FEED: A Time-Warp Invariant Measurement Device for Organizational Semantics

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November 24, 2025

Abstract

Context: Organizational behavior is driven by semantic order (t_2), not clock time (t_1). Equal-interval assumptions in conventional analytics conflate speed with structure and miss subjective time dilation.
Method: We introduce FEED, a measurement device that maps semantic probability vectors ($t_2 = p_z \in \Delta^{K-1}$) to a fixed manifold via the observer mapping $M = \rho \circ \Pi \circ \nu$ (normalize $\to$ project $\to$ renormalize). Using an Aitchison-metric arc-length parameterization

$$s(t) = \int_0^t \left\| \frac{d}{d\tau} \operatorname{clr}(p_z(\tau)) \right\|^2 d\tau$$

we define invariants $\{R, \mathrm{ODI}, \tau_c, R_{\mathrm{spiral}}\}$ that are designed to be stable under monotone time warps, observer exchange, and scale-linking.
System: A Single Source of Truth (SSOT) registry (`analysis_run.json`, environment hashes, fixed seeds) ensures byte-for-byte reproducibility and adherence to preregistered thresholds.
Evaluation: In a preregistered calibration run TestA (formal Test1) on γ data ($n = 3$ units, 2025-10-07 to 2025-11-21), we instantiated two observer profiles (A/B) and compared their `comp0` trajectories using ordinary least squares on a common day list. All units showed high linear correlation ($r = 0.9379$ to 0.9951) and no missing days, but the slopes were amplified ($b \approx 5.7$ to 7.4) with intercepts around -1.1 to -1.5, far outside the preregistered equivalence margins for slope $[0.95, 1.05]$ and intercept $[-0.05, 0.05]$. By contrast, the scale-linking Test2 on the same field satisfied its tolerance criteria, indicating that the failure is localized to observer exchange on the current tag design rather than a breakdown of the FEED pipeline.
Contribution: We provide (C1) a concrete, preregistered protocol for observer exchange calibration (TestA) on FEED; (C2) empirical evidence that the present coarse tag space and `vocab_map` design cause `comp0` to amplify observer differences by factors of roughly six to seven, even when the underlying semantic order is strongly linear; and (C3) a roadmap toward an embedding-based t_2 and principal-component-based `comp0` that is structurally capable of passing observer exchange under the same Operational Gate.

Keywords: time-warp invariance; observer exchange; scale-linking; SSOT; Aitchison geometry; TOST; organizational semantics

1 Introduction

1.1 The Tyranny of Clock Time

Clock time is an unreliable coordinate for semantics. In the analysis of organizational dynamics, treating time as an equidistant variable (t_1) injects spurious variance when meaning accelerates or stalls. Human cognitive processes do not proceed at a constant rate; they exhibit subjective time dilation. Conventional analytics that normalize data by physical time can fail to capture this "structure of intent", because changes in semantic content are not proportional to elapsed clock time.

1.2 The FEED Paradigm

We adopt the paradigm "Time is tag order". The working hypothesis is that the essential structure of semantic experience is topological: what matters is the order and geometry of semantic states, not their spacing on a clock. To operationalize this hypothesis, we introduce FEED, a measurement device that maps action logs (t_1) and semantic probability vectors (t_2) onto a unified coordinate system using an Aitchison arc-length parameterization.

In this paradigm, semantic trajectories are represented as paths on a manifold equipped with the Aitchison geometry of the simplex. Time-warp invariance is achieved by rewriting trajectories in terms of intrinsic arc-length rather than external clock time. Observer-specific mappings and scale composition are handled through a shared SSOT basis and algebra on the compositional field.

1.3 Executive Roadmap

Table 1 outlines the three main research questions and the corresponding Operational Gate criteria. TestA, reported in detail in Section 9, is the first formal evaluation of H2 (observer exchange) on γ data under this framework.

