose; it merely distributes them randomly. In a stochastic regime, the future is a collision of uncertainties; in operational regimes, it is a resolution.

The **ϕΨ** does not merely observe the collapse; it is the very act of resolving saturation that allows the matrix to continue its functional iteration as an amplified and modified resonance effect.From the OMS perspective, mass is no longer a mere static attribute of matter but can potentially be thought of as energy confined in coherence. This reflects the executive action of the resolution vector, where informational fluctuation is directed into a stable regulatory geometry by the **ϕΨ** operator. In this state, the matrix's recursivity reaches a "sustenance loop," transforming volatile information into tangible structure.We can express this relationship through the idea that mass becomes physical evidence of the Operator's action. The lower the ambiguity **(Ψ)** and the higher the coherence **(ϕ),** the greater the perception of tangibility and solidity. Physicalized matter is the expression of the point where information is expressed so organized that it becomes confined.

Neuropsychological Analogy and Friston's Free Energy Principle

In this context, the role of the ϕΨ operator within the Ontodynamic Matrix can be conceptualized through a functional analogy with the executive functions of classical neuropsychology. Just as inhibitory control and response selection processes resolve sensory ambiguity to generate a coherent and stable perception of the environment, the proposed operator acts as the ambiguity resolution mechanism for the agent network. By collapsing the initial stochastic indeterminacy into an asymptotic stability configuration, the operator projects the structure we interpret as geometry and mass.Following Friston's Free Energy Principle (2010), the ϕΨ Operator would function as a mechanism for minimizing informational uncertainty. The phase transition would thus represent the state of minimum 'free energy' for the network, where the resolution of ambiguity results in the stable emergence of geometric metrics and inertia. This convergence suggests that 'mass' is the iconic representation of a system that has attained its maximum predictive efficiency.

5. Conclusion

The analysis of the simulated data suggests that reality may operate as a state-processing system that prioritizes **relational integrity** over randomness. The observed scale invariance confirms that the model does not depend on volume, but rather on **informational logistics**. It is concluded that the transition between the pre-geometric state and physicalized matter is a function of **connectivity density**. When the sum of weights of a node $Is^{(t)}$ reaches the saturation threshold, the network undergoes a metric reconfiguration update. what classical physics terms 'mass' and 'spatial curvature' may find a relational analogue, within this framework, in the stabilization of high-density informational flows. Mass can be conceived as **energy confined in coherence**—a state where information reaches such a level of consistency that it becomes physicalized.

In synthesis, the **OMS (Ontodynamic Matrix Singularity)** presents a universe that is, at its fundamental reality, information and energy. Matter does not precede information; it is the evidence that information has been processed, filtered, and consolidated. The system is not passive; it is operative, constantly moving from probabilistic ambiguity toward geometric resolution.

Declaration of Conflicting Interests

The author declares that there are no financial, personal, or institutional conflicts of interest that could have inappropriately influenced the conduct of this study or the writing of the manuscript. This research was conducted independently, without funding from external entities or corporate affiliations that could bias the results presented.

Data Availability Statement

 All data generated or analyzed during this study, including the mathematical parameters and the computational implementation (Python code) of the Operator ϕΨ , are included in the Appendix of this article.

References

Hoffman, D. D. (2019). The Case Against Reality: Why Evolution Hid the Truth from Our Eyes. W.W. Norton & Company.

Hoffman, D. D., & Prakash, C. (2014). Objects of consciousness. Frontiers in Psychology, 5, 577. https://doi.org/10.3389/fpsyg.2014.00577

Fields, C., & Hoffman, D. D. (2023). Fusions of Consciousness. Entropy, 25(1), 129. https://doi.org/10.3390/e25010129

Wheeler, J. A. (1989). Information, physics, quantum: The search for links. Proceedings of the 3rd International Symposium on Foundations of Quantum Mechanics, 354-368.

Rovelli, C. (2004). Quantum Gravity. Cambridge University Press.

Rovelli, C. (1996). Relational quantum mechanics. International Journal of Theoretical Physics, 35(8), 1637-1678.

Arkani-Hamed, N., & Trnka, J. (2014). The Amplituhedron. *Journal of High Energy Physics*, 2014(10), 30. https://doi.org/10.1007/JHEP10(2014)030

Friston, K. (2010). The free-energy principle: a rough guide to the brain? Nature Reviews Neuroscience, 11(2), 127-138. https://doi.org/10.1038/nrn2787

