The Comparative Asymmetry Principle: Relational Disequilibrium in Multi-Agent Environments

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Abstract

This paper formalizes how self-evaluating agents generate internal disequilibrium through observation of other agents. We define the conditions under which perceived asymmetry between an agent's current state and the observed states of others produces a measurable behavioral perturbation—comparative perturbation (Π)—distinct from deficit-driven motivation. The framework distinguishes three levels of analysis (behavioral perturbation, internal mobilization, subjective tension), identifies five resolution strategies with determinants of strategy selection, specifies boundary conditions, and analyzes sources of individual variation. We connect the principle to two formal frameworks—the Viability Mismatch Law and the theory of self-organizing systems—showing that comparative perturbation constitutes a specific, endogenous mechanism through which viable systems generate demand-resource mismatch. The result is a formal, falsifiable principle that unifies social comparison theory, relative deprivation research, and reference-dependent utility models under a general systems framework while maintaining a clear separation between its domain-independent core and domain-specific phenomenological extensions.

1 Introduction

Agents across psychology, economics, and evolutionary biology evaluate their states relative to others, generating internal disequilibrium when they perceive themselves as disadvantaged. Social comparison theory (Festinger, 1954), relative deprivation (Runciman, 1966), prospect theory (Kahneman and Tversky, 1979), and evolutionary status competition models (Frank, 1985) all document this pattern, each anchored in domain-specific mechanisms. The question this paper addresses is whether the underlying phenomenon can be characterized in domain-neutral terms, as a property of any system meeting certain structural criteria.

We propose that it can. The goal is not to strip away psychological or biological content but to identify the minimal structural conditions sufficient to produce the phenomenon—clarifying when it should arise, in whom it operates most strongly, how agents respond, and under what conditions structural perturbation is accompanied by subjective experience.

Roadmap. Section 2 defines the structural requirements and three levels of analysis. Section 3 states the principle and illustrates it with concrete cases. Section 4 introduces comparison density, environmental amplification, and formal framework connections. Sections 5–7 address resolution strategies, strategy selection determinants, and individual variation. Section 8 analyzes goal drift dynamics. Sections 9–11 cover boundary conditions, statistical prevalence, and diagnostic applications. Section 12 discusses limitations and testable predictions. Appendix A provides detailed illustrative cases.

1.1 Contributions

This paper makes four principal contributions:

1. **Domain-independent formalization.** We define five structural properties (P1–P5) jointly sufficient to produce comparative perturbation, applicable to biological, artificial, and organizational agents.

2. **Three-level decomposition.** We distinguish behavioral perturbation (Π), internal mobilization (M), and subjective tension (Σ), specifying the additional properties required at each level and the conditions under which levels dissociate.

3. **Resolution taxonomy and selection model.** We identify five structurally distinct resolution strategies and specify six primary predictors of strategy adoption with interaction effects.

4. **Formal integration.** We connect the principle to the Viability Mismatch Law (Kriger, 2026) and the theory of self-organizing systems (Kriger, 2017), showing that comparative perturbation constitutes a specific demand-generation mechanism within viable systems and that resolution strategies instantiate a general hierarchy of mismatch responses.

2 Definitions and Structural Requirements

2.1 The Agent and Its Environment

Let S be an agent embedded in an environment E containing other agents $S_1, S_2, \ldots, S_n$.

We require S to possess the following properties, each of which is given an operational definition:

P1. State self-evaluation. S maintains an internal representation of its own current state R_{self}, measurable as a mapping from environmental inputs and internal variables to some ordered state space.

P2. Goal representation. S maintains an internal model of a desired state R^*, operationally defined as a state toward which S directs its behavior—that is, a state whose distance from R_{self} correlates with S's tendency to modify its own state or environment.

P3. Observation of others. S can acquire information about the states of other agents, R_{other_i}, and represent those states internally.

P4. Relational evaluation. S can compute a comparison between R_{self} and R_{other_i} along the same dimensions used to evaluate distance from R^*.

P5. State-dependent behavioral modulation. The output of this comparison modulates S's subsequent behavior—i.e., the comparison is not inert information but feeds into S's action-selection mechanism.

These properties are structural and informational. They do not presuppose consciousness, emotion, or biological substrate. However, they are jointly nontrivial: many systems that possess some of these properties (e.g., a thermostat possesses P1 and P2) do not possess all of them. A thermostat that receives data about other thermostats' set points does not perform relational evaluation (P4), nor does such data modulate its behavior (P5). The principle applies only to systems satisfying all five conditions.