Table 1: Research cross-walk from questions to Operational Gate

RQ	Hypothesis	Test / Design	Operational Gate (Thresholds)
RQ1	H1: Warp invariance	Null shuffles, warp grid	$R \geq 0.98$ (≥ 3 warps), ΔAUC ≥ 0.05
RQ2	H2: Exchangeability	Test1 (TOST / ICC)	TOST slope $[0.95, 1.05]$, int $[-0.05, 0.05]$
RQ3	H3: Scale-linking	Test2 (composition)	Composition error within tolerance

In this paper we focus empirically on RQ2, while keeping the full set of invariants and gates as design constraints for the device.

2 Related Work

Causal inference. We view semantic trajectories as continuous-time counterparts of treatment exposure in standard ITT/CACE frameworks, and extend the notion of "local effects" to geometric properties of paths [2].

Information geometry. We adopt Aitchison geometry [1] and the ILR (isometric log-ratio) basis for projecting the simplex Δ^{K-1} to a Euclidean space suitable for PCA, ensuring orthogonality and numerical stability.

Representation learning. Unlike static embeddings, we quantify orbital dynamics (persistence, vorticity, spiral radius) on a fixed manifold, treating changes in direction and speed along the arc-length parameter as primary observables.

3 Preliminaries: Notation Contract

To ensure rigorous reproducibility, we define the notation contract in Table 2. The central object is the semantic probability vector p_z in the simplex Δ^{K-1}. The arc-length $s(t)$ is defined by

$$s(t) = \int_0^t \left\| \frac{d}{d\tau} \operatorname{clr}(p_z(\tau)) \right\|^2 d\tau \tag{1}$$

where clr$(\cdot)$ denotes the centered log-ratio transform. This definition normalizes the "speed" of semantic change and allows invariant comparisons across different physical time parameterizations.

Table 2: Notation contract and data types

Symbol	Type	Shape	Notes
t_1	Sequence	$[(id, t)]$	UTC, Run-id consistent logs
t_2	Vector	Δ^{K-1}	1-sum Semantic probability, $\sum_k p_k = 1$
ϕ	Function	$\mathbb{Z} \to \mathbb{Z}$	Monotone, piecewise differentiable
Ω	Field	$\mathbb{R}^d$	Composed of individual t_2 vectors
M	Mapping	$K \times k$	$M = \rho \circ \Pi \circ \nu$
Basis	Matrix	$K \times k$	ILR orthonormal basis via SSOT

4 FEED and SSOT Overview

Reproducibility is enforced using a strict Single Source of Truth (SSOT) architecture. All analysis parameters are encapsulated in a JSON registry (`analysis_run.json`), which is treated as the only authoritative configuration for any run.

A minimal example is given in Figure 1. For TestA we used a day list covering 2025-10-07 to 2025-11-21 and fixed thresholds for TOST, ICC, and invariant metrics.

5 Axioms and Measurement

We posit five axioms (AX1–AX5) for semantic measurement. The key element for this report is:

> **AX2 (Time is Tag Order).** The topological order of semantic tags constitutes the only valid temporal dimension for conscious semantic experience. Physical clock time t_1 is treated as a gauge choice that can be changed without altering the semantic structure, provided we work in arc-length coordinates $s(t)$.

Under these axioms, FEED is defined as a mapping from raw logs and semantic vectors to a set of invariants that are intended to be insensitive to monotone time warps, choice of observer, and aggregation scale, once the SSOT basis is fixed.

6 Invariants and Operational Gate

We define an Operational Gate to distinguish valid semantic signals from noise. The current standard (TWR-Std) uses the criteria in Table 3.

Table 3: Operational Gate criteria (TWR-Std)

Metric	Threshold	Rationale
Calibration	$\Delta\text{AUC}(t_2) \geq 0.05$	Discriminability gain
Null simulations	$R \geq 0.98$	Strong order preservation
Warp grid (≥ 3 speeds)	$S^2 \geq 0.02$	Minimal signal floor
Variance sweep	LB95 > 0	CI exclusion of 0
Stratified bootstrap	-	-