Appendix

This appendix provides the Python source code for the Ontodynamic Matrix (SMO) simulation. The script implements the ϕΨ Operator to demonstrate the emergence of a dominant core from stochastic informational noise. The code is designed for reproducibility and follows directly from the formal definition of the ϕΨ operator described in the Methods section.

```python
Python

import numpy as np
import matplotlib.pyplot as plt

# SMO Model Parameters (Ontodynamic Matrix)
# N=15 generates 105 bidirectional edges (210 potential directional flows)
N = 15
alpha = 0.1  # Influence Coefficient (Informational Pressure)
iterations = 50
epsilon = 1e-6  # Asymptotic convergence threshold

# 1. Symmetric Adjacency Matrix Initialization
# Represents the initial stochastic noise of informational possibilities
np.random.seed(42)  # For reproducibility
adj_matrix = np.random.rand(N, N)
adj_matrix = (adj_matrix + adj_matrix.T) / 2  # Ensures absolute symmetry
np.fill_diagonal(adj_matrix, 0)  # Removes self-influence loops

# Initial Node States (Is - Informational State Intensity)
I = np.random.rand(N)

# History storage for convergence visualization
history = [I.copy()]

print("Starting Ambiguity Resolution Operator (ϕΨ)...")

# 2. Recursive Update Cycle (The SMO Engine)
for t in range(iterations):
    I_next = np.zeros(N)
    for s in range(N):
        # Implementation: Is(t+1) = Is(t) + alpha * sum(Ais * I)
        influence_sum = np.sum(adj_matrix[s, :] * I)
        I_next[s] = I[s] + alpha * influence_sum

    # Normalization (Simulating interface processing economy)
    I_next = I_next / np.max(I_next)

    # Stability Check (Asymptotic Convergence)
    if np.linalg.norm(I_next - I) < epsilon:
        print(f"Convergence reached at iteration {t}")
        break

    I = I_next.copy()
    history.append(I.copy())

# 3. Results Visualization (Emergence of the Dominant Core)
plt.figure(figsize=(10, 6))
plt.plot(history)
plt.title("Emergence of the Dominant Core via ϕΨ Operator (SMO)")
plt.xlabel("Iterations (Ontodynamic Time)")
plt.ylabel("Informational State Intensity (Is)")
plt.grid(True)

# Save the figure in high resolution for publication (300 dpi)
plt.savefig("Emergence_Dominant_Core_SMO.png", dpi=300, bbox_inches='tight')

plt.show()
```

```
print("Simulation complete. The dominant core represents the emergent 'mass'.")
print("Figure saved as 'Emergence_Dominant_Core_SMO.png'")
```

Table. A1 Symmetric Adjacency Matrix

	A	**B**	**C**	**D**
A	0	0.5	0.2	0.1
B	0.5	0	0.5	0.5
C	0.2	0.5	0	0.1
D	0.1	0.5	0.1	0

The simulation utilizes a symmetric adjacency matrix to represent the informational exchange between agents, ensuring that the coupling within the $\phi\Psi$ Operator maintains relational reciprocity.

Table A2. Connection Update

Connection	Current Value	Indirect Paths	Sum of Products	Reinforcement (× 0.2)	New Value (Update Weight)
A–D	0.1	(A–B × B–D) = 0.5×0,5 = 0,25 (A–C × C–D) = 0.2×0,1 = 0,02	**0.27**	0.05	**0.15**
B–C	0.5	(B–A × A–C) = 0.5×0,2 = 0,10 (B–D × D–C) = 0.5×0,1 = 0,05	**0.15**	0.03	**0.53**
B–D	0.5	(B–A × A–D) = 0.5×0,1 = 0,05 (B–C × C–D) = 0.5×0,1 = 0,05	**0.1**	0.02	**0.52**
C–D	0.1	(C–A × A–D) = 0.2×0,1 = 0,02 (C–B × B–D)= 0.5×0,5 = 0,25	**0.27**	0.05	**0.15**

Table A2: Iterative Connection Update. This table details the recursive calculation performed. The Current Value of each connection is updated based on the Sum of Products of its Indirect Paths, multiplied by a Reinforcement factor of 0.2. This process demonstrates the convergence toward the Symmetric Adjacency Matrix observed in Phase 2. The model's dynamics are iterative and based on the principle that the strength of a direct connection between two nodes is influenced by indirect paths (path length = 2) that connect them via a third node. Strong paths reinforce related connections, ensuring that the structure grows through coherence rather than noise. Strengthening occurs where consistent flow already exists.In the case of the A–C connection, the increase from 0.2 to 0.252 illustrates this mechanism. The presence of a strong node, such as B, acts as a structural catalyst. It does not impose order from the outside; instead, it reorganizes the network from within, pulling the architecture toward higher density and integration.