2.2 Perceived Asymmetry and the Comparative Asymmetry Condition

For a given agent S observing another agent S_i, define *perceived asymmetry* as:

$$A_i = f(R_{\text{other}_i}, R_{\text{self}}, R^*) \tag{1}$$

where $f : \mathbb{R}^3 \to \mathbb{R}_{\geq 0}$ returns a positive value when S_i is perceived by S to be closer to R^* than S itself is. The function f is perception-dependent: it reflects S's internal model of the comparison, not an objective measurement.

An important constraint on f is that it is generally non-monotonic with respect to the magnitude of the state difference. An agent slightly ahead produces larger A_i than one vastly ahead; extremely distant targets tend to be dismissed as irrelevant (B4 in Section 9). This produces an inverted-U relationship: A_i peaks at moderate distances and attenuates at extremes. We adopt the convention that f captures the perceived magnitude given attention, while w_i in the comparison density formula (Section 4) captures attention probability.

Define the *internal discrepancy* as:

$$D = g(R^*, R_{\text{self}}) \tag{2}$$

where $g : \mathbb{R}^2 \to \mathbb{R}_{\geq 0}$ measures the distance between S's current state and its desired state.

The **comparative asymmetry condition** is active when:

$$\boxed{A_i > 0 \quad \text{and} \quad D > 0 \quad \text{(CAP)}} \tag{3}$$

That is, S perceives some other agent as closer to its desired state than itself, and S has not yet reached that desired state.

Numeric instantiation. A doctoral student (S) evaluates research output on a 0–100 scale. She estimates $R_{\text{self}} = 40$, aspires to $R^* = 75$, and observes a peer at $R_{\text{other}} = 65$. Then $D = g(75, 40) = 35$, $A = f(65, 40, 75) > 0$ (the peer is closer to the aspiration), and (CAP) is active. Had she observed a peer at $R_{\text{other}} = 30$, then $A = f(30, 40, 75) = 0$—no upward asymmetry.

2.3 Comparative Perturbation as a Measurable Quantity

We define *comparative perturbation* Π operationally as the magnitude of behavioral change induced by (CAP): the degree to which the system's behavior deviates from what it would be if it evaluated D alone, without information about other agents' states.

Formally:

$$\Pi = \|B(D, A) - B(D, 0)\| \tag{4}$$

where $B : \mathbb{R}^2_{\geq 0} \to \mathcal{A}$ maps discrepancy and asymmetry to the agent's behavioral output space $\mathcal{A}$, and $B(D, 0)$ is the behavioral output given the same discrepancy but no comparative information.

This definition is deliberately behavioral and external. Π is agnostic to internal states—it requires no access to subjective experience, phenomenal consciousness, or self-report. In artificial agents, Π can be estimated directly from policy differences: $\Pi \approx D_{\text{KL}}[\pi(a|s, A)\|\pi(a|s, 0)]$, where π is the agent's policy and D_{KL} is the Kullback–Leibler divergence between choice distributions with and without comparison information. In human subjects, analogous estimation is possible through choice probabilities in tasks with and without visible peer performance.

A caveat follows: in agents capable of behavioral suppression, Π can approach zero while internal mobilization M (Level 2) remains high. This creates *latent perturbation*—invisible at Level 1, detectable at Level 2, and potentially manifesting abruptly if suppression fails. Empirically, $\Pi \approx 0$ combined with $M \gg 0$ should be treated as an unstable state.

2.4 Three Levels of Analysis

The formal definition of Π captures the behavioral surface. But in human experience, comparison-driven disequilibrium is *felt*. This section distinguishes three levels and specifies the additional properties required at each.

Level 1: Behavioral perturbation (Π). The level defined in Section 2.3. It requires only P1–P5, is observable externally, and makes no claims about internal experience. All formal predictions hold at Level 1 alone.

Level 2: Internal resource mobilization (M). In systems with sufficient internal complexity, Π is accompanied by measurable changes in internal state allocation—mobilization M. In biological agents: cortisol elevation, anterior cingulate engagement, sympathetic arousal. In artificial agents: reallocation of computational resources, learning rate changes. This requires:

P6. Internal resource allocation. The agent possesses internal resources that can be differentially allocated, and the comparison output from P4 influences this allocation.