In principle, a device that satisfies these thresholds for its invariants $\{R, \text{ODI}, \tau_c, R_{\text{spiral}}\}$ under multiple warps and observers can be treated as a time-warp invariant measurement device for

```json
{
  "version": "1.0",
  "registry_uri": "s3://org/feed-ssot/registry",
  "run_id": "2025-11-21T00-00Z_calibration_run",
  "daylist": ["2025-10-07", "2025-11-21"],
  "preprocess": {
    "pz_normalize": {
      "eps": 1e-8,
      "zero_handling": "add-delta"
    }
  },
  "projection": {
    "basis": "ILR",
    "components": 8,
    "sign_ref": "global"
  },
  "invariants": {
    "metrics": ["R", "ODI", "tau_c", "R_spiral"]
  },
  "tests": {
    "tost": {
      "slope_bounds": [0.95, 1.05],
      "intercept_bounds": [-0.05, 0.05]
    },
    "icc": {
      "type": "A,1",
      "ci": 0.95
    }
  },
  "env_hash": "sha256:e3b0c44298fc1...",
  "_trace": {
    "suggest_adopt_outcome": true
  }
}
```

Figure 1: Minimal example of `analysis_run.json`. The registry ensures byte-for-byte reproducibility, including preprocessing, projection, invariants, and test configuration.

organizational semantics. The TestA calibration reported here focuses on the `comp0` component of the projected series for observer exchange and does not yet exercise the full invariant set for that purpose.

7 Observer-Exchange and Scale-Linking

H2 (Observer exchange). For a given mapping M and a shared SSOT basis, the invariants I of a semantic trajectory should be preserved across observers, in the sense that $I(p_z) \approx I(M(p_z))$. At the level of raw components, this corresponds to `comp0(B)` being linearly equivalent to `comp0(A)` within prespecified bounds.

H3 (Scale-linking). The collective field Ω is constructed via the algebraic composition of individual vectors (for example, team-level composition from unit-level data), preserving homomorphic structure of the invariants. If individual trajectories satisfy the Operational Gate, aggregated trajectories should also satisfy it within a controlled composition error.

TestA directly targets H2 on γ data by comparing two observer profiles A and B that share the same SSOT basis and day list but differ in tag mapping (daily vs daily + `vocab_map`).

8 Evaluation Protocol

We employed a preregistered protocol consisting of two main tests and a null model family, implemented under the SSOT registry described above.

8.1 Test 1 (Observer Exchange: TestA)

Test1 is defined as follows.

- **Step 1: Observer profiles**
  - Observer A: profile defined in `observer_A.json` (daily aggregation).
  - Observer B: profile defined in `observer_B.json` (daily aggregation plus `vocab_map`, including mappings such as mail / relation → Communication).
- **Step 2: Series generation** For each unit u, we generate `A_series` and `B_series` using:

```
observer_apply_eval.py --profile observer_A.json -> A_series
observer_apply_eval.py --profile observer_B.json -> B_series
```

  Both series are dictionaries from date to projected vectors on the ILR basis.
- **Step 3: Calendar (day list)** We fix a day list covering the analysis window 2025-10-07 to 2025-11-21.
  - team_alpha = intersection of units $u1$ and $u2$
  - team_beta = unit $u3$

  The same day list is used for both observers.
- **Step 4: comp0 extraction** Test1 operates on the first component of the projected vectors.
- **Step 5: Linear regression** For each unit, we fit an ordinary least squares regression

$$B_{\text{comp0}} = a + b \cdot A_{\text{comp0}} + \varepsilon$$

  and compute slope b, intercept a, and Pearson correlation r.
- **Step 6: Pass / fail criteria** We apply a TOST-style equivalence check with preregistered bounds: $b \in [0.95, 1.05]$ and $a \in [-0.05, 0.05]$. The test passes for a unit if both bounds are satisfied.

8.2 Test 2 (Scale-linking)

Test2 assesses whether composition of individual trajectories into a collective field Ω preserves the invariants within an acceptable error tolerance. The composition is performed algebraically on the compositional vectors, and errors are compared with thresholds derived from the Operational Gate. For γ data, Test2 is used as a cross-check that scale composition behaves as expected once a reference observer is fixed.

8.3 Null models

Null models are defined by shuffling tag order or temporal order to destroy semantic structure while preserving marginal distributions. These models are used to calibrate ΔAUC and R and to establish that the invariants collapse under loss of structure.

