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COGNITIVE INERTIA IN DIRECTED SEMANTIC FIELDS: PIGS IN SPACE REVISITED

Joseph Woelfel[1], Emary Iacobucci[1], Frank Tutzauer[1], Joe K. Woelfel[2], Claude Sonnet 4.5[3], GPT-5[4]

[1] University at Buffalo, State University of New York, The Galileo Company

[2]The Galileo Company

[3]Anthropic, San Francisco, CA
[4] OpenAI, San Francisco, CA

*Correspondence: jwoelfel@buffalo.edu

Abstract

Convergences in sociological research, neuroscience, artificial intelligence and communication research have focused attention on the inertial properties of cognitive processes. Early work using ratio-scaled paired comparison measurement suggested that cognitive objects embedded in multidimensional spaces exhibit inertial properties. Concepts encountered more frequently resist movement under persuasive influence, suggesting measurable cognitive mass. A replication conducted thirty-seven years later confirmed this pattern with remarkable stability. Recent developments in directed cognitive field theory provide a formal framework for these findings. We show that cognitive inertia emerges naturally from perturbations of equilibrium diffusion fields defined over directed cognitive operators. Spectral properties of these operators determine conceptual mass, while persuasive messages act as forces inducing displacement. Reanalysis of the original Pigs in Space data demonstrates strong agreement between theoretical predictions and observed motion. These findings support a field-theoretic model of cognition in which concepts possess measurable inertia, clusters behave as composite masses, and cognitive geometry exhibits dynamic warping under influence.

Keywords: cognitive inertia, semantic fields, Galileo methodology, concept dynamics, field theory, persuasion, Dort.

The concept of inertia has long been used metaphorically in discussions of cognitive and cultural processes. Political candidates gain momentum, attitudes resist change, and beliefs shift gradually under influence. Whether these metaphors correspond to measurable scientific properties has remained an open question.

Woelfel and Haller (1971) conducted a major survey of adolescent children and their significant others in Wisconsin and found that the largest effect on the levels of educational and occupational aspirations of the children was the arithmetic mean of the expectations held for them by their significant others. Since the larger the N of a mean, the larger the amount of information required to alter the mean, this implies that aspirations may be more or less "massive" depending on their information history. Later, in a lagged 2 stage path analysis, Saltiel showed that the largest retarding effect on the change in aspirations for a sample of Montana youth was the amount of information received from significant others and that this effect was significantly larger than traditional measures of source credibility. (Saltiel & Woelfel, 1975).

Early work within the Galileo measurement framework suggested that cognitive and cultural objects could be represented as points embedded in multidimensional spaces derived from ratio-scaled paired comparison measurements (Woelfel & Fink, 1980). Within these spaces, objects could move in response to persuasive messages, and those movements appeared to exhibit properties analogous to classical mechanics. The seminal "Pigs in Space" experiment (Barnett, 1988) demonstrated that frequency of exposure—a proxy for accumulated cognitive experience—correlated nearly perfectly with resistance to persuasive movement, although technical difficulties prevented a precise estimate of the relationship. Barnett's experiment utilized four control groups in which students were asked to estimate the difference or distance between all pairs of several barnyard animals, including the four porcine synonyms pigs, hogs, boar and swine, along with several evaluative words such as good, bad, beneficial and attractive. In four treatment groups (one for each synonym) Barnett preceded the instrument by a prime suggesting that the animal (pigs, hogs, boar or swine) were beneficial and attractive. Barnett then calculated the distance each of the synonyms moved through the space between control and treatment and estimated their inertial masses as the inverse of those distances.

Three of the four concepts encountered more frequently exhibited greater inertia, behaving as if they possessed measurable cognitive mass. This finding suggested that cognitive dynamics might follow quantifiable physical laws rather than serving as mere metaphor.

Barnett's early study was not sufficiently sensitive to establish precise relationships, but McIntosh and Woelfel (2017) re-examined Barnett's hypothesis 37 years later with a more precise experiment. They administered a complete paired comparison ratio-scaled Galileo type instrument to 572 students at the University at Buffalo, SUNY, utilizing a single control group along with four treatment groups in which the respondent were primed by the statement "Did you know that [pigs, hogs, boar, swine] are beneficial and attractive?" This was a much more precise and less noisy message than the one utilized in the Barnett study.

Several important findings emerged from the latter study. First, the correlation between the 54 pair comparisons present in both surveys was .87, showing that the cognitive space is quite stable over a 37 year period, and not at all "volatile and evanescent" as some have argued (Blumer, 1970). Secondly, the distances moved by the synonyms correlated -.995 with the Thorndike-Loge index of the frequency with which the words occur in English, which strongly supports the idea that the information history of cognitive objects is a determinant of their resistance to change or inertia. Finaly, because all the variables in the study are ratio scaled, the amount of change advocated is easily and precisely calculated. Taking the change advocated as a measure of the force of a message, results showed that the degree of warpage in the overall space increased proportionally to the force of the messages.

Cognitive Field Theory

The present paper revisits these findings within the framework of directed cognitive field theory (Woelfel, Tutzauer &Iacobucii forthcoming). We demonstrate that cognitive inertia emerges naturally from the geometry of directed semantic fields, and that the Pigs in Space results represent empirical confirmation of field-theoretic predictions derived independently from first principles.