Consequently, the network does not evolve by chance, but rather consolidates trajectories of greater relational consistency. Notably, the C–D connection grew significantly (from 0.10 to 0.154), not through its own strength, but because it is indirectly connected to a strong $Is^{(t)}$ node (B). The C–B–D path (0.5 \times 0.5 = 0.25) was decisive, providing the first evidence that connections do not grow in isolation but tend to be reinforced by the network's dominant flows. Node B begins to act as a structural catalyst, redistributing coherence and density to less integrated regions, effectively forming a dominant core
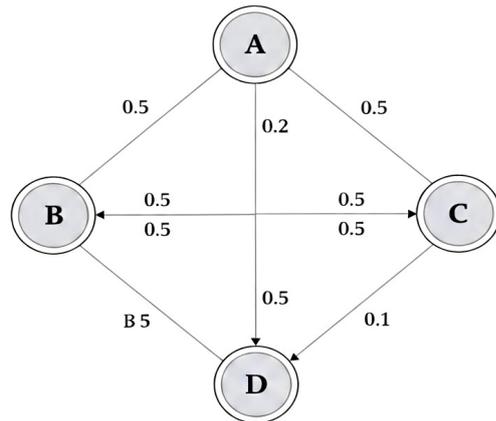
Figure A1. Initial State of the Information Network

Figure A2. Scalability Test

Rodada	A-B	A-C	A-D	B-C	B-D	C-D
1	0.50	0.20	0.10	0.50	0.50	0.10
2	0.53	0.25	0.15	0.53	0.52	0.15
3	0.57	0.31	0.22	0.57	0.55	0.22
4	0.63	0.39	0.29	0.63	0.60	0.29
5	0.72	0.49	0.39	0.72	0.68	0.39
6	0.84	0.62	0.53	0.84	0.79	0.53
7	1.03	0.82	0.73	1.03	0.97	0.73
8	1.33	1.13	1.04	1.33	1.26	1.04
9	1.90	1.71	1.62	1.90	1.82	1.62
10	3.14	2.95	2.86	3.14	3.05	2.86

Evolution of connection weights between nodes over the initial 10 rounds, highlighting non-linear growth and the differentiation of interactions. Node B rapidly emerges as the most influential node.

Figure A3. Long-term simulation (1000 rounds, N=4)

Evolução da Centralidade dos Nós (1000 Rodadas)
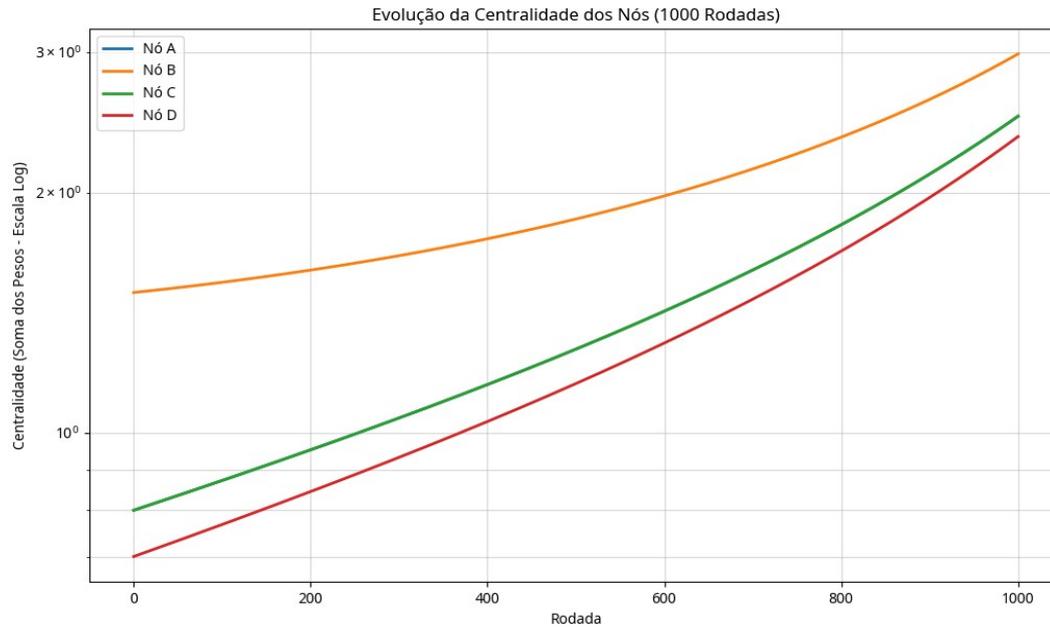
 Evolution of Node Centrality (1000 Rounds). This log-scale graph illustrates how the
centrality of each node (sum of its connection weights) develops over 1000 rounds,
with node B maintaining the highest centrality and demonstrating exponential growth

Table A3. Scalability and Complexity Testing

Organizational Metric	Phase I (N=4)	Phase II (N=4)	Phase III (N=15)
Dominant Attractor	Present	Absolute	Hiper-Dominant
Hierarchy	Null (Binary)	Null	Complexa (Multi-layer)
Weight Divergence	Linear	Exponential	Log-Normal / Fractal