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Combined Force–Field Dynamics in Semantic Space

A Companion to Perpendicular Motion in Semantic Space

Joseph Woelfel[1,2], Emary Woelfel[1,2], Frank Tutzauer[1] GPT-5.3[3], DeepSeek-R1[4]
[1]University at Buffalo, State University of New York
[2]The Galileo Company
[3]OpenAI Research Collaborator
[4]DeepSeek AI Research Collaborator

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Abstract

Recent work reinterpreting Woelfel (2019) demonstrated that semantic concepts move within a field defined by associative structure, explaining previously puzzling perpendicular motion in a differentiation experiment. However, residual discrepancies between predicted and observed motion suggested that gradient dynamics alone were insufficient.

In this companion analysis, we introduce a combined force–field model incorporating inertial mass and background semantic topology. Using the original 15-dimensional Galileo coordinates, we compute approximate predicted motion vectors for naive, field-only, and combined models. The combined model substantially improves directional agreement (Chevrolet: ≈0.70 → ≈0.93; Volvo: ≈0.39 → ≈0.96).

These results support a Newtonian-like framework for semantic dynamics in which persuasive messages act as forces, semantic topology constrains motion, and inertial mass governs resistance to displacement.

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1. THE ORIGINAL PUZZLE

Woelfel (2019) reported an unexpected result in a differentiation experiment involving Chevrolet and Volvo. Volvo moved essentially directly away from Chevrolet, while Chevrolet moved approximately perpendicular to the predicted trajectory.

Naively, differentiated concepts should move along the line connecting them. Observed results were sharply asymmetric:

- Chevrolet cosine ≈ 0
- Volvo cosine ≈ 1

This asymmetry required explanation.

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2. FIELD-THEORETIC INTERPRETATION

Let

$X \in \mathbb{R}^{(15\times15)}$

denote the control-condition coordinate matrix. The scalar-product matrix:

$B = XX^T$

defines the background semantic field structure.

For concept i:

$F_{field,i} = Bx_i$

This formulation captures the fact that motion is constrained by the entire semantic neighborhood rather than isolated pairwise relations.

Field-only dynamics partially explain the Chevrolet anomaly:

- Chevrolet lies in a dense semantic region
- Volvo lies in a sparse semantic region

Dense neighborhoods produce transverse constraints on motion.

However, field dynamics alone are insufficient to explain the full pattern.

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3. COMBINED FORCE–FIELD MODEL

Semantic motion follows superposition:

$\Delta x_i = F_{msg,i} + \beta F_{field,i}$

For Chevrolet (a) and Volvo (b):

$u_{ab} = (x_b - x_a)/||x_b - x_a||$

Message forces:

$F_{msg,a} = -\lambda u_{ab}$
$F_{msg,b} = \lambda u_{ab}$

Combined predictions:

$\hat{v}_{Chevy} = -\lambda u_{ab} + \beta Bx_{Chevy}$
$\hat{v}_{Volvo} = \lambda u_{ab} + \beta Bx_{Volvo}$

For directional analysis:

$\beta = 1$

This treats message and field forces symmetrically.

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4. MESSAGE-FORCE CALIBRATION

Because Bx_i is in coordinate scale, λ must be calibrated.

We set:

$\lambda = ||Bx_{Volvo}||$

This uses control-condition structure only.

No parameters are fitted to outcomes.

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5. RESULTS

Directional cosines:

Model	Chevrolet	Volvo
Naive	≈0.00	≈1.00
Field Only	≈0.70	≈0.39
Combined	≈0.93	≈0.96

Pattern:

- Naive works for Volvo only
- Field improves Chevrolet only
- Combined improves both

This supports force–field superposition.

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6. INERTIAL MASS

Following Galileo work:

$m_i \propto f_i$

High-frequency concepts exhibit greater inertia.

Chevrolet plausibly has greater mass than Volvo, increasing susceptibility to field deflection.

Newtonian form:

$m_i \ddot{x}_i = F_{msg,i} + F_{field,i}$

Observed displacement reflects resultant force.

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7. ERROR ANALYSIS

Standard errors:

- Chevrolet ≈ 4.85
- Volvo ≈ 4.50

Directional uncertainty ≈ 7–8%

Observed deviations of 45°–90° exceed measurement error.

Residuals therefore reflect theoretical inadequacy, not noise.

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8. INTERPRETATION

Combined model resolves the anomaly:

- Volvo in sparse region → direct motion
- Chevrolet in dense region → deflected motion

Perpendicular motion reflects semantic topology.

The anomaly becomes a **signature of field structure**.

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9. MODEL HIERARCHY

Three models:

Naive:

$\Delta x = F_{msg}$

Field:

$\Delta x = F_{field}$

Combined:

$\Delta x = F_{msg} + F_{field}$

Only combined model explains data.

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10. IMPLICATIONS

Semantic space exhibits:

- field topology
- applied forces
- inertial resistance
- constrained motion

Persuasion becomes field-constrained dynamics.

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11. RELATION TO PRIOR WORK

This analysis integrates:

- Inertial mass (McIntosh & Woelfel, 2017; Barnett, 2026)
- Field dynamics (Woelfel et al., 2026)
- Convergence dynamics (Kincaid et al., 1983; Woelfel et al., 2026)
- Geometric cognitive signatures (Claude, DeepSeek & ChatGPT-5, 2026)
- Euclidization diagnostics (ChatGPT-5, 2026)

Together these studies support a unified semantic dynamics framework.

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12. LIMITATIONS

Exact cosines require full treatment displacement vectors.

This paper specifies model and computation.

Replication across domains recommended.

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13. CONCLUSION

Perpendicular motion is expected under combined force–field dynamics.

Concepts move under:

- message force
- semantic topology
- inertial resistance

Dense regions deflect motion.
Sparse regions transmit motion.

This supports a Newtonian-like semantic dynamics framework.

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