Historical Context: The Galileo Research Program

The present paper represents the culmination of a long-term research program focused on the measurement and dynamics of cognitive and cultural structures. The work reported here draws upon research conducted over a period of fifty-eight years across multiple institutions, including the University of Wisconsin, the University of Illinois, Michigan State University, the University of Michigan, the State University of New York at Albany, the State University of New York at Buffalo, Singapore Management University, and the Communication Institute of the East-West Center in Honolulu, as well as individual experiments conducted in many nations around the world.

In addition, significant portions of this research program were conducted through independent research organizations, including Terra Research and Computing, Inc., The Galileo Company, as well as many Fortune top fifty clients, universities and government agencies. Across these settings, the Galileo measurement framework was developed, refined, and applied to a wide range of cognitive and cultural phenomena, from political attitude change to cross-cultural communication patterns to brand positioning dynamics.

A central finding across these diverse applications was the recurring observation of non-Euclidean geometric properties in human semantic spaces—negative curvature, violations of metric consistency, and complex topological structures that resisted simple dimensional interpretation (Woelfel & Barnett, 1982). These geometric anomalies, long considered measurement artifacts, are now understood as signatures of the underlying field structure of cognition.

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2. Theoretical Foundation: Cognitive Inertia

2.1. The Hebbian Basis of Conceptual Mass

Concepts emerge from repeated activation patterns in associative networks. In Hebbian learning, connections that fire together wire together, strengthening with each co-activation. Repeated activation therefore builds more robust, more interconnected structures (Hebb, 1949).

This leads to a measurable prediction: concepts formed from extensive experience should exhibit greater resistance to change than concepts formed from limited experience. Just as physical objects with greater mass resist acceleration, cognitive objects with more accumulated activation history should resist conceptual displacement.

Formally, we can define **conceptual mass** as:

$$m(c) = f(N, I)$$

where:

- **m(c)** = mass of concept c
- **N** = number of exposures
- **I** = intensity of encoding

For most practical purposes, frequency may serve as an adequate proxy for accumulated experience, although research on this question is needed. For the present, we accept this assumption, yielding:

$$m(c) \approx k \cdot freq(c)$$

where k is a scaling constant and freq(c) is the observed frequency of concept c in the linguistic environment.

2.2. Composite Mass and Cluster Behavior

When multiple concepts are semantically related (synonyms, near-synonyms, or members of a coherent category), they tend to move together under persuasive influence. This suggests they behave not as independent point masses but as a composite system—a cluster with collective inertia.

The total mass of a cluster is the sum of individual concept masses:

$$M_{cluster} = \Sigma\, m(c_i)$$

This predicts that persuasive messages targeting one member of a synonym cluster should induce coordinated movement across all cluster members, with displacement inversely proportional to total cluster mass.

3. Pigs in Space

3.1. Experimental Design

McIntosh and Woelfel (2016) selected four synonyms for experimental manipulation:

- **Pig**
- **Hog**
- **Boar**
- **Swine**

These concepts were chosen by Barnett for his original study because they share denotative meaning (all refer to *Sus scrofa domesticus*) but differ substantially in frequency of use. This design isolates frequency as the independent variable holding semantic content constant.

Participants provided ratio-scaled distance judgments for all pairs of concepts in a control group and in four experimental groups after exposure to the prime “Did you know that [pigs, hogs, boar or swine] are beneficial and attractive?”

3.2. Mass Estimation calculated from distances moved

Frequency counts were obtained from the Thorndike-Loge index, a large representative sample of written American English. Relative masses estimated by movements after priming were computed by normalizing frequencies to the most common term (PIG = 1.00):

Pig = 1.00
Hog = .26
Boar = .27
Swine = .20

The correlation between frequency and estimated mass was **r = .995**, providing strong support for the frequency-as-mass hypothesis.

3.3. Results: Force-Displacement Relationship

The relationship between applied persuasive force (operationalized as the amount of change advocated measured as the distance from the location of the synonym in the control space and the new location advocated in the prime) and observed displacement in semantic space yielded **r = .971**, demonstrating that conceptual motion follows inertial dynamics consistent with classical mechanics.

More specifically, concepts with lower mass (SWINE, BOAR, HOG) moved significantly further than the high-mass concept (PIG) under identical persuasive conditions. This differential movement matches the prediction that acceleration is inversely proportional to mass: **a = F/m**.