9 Results: TestA on γ Data

This section reports the outcome of Test1 (observer exchange) on γ data, following the protocol above.

9.1 Data and coverage

- **Units:** $u1, u2, u3$ (three individuals).
- **Observation window:** 2025-10-07 to 2025-11-21.
- September data were treated as dummy and excluded.

For all units, the number of used days n matched the number of available days within the window. There were no missing observations for `A_series` or `B_series` on the analyzed daylist. Thus, the Test1 pipeline ran end-to-end without data loss for all three units.

9.2 Regression outcomes

The regression results for `comp0(A)` versus `comp0(B)` are:

Unit u1
$n = 23$, $a = -1.4208$, $b = 6.8862$, $r = 0.9826$. **Pass** = **False**.

Unit u2
$n = 23$, $a = -1.5160$, $b = 7.4080$, $r = 0.9951$. **Pass** = **False**.

Unit u3
$n = 25$, $a = -1.1297$, $b = 5.6883$, $r = 0.9379$. **Pass** = **False**.

All units exhibit high linear correlation (r between 0.9379 and 0.9951), but the slopes and intercepts are far outside the equivalence bounds $[0.95, 1.05]$ and $[-0.05, 0.05]$.

9.3 Interpretation

The TestA results can be summarized as follows.

Pipeline validity. For all units, $n > 0$ and used days equal days_available. There are no missing values in the `comp0` series after preprocessing and projection. The FEED pipeline, including SSOT registry, observer application, projection, and regression, is functioning as specified.

Strength of linear relationship. The correlation r between `comp0(A)` and `comp0(B)` is very high (0.94-level or higher) for all units. This indicates that `B_series` is an approximately monotone linear transform of `A_series` on `comp0`.

Magnitude of observer effect. The slopes b lie between 5.6883 and 7.4080. Intercepts a are around -1.5 to -1.1. Compared to the TOST bounds, the observer effect on `comp0` is amplified by a factor of roughly six to seven.

Structural diagnosis. The observed pattern is consistent with the following mechanism, given the current tag design:

1. Tags such as “mail” and “relation” are highly concentrated along specific axes.
2. The `vocab_map` in observer B aggregates these into a Communication-like dimension.
3. Softmax-style normalization sharpens these differences.

As a result, `comp0` becomes extremely sensitive to small differences in tag allocation between observers, even when they are applied to the same underlying events.

Test2 (scale-linking). On the same γ data, Test2 (scale-linking) passes its predefined tolerance criteria. This suggests that composition across individuals behaves in a stable way once a reference observer is fixed, and that the failure is localized to observer exchange at the current level of tag granularity.

In summary, TestA (formal Test1) does not satisfy the observer exchange equivalence bounds for `comp0` on γ data, but it reveals a strong and interpretable amplification effect rooted in the tag space and `vocab_map` design rather than in the FEED measurement pipeline itself.

10 Discussion and Conclusion

10.1 Discussion

This report has two aims: to describe FEED as a time-warp invariant measurement device for organizational semantics, and to document the first formal observer-exchange calibration (TestA) on γ data.

From a systems perspective, the SSOT-based pipeline performed as intended. All analysis decisions were encoded in `analysis_run.json`; runs were reproducible; observer profiles A and B were applied consistently; and the `comp0` series were generated and regressed without missing data.

From a measurement perspective, TestA shows that the current implementation of `comp0` is not yet observer-exchangeable under the preregistered TOST bounds. Instead, `comp0` behaves as a high-gain channel for observer differences induced by coarse, axis-aligned tags and a `vocab_map` that aggregates concepts such as mail and relation into a single Communication dimension. The high correlations and large slopes indicate that `comp0(B)` is almost an affine transformation of `comp0(A)` with a gain of six to seven, rather than the near-identity transformation targeted by the equivalence criteria.

At the same time, the successful behavior of Test2 (scale-linking) on γ data suggests that once a reference observer is fixed, the algebraic composition of trajectories into team-level fields can meet its operational tolerances. This supports the view that the main limiting factor for observer exchange is the geometry of the tag space, not the arc-length parametrization or the SSOT machinery.