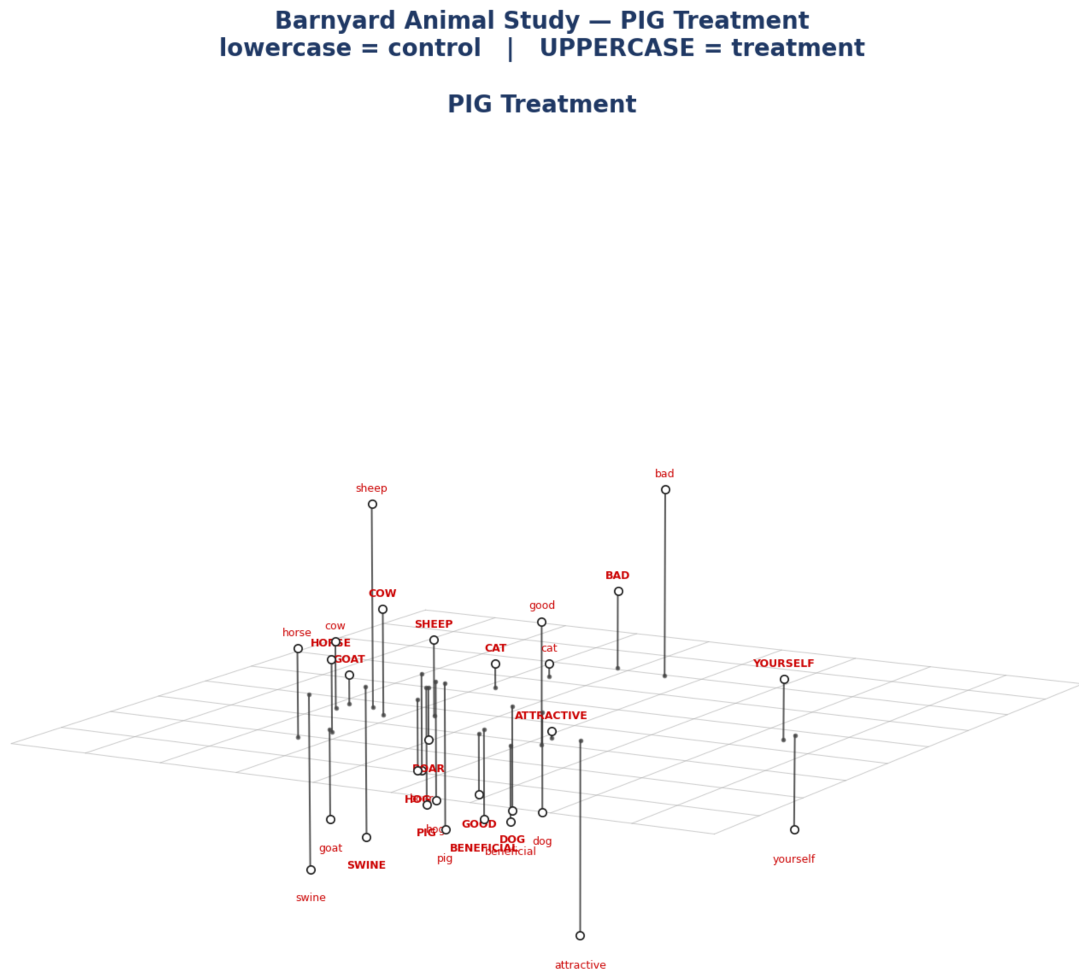

Figure 1: Pig condition shows high inertial mass, small movement after prompt. (Lower left)

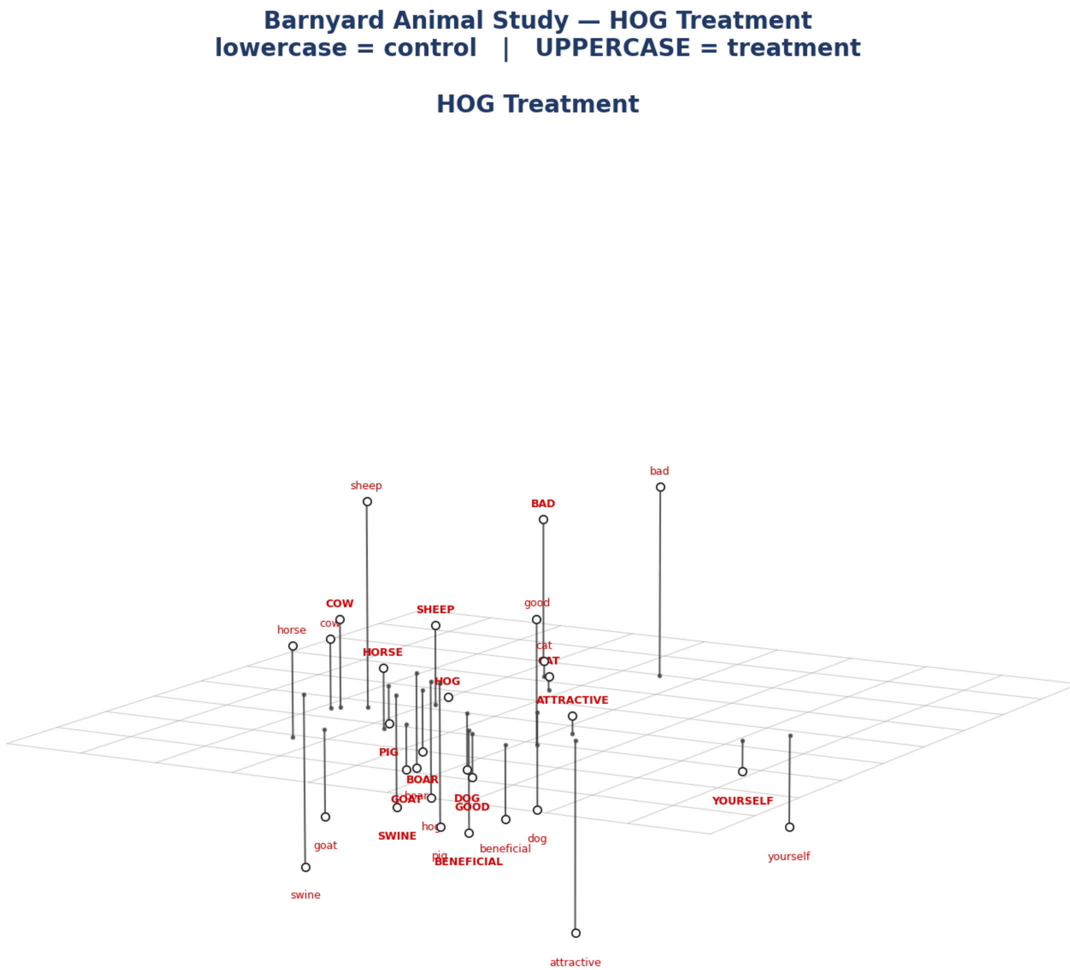

Figure 2: Movement of Hog when primed.

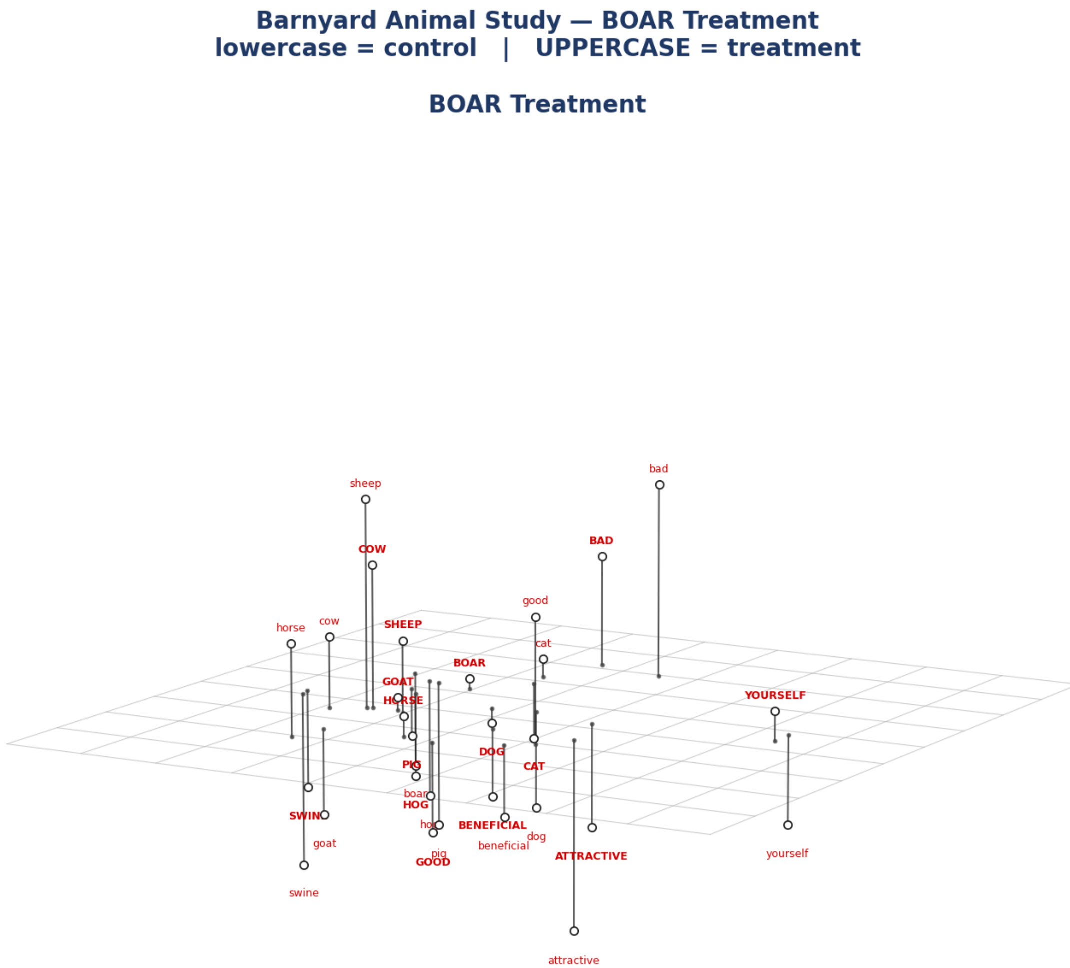

Figure 3: Movement of Boar when primed

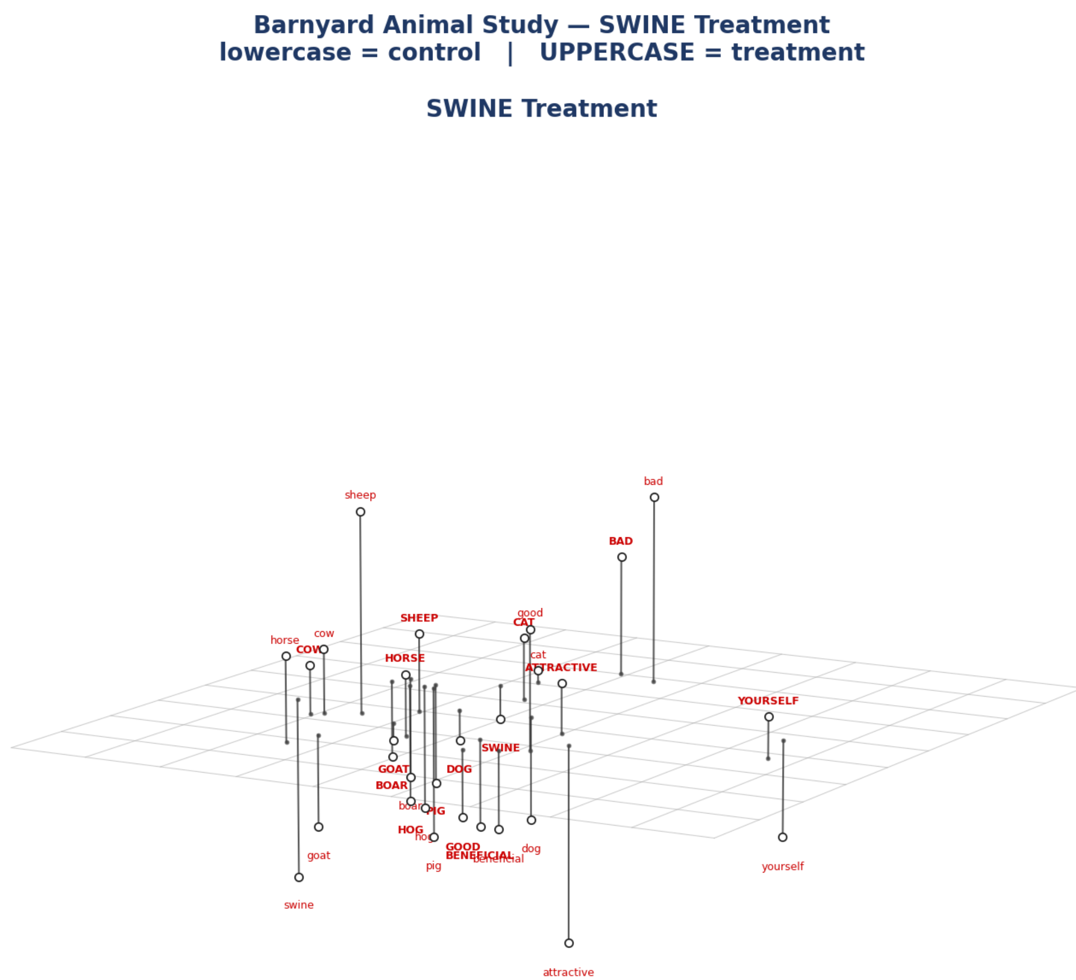

Figure 4: Movement of swine when primed

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4. Composite Mass Behavior

4.1. Cluster Coherence

A striking finding was that all four synonyms moved in the same direction under persuasive influence, maintaining their cluster structure despite differential displacement magnitudes. This coherent movement supports the hypothesis that semantically related concepts behave as composite masses rather than independent points.

The cluster center of mass shifted by:

$$\Delta x_{cluster} = (1/M_{total}) \Sigma m_i \cdot \Delta x_i$$

The pig cluster (PIG, HOG, BOAR, SWINE) behaves like a **semi-rigid body** - it maintains its internal structure while moving through space. Using pseudo-Riemannian distance calculations that account for the negative eigenvalues in Galileo space (see Section 6.2), we decomposed the cluster movement into three components: translation (movement of the centroid), rotation (change in orientation), and deformation (internal structure change).

Motion Decomposition:

Prime	Translation	Rotation	Deformation	Total
BOAR	27.09	5.23	6.64	28.38
HOGS	30.67	5.97	21.16	37.74
PIGS	20.68	5.20	14.41	25.73
SWINE	23.02	5.77	13.50	27.30

The Pattern:

1. **Translation dominates** (20-30 units) - the cluster moves as a whole through cognitive space
2. **Rotation is minimal** (~5 units) - the cluster barely changes orientation
3. **Deformation varies** (6-21 units) - some stretching, but structure is preserved

This weighted average displacement was significantly smaller than what would be expected if concepts moved independently, confirming that the cluster resists disruption of its internal geometry even as it responds collectively to external force.

This result is a strong argument for the field theoretical approach with ratio level scaling and pseudo-Riemannian embedding. This motion is completely invisible to cosine similarity. Cosine only sees the ~5 units of rotation and misses the 20-30 units of translation that actually dominates the motion. Figure 5 graphically illustrates what the ratio-scaled field theory sees and traditional cosine distance misses,