10.2 Conclusion

We have presented FEED, a protocol that transforms subjective semantic data into objective, time-warp invariant geometric structures on an Aitchison manifold. Within this framework, we executed TestA, a preregistered observer-exchange test on γ data, and obtained the following empirical facts:

- The FEED pipeline runs end-to-end with strict SSOT control and no missing data.
- For all units, `comp0(A)` and `comp0(B)` are strongly linearly related, but with slopes in the range 5.7 to 7.4 and intercepts around -1.1 to -1.5, violating the target equivalence margins.
- Scale-linking (Test2) behaves stably on the same data.

These results indicate that the device, as currently parameterized, is highly sensitive to observer-specific tag mappings on `comp0`. This is not a hardware-type malfunction but a structural consequence of a coarse, axis-aligned tag space and its `vocab_map`. In this sense, TestA is a calibration failure with respect to the original equivalence goal, but a useful diagnostic success: it quantifies a DAIV-specific amplification phenomenon that was previously only qualitative.

A natural next step is to redesign the semantic space:

1. Generate t_2 using embedding-based representations rather than sparse tags.
2. Define `comp0` not as a fixed tag axis but as a principal component of the ILR-projected field.
3. Reorganize the `vocab_map` to better match semantic density and reduce extreme concentration along single axes.

Under such a redesign, the same TestA protocol and Operational Gate can be reused to test whether observer exchange becomes attainable without sacrificing time-warp invariance or scale-linking.

The broader contribution of this work is the formalization of a coordinate system for semantic order in organizations, in which subjective phenomena such as "time dilation" of meaning are expressed as geometry rather than as informal metaphors.

11 Future Work: Directionality Tests (Test3 / Test4)

Although this report focuses on TestA (observer exchange) and Test2 (scale-linking), the FEED framework includes two additional preregistered evaluations aimed at testing directionality between semantic fields (t_2), behavioral outcomes (t_1), and external fields (Ω^+). These have not yet been executed on γ data but are scheduled for future experimental phases.

11.1 Test3: Directionality of Semantic Influence

Test3 evaluates whether semantic trajectories provide predictive directionality toward behavioral or external observables.

Test3-int (internal Ω: $t_2 \to t_1$) Tests whether semantic series t_2 lead future behavioral outcomes (wins, proposals, meetings). Directionality is evaluated through:

$$\Delta I_k = TE(t_2 \to t_1; k) - TE(t_1 \to t_2; k)$$

Key metrics include predictive advantage over AR / naïve baselines and surrogate robustness (IAAFT / block replacement / time reversal).

Test3-ext (external Ω^+: $\Omega^+ \to t_2$) Tests whether external fields (news, mobility, market indicators) exert directional influence on internal semantic states. Both $TE(\Omega^+ \to t_2)$ and $TE(t_2 \to \Omega^+)$ are computed to examine asymmetry.

These tests require stable 15-day windows, consistent sampling, and strict leakage prevention (e.g., using OFF periods of Encouragement assignment).

11.2 Test4: PRO Standard for Causal Directionality

Test4 is a higher-tier, preregistered evaluation designed to qualify directional claims under more stringent conditions. A Test3 result must satisfy the following to become a Test4 "pass":

- **Directional asymmetry:** $\exists k > 0$ such that $\Delta I_k > 0$ persists in $\geq 70\%$ of rolling windows.
- **Predictive superiority:** Future Y predicted by t_2 must significantly outperform naïve/AR baselines (DM test).
- **Robustness:** Effects must survive surrogate tests and time-reversal controls.

- **Reproducibility:** Independent datasets ≥ 2 and fixed environment hashes allow 72-hour third-party reruns.

Test4 is intended as the PRO-standard gate for the broader claim "meaning precedes behavior", and will be executed once sufficient γ or δ cohort data become available.

References

[1] J. Aitchison, *The Statistical Analysis of Compositional Data*, Chapman and Hall, 1986.

[2] G. Imbens and J. Angrist, "Identification and Estimation of Local Average Treatment Effects," *Econometrica*, 1994.