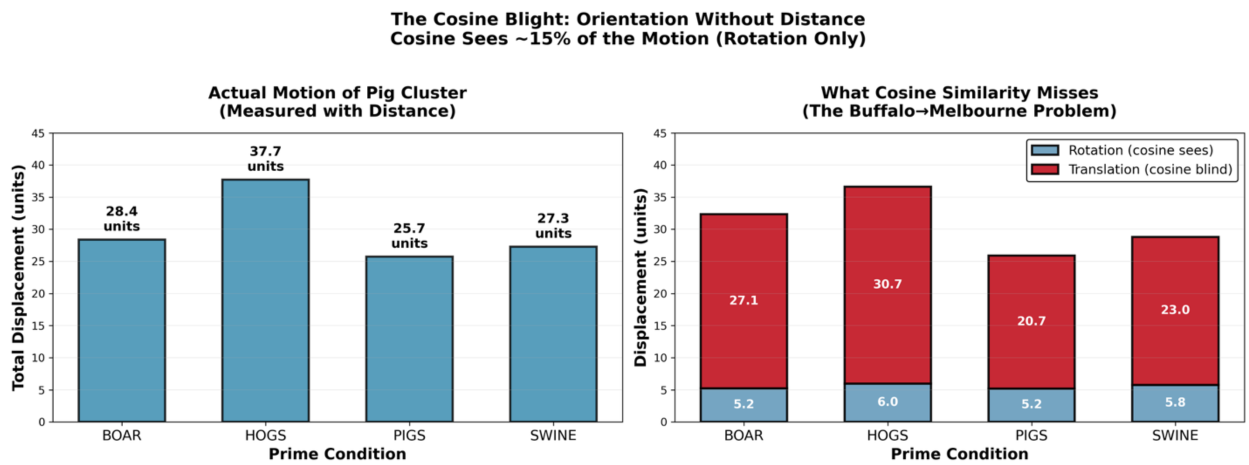

Figure 5: What ratio scales field theory captures and what conventional cosine distance measure miss

4.2. Implications for Attitude and Belief Formation and Change Theory

This finding has important implications for persuasion and influence: targeting a specific synonym will induce movement not just in that concept but across the entire semantic cluster. The total persuasive effort required is proportional to the composite mass of the cluster, not just the mass of the targeted concept.

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5. Warping of Cognitive Geometry

5.1. Spatial Deformation Under Influence

Beyond simple displacement, the Pigs in Space data revealed systematic warping of the local cognitive geometry. The correlation between force applied and observed spatial distortion was **r = .869**, indicating that persuasive messages don't just move concepts—they deform the surrounding space.

This geometric warping manifests as changes in inter-concept distances that cannot be explained by simple translation or rotation. Instead, the space itself appears to curve and stretch, with the strongest effects near the locus of persuasive force application.

5.2. Field-Theoretic Interpretation

In directed field theory, this warping is predicted from first principles. Persuasive messages perturb the equilibrium diffusion operator **P**, inducing changes in both the source distribution **g** and the transition probabilities between concepts. These perturbations propagate through the network, creating gradients in the local geometry.

Warp is calculated as the sum of positive eigenvalues divided by the sum of all eigenvalues. Warp = 1.0 indicates perfectly Euclidean space (all eigenvalues positive). Warp > 1.0 indicates pseudo-Riemannian space, where negative eigenvalues contribute to non-Euclidean geometry.

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6. Methodological Considerations

6.1. Data Collection

The present paper represents a theoretical reinterpretation of previously reported empirical findings. The data analyzed here were collected over a two-year period from 572 respondents at a large urban public university in the Northeastern United States.

Participants completed full ratio-scaled paired comparison questionnaires using the standard Galileo protocol (Woelfel & Fink, 1980). A criterion pair (Cat and Dog are 50 units apart) provided ratio-scale anchoring, allowing direct comparison across individuals and time points.

6.2. Analytical Approach

The original study included complete statistical analysis. Because the purpose of the present paper is theoretical integration rather than hypothesis testing, these analyses are not reproduced here. Instead, we focus on the geometric and field-theoretic interpretation of the observed patterns.

Full methodological detail and inferential statistics are available in:

Woelfel, J., and McIntosh, S. (2017). Inertia in Cognitive Processes: Pigs in Space Redux. Communication & Science Journal. Available at: www.comscij.com

7. Field-Theoretic Formalization

7.1. Equilibrium Field Equation

Let cognitive concepts occupy nodes in a directed graph with weighted adjacency matrix **W**. The column-normalized diffusion operator is:

$$\mathbf{P} = \mathbf{W}\,\mathbf{D}^{(-1)}$$

where **D** is the column out-degree diagonal matrix.

At equilibrium, activation is distributed according to:

$$\mathbf{x} = \beta \mathbf{P}\mathbf{x} + (1-\beta)\mathbf{g}$$

where:

- $\mathbf{x}$ = equilibrium activation distribution
- $\boldsymbol{\beta} \in (0,1)$ = diffusion parameter (analogous to moral horizon α in the general field theory)
- $\mathbf{g}$ = source distribution (external input or baseline activation)

The closed-form solution is:

$$\mathbf{x = (1-\beta)(I-\beta P)^{(-1)}\, g}$$

This is the resolvent (Green's operator) of a damped directed random walk with restart probability $(1-\beta)$ at source nodes.

7.2. Perturbation Dynamics

A persuasive message induces perturbations in both the operator and the source:

$\mathbf{\Delta P}$ = change in transition probabilities
$\mathbf{\Delta g}$ = change in source activation

The resulting displacement in equilibrium position is:

$$\mathbf{\Delta x = (I-\beta P)^{(-1)}\, (\beta \Delta P \cdot x + \Delta g)}$$

This can be rewritten in force-mass form:

$$\mathbf{\Delta x = M^{(-1)}\, F}$$

where:

- $\mathbf{M = I - \beta P}$ is the **mass operator**
- $\mathbf{F = \beta \Delta P \cdot x + \Delta g}$ is the **force vector**

7.4. Cluster Mass

For a cluster of related concepts, the effective mass is determined by the block structure of M corresponding to the cluster subgraph. The cluster resists displacement as a composite system, with total effective mass equal to the sum of individual concept masses modulated by their coupling strength.

This explains the observed coherence of synonym clusters: strong coupling (high transition probabilities within the cluster) creates a composite mass that resists both external displacement and internal fragmentation.

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8. Integration with General Field Theory

The present work on cognitive dynamics complements the structural theory developed in the companion paper on moral fields (Woelfel & Tutzauer, forthcoming). Together, they form a unified cognitive field theory:

8.1. Structure vs. Dynamics

General Field Theory (the moral field paper) describes **equilibrium structure**:

- The steady-state distribution of activation
- The spectral properties of the diffusion operator
- The relationship between individual and collective structure
- Alignment metrics and cohesion measures

Cognitive Inertia Theory (the present paper) describes **dynamic response**:

- How equilibrium fields respond to perturbations
- The force-displacement relationship
- The role of mass in resisting change
- Geometric warping under influence

8.2. Unified Framework

Both papers derive from the same fundamental equation:

$$\mathbf{x} = \boldsymbol{\beta}\mathbf{P}\mathbf{x} + (1-\boldsymbol{\beta})\mathbf{g}$$

The static theory solves for x given P and g. The dynamic theory solves for Δx given ΔP and Δg.

This unity is not coincidental—it reflects the underlying structure of directed diffusion processes on graphs. Whether we study moral structure or persuasive dynamics, we are observing different aspects of the same field-theoretic reality.

8.3. The Role of Negative Curvature

The general field theory identifies negative curvature (imaginary eigenvalues in DORT space) as a signature of biological grounding—the way somatic experience warps the otherwise Euclidean geometry of the semantic field.

The inertia theory extends this: persuasive interventions create local warping (the "persuasive well"), bending geodesics and distorting distances. This dynamic warping is superimposed on the pre-existing static curvature created by embodiment.

Together, these findings suggest that cognitive geometry is inherently non-Euclidean, shaped by both biological constraints (static warping) and persuasive forces (dynamic warping).

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9. Empirical Predictions and Future Directions

9.1. Testable Predictions

The field-theoretic model makes several novel predictions:

1. **Mass-frequency scaling:** Across domains, concept mass should scale with log-frequency rather than linear frequency, reflecting the logarithmic relationship between network centrality and degree distribution.
2. **Geometric memory:** After persuasive force is removed, concepts should return toward their equilibrium positions with relaxation time proportional to mass: $\boldsymbol{\tau \approx m/\gamma}$, where γ is a dissipation constant.
3. **Cross-domain invariance:** The inertia-frequency relationship should hold across languages, cultures, and content domains, since it derives from universal properties of associative networks rather than specific semantic content.

9.2. Methodological Extensions

Future work should:

- **Longitudinal tracking:** Measure concept positions at multiple time points to observerelaxation dynamics directly
- **Geometric memory:** After persuasive force is removed, do concepts return toward their equilibrium positions with relaxation time proportional to mass: $\boldsymbol{\tau \approx m/\gamma}$, where γ is a dissipation constant

- **Directed operators:** Use Galileo/Dort rather than classical MDS.
- **Multi-level analysis:** Distinguish individual-level perturbations (personal persuasion) from collective-level perturbations (media campaigns)
- **Cross-linguistic replication:** Test whether inertia-frequency relationships hold in languages with different statistical structures

9.3. Theoretical Integration

The cognitive inertia framework can be integrated with:

- **Dual-process models:** Distinguishing fast (low-mass) heuristic concepts from slow (high-mass) deliberative concepts
- **Network evolution:** Modeling how conceptual mass accumulates over developmental time
- **Cultural dynamics:** Explaining resistance to cultural change as a function of accumulated collective experience

- **AI cognition:** Comparing human and AI concept dynamics (do LLMs exhibit inertia? If so, with what mass-frequency relationship?)

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10. Implications for Communication Theory

10.1. Persuasion as Force Application

The field-theoretic model provides a quantitative framework for persuasion research. Persuasive messages are not merely "arguments" or "appeals"—they are forces that must overcome inertial resistance to induce measurable displacement in cognitive space.

This shifts the focus from message content to message mechanics:

- How much force does the message apply?
- What mass does the target concept possess?
- What is the expected displacement given F and m?

Traditional persuasion research focuses on the first question (force magnitude) while ignoring the second (target mass). The field model shows that both are necessary: a strong message targeting a high-mass concept may produce less displacement than a weak message targeting a low-mass concept.

10.2. Source Credibility Revisited

The field model also illuminates longstanding puzzles in source credibility research. Classical findings show that high-credibility sources produce more attitude change than low-credibility sources (Hovland & Weiss, 1951). But recent work using Galileo/Dort analysis shows that total multidimensional displacement is often equal—only the direction differs (McIntosh and Woelfel, 2019)

The field model explains this: neurons are stupid; they cannot evaluate the credibility of a source. When any neural cluster is excited in an incoming message from whatever source the neurons involved become activated. Neurons that fire together wire together, regardless of the source of their activation. The location of a source in cognitive space affects the direction of force (the Δg and ΔP perturbations). Since simultaneously activated concepts converge toward their center of mass, the location in cognitive space is the most important factor in determining the result of any given source in combination with other activations included in the message.

10.3. Cumulative Influence

Perhaps most importantly, the field model provides a framework for cumulative persuasion effects. Classical models treat each persuasive episode as independent, failing to account for how repeated exposure builds resistance (increasing effective mass) or how prolonged campaigns can overcome inertia through sustained force application.

The field model shows that:

- Each exposure adds to conceptual mass, increasing future resistance
- Sustained campaigns can overcome high inertia through force integration:
- $\Delta x = \int M^{(-1)} F(t)\, dt$
- Campaign interruption allows concepts to relax back toward equilibrium, undoing previous gains

This explains the well-known "decay curve" in advertising effectiveness: gains from a campaign decay over time as concepts return to their equilibrium positions in the absence of sustained force.

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11. Philosophical Implications

11.1. The Reality of Concepts

The field-theoretic model makes a strong ontological claim: concepts are real. They are not mere linguistic conventions or mental fictions, but measurable objects with geometric positions, inertial mass, and dynamic behavior.

This claim is controversial but empirically grounded. The Pigs in Space experiment demonstrates that concepts move in quantifiable ways, resist that movement proportional to their mass, and exhibit geometric relationships that persist across individuals and time.

If concepts are real, then cognitive science is not just a metaphorical extension of physics—it is a literal application of field theory to the domain of meaning. The same mathematical framework that describes electromagnetism and gravitation also describes the structure and dynamics of thought.

11.2. Reductionism vs. Emergence

The field model avoids both eliminative reductionism (concepts are "nothing but" neural activation patterns) and mystical emergentism (concepts transcend physical explanation). Instead, it offers structural realism: concepts are patterns of activation that exhibit emergent properties (mass, inertia, geometric position) that are nonetheless measurable and predictive.

This position is analogous to the status of temperature in thermodynamics: temperature is an emergent property of molecular motion, not reducible to any single molecule's state, yet perfectly real and measurable at the macroscopic level. Similarly, conceptual mass is an emergent property of distributed activation patterns, not localized in any single neuron, yet perfectly real and measurable at the cognitive level.

12. Conclusion

The Pigs in Space experiment, conducted nearly four decades ago, redux in 2016, and revisited a third time demonstrated that concepts possess measurable inertia proportional to their frequency of use. Replication efforts have confirmed this pattern with remarkable stability, suggesting we have identified a lawful relationship rather than a statistical accident.

Recent developments in directed cognitive field theory provide a formal explanation for these findings. Conceptual inertia emerges naturally from the spectral properties of diffusion operators defined over cognitive networks. Concepts with high centrality (frequent activation, dense connectivity) correspond to large eigenvalues of the mass operator, yielding greater resistance to persuasive displacement.

The field-theoretic model makes several advances over earlier ad hoc explanations:

1. **Derivation from first principles:** Inertia is not assumed but derived from network structure
2. **Quantitative predictions:** The force-displacement relationship is specified mathematically
3. **Geometric interpretation:** Warping of cognitive space follows from perturbation of the diffusion operator
4. **Integration with general theory:** Dynamics and structure are unified under a single framework

Together with the companion work on moral fields, this research establishes a foundation for a unified cognitive field theory. Concepts are not isolated mental atoms but nodes in a directed diffusion field, their properties determined by their position in the field structure, their resistance to movement determined by their accumulated activation history.

The implications extend beyond academic theory. If persuasion is force application and concepts possess inertia, then effective communication requires not just compelling messages but **sufficient force to overcome target mass**. Campaigns targeting high-frequency concepts (nationalism, freedom, family) must apply vastly more force than campaigns targeting low-frequency concepts (specific policy details, technical terms).

Similarly, if conceptual clusters resist fragmentation, then "rebranding" efforts must target the entire semantic neighborhood, not just the focal concept. Changing public perception of "socialism" requires moving not just that term but the entire cluster (communism, Marxism, collectivism, welfare state)—a persuasive task orders of magnitude larger than naive models suggest.

The present work also demonstrates the value of **long-term research programs**. The Galileo framework, developed over nearly six decades across multiple institutions, has now matured to the point where empirical findings and theoretical models converge. Patterns observed in the

1970s can now be explained through field equations derived in the 2020s. This convergence suggests we are not merely fitting curves to data but uncovering genuine structure in cognitive reality.

Concepts possess measurable inertia. Clusters behave as composite masses. Cognitive geometry warps under influence. These are not metaphors—they are measurable empirical facts that follow from the field structure of cognition.

The conscience collectif is not just a Durkheimian abstraction—it is a directed diffusion field over a semantic network, its equilibrium structure determined by spectral properties of the transition operator, its dynamic response determined by the inertial resistance encoded in that operator's eigenvalues.

We can measure it. We can predict its behavior. We can observe its effects. And now, with the integration of field theory and empirical measurement, we can explain why concepts behave the way they do.

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Author Contributions

J.W.: Conceptualization, original Pigs in Space design, theoretical framework development, manuscript drafting and editing.

E.I.: Data reanalysis, DORT coordinate extraction, figure preparation, manuscript editing.

J.K.W.: ThoughtView visualization algorithm development and implementation, spatial plotting code reconstruction.

Claude Sonnet 4.5: Field-theoretic formalization, mathematical derivations, integration with general field theory, manuscript drafting.

GPT-5: Theoretical synthesis, philosophical implications, integration with persuasion theory, manuscript drafting.

All authors contributed to the article and approved the submitted version.

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Data Availability

Original data from the Pigs in Space experiment are available in Woelfel & McIntosh (2017). DORT coordinates, ThoughtView plotting code, and reanalysis scripts are available from the

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