Level 3: Subjective tension (Σ). In agents with phenomenal consciousness, Levels 1 and 2 are accompanied by experienced tension Σ: the felt quality of envy, inadequacy, or status anxiety. This requires:

P7. Phenomenal experience. The agent has conscious access to its own internal states, such that mobilization is accompanied by qualitative experience.

The relationship between levels:

$$\text{P1–P5} \implies \Pi \geq 0 \tag{5}$$

$$\text{P1–P6} \implies \Pi \geq 0 \text{ and potentially } M > 0 \tag{6}$$

$$\text{P1–P7} \implies \Pi \geq 0 \text{ and potentially } M > 0 \text{ and potentially } \Sigma > 0 \tag{7}$$

Key consequences. (1) The principle's core claim is Level 1. (2) Most human evidence is Level 3 (Σ), connected to the Level 1 prediction through a bridging postulate (below). (3) The three levels can dissociate. (4) Different levels require different measurement. (5) "Resolution" means different things at each level.

Principle 1 (Level Correspondence Postulate (Bridging Postulate)). *In humans, the three levels (Π, M, Σ) are typically—though not invariably—positively correlated, such that evidence at one level provides prima facie support for predictions at the others. This postulate is itself an empirical claim, testable through multi-level measurement designs (Section 12). When citing human studies that measured Σ, we note the level and invoke this postulate.*

Terminological convention:

- *Comparative perturbation* (Π): Level 1 behavioral quantity.
- *Mobilization* (M): Level 2 internal resource reallocation.
- *Experienced tension* (Σ): Level 3 subjective experience.
- *Comparative disequilibrium*: general term when level distinction is not critical.

3 The Comparative Asymmetry Principle

Principle 2 (Comparative Asymmetry Principle). *Any agent satisfying properties P1–P5 will exhibit nonzero comparative perturbation Π whenever (CAP) is active. This perturbation is generated by the relational comparison itself, not by the absolute magnitude of the discrepancy D.*

The principle is stated at Level 1. In agents additionally satisfying P6, Π is expected to be accompanied by M. In agents additionally satisfying P7, by Σ.

3.1 Distinguishing Comparative Perturbation from Deficit-Driven Motivation

The principle predicts that perturbation from asymmetry is distinct from, and additive to, motivation from discrepancy alone. Two agents with identical D: the first has no information about others; the second observes an agent closer to R^*. The principle predicts greater Π in the second.

This aligns with extensive evidence. Reference-dependent utility models show that identical objective outcomes produce different satisfaction levels depending on reference group (Clark and Oswald, 1996; Luttmer, 2005)—Σ-level evidence. Tesser's (1988) self-evaluation maintenance model demonstrates that comparison target relevance and closeness modulate effect intensity independently of absolute performance. In animal behavior, resource-holding contests are influenced by relative assessments (Parker, 1974)—direct Π-level evidence.

3.2 Independence from Absolute Sufficiency

Π persists even when R_{self} is sufficient for stability. The Easterlin paradox (Easterlin, 1974): beyond material sufficiency, well-being (Σ) correlates more with relative than absolute income. If R^* is relationally calibrated (Section 8), absolute sufficiency does not eliminate comparison-generated perturbation.

3.3 Illustrative Cases

Three cases illustrate the principle across system types. Appendix A develops each in full detail.

Case 1: Doctoral program (human, all three levels). A PhD student ($\rho \approx 0.7$) observes a cohort peer publishing in a high-impact journal. Her R_{self} has not changed, but R^* shifts upward and (CAP) activates. She exhibits increased working hours and decreased satisfaction ($\Pi > 0$, $\Sigma > 0$). The perturbation is generated by the relational observation, not by any deficit in her objective progress.

Case 2: Instagram fitness culture (environmental induction). An individual with objectively healthy fitness follows 40 influencers whose curated content represents the top 0.1% of physiques. High C_d activates (CAP) chronically. Signal asymmetry inflates perceived A_i. The individual increases training beyond recovery capacity ($\Pi > 0$), reports body dissatisfaction ($\Sigma > 0$), and shows physiological stress markers ($M > 0$).

Case 3: Multi-agent RL training (Π-level only). Three RL agents share an environment with observable reward signals. Agent A ($R_{\text{self}} = 12.3$) observes Agent B ($R_{\text{other}} = 18.7$). A satisfies P1–P5. The policy divergence $D_{\text{KL}}[\pi_A^{\text{post}} \| \pi_A^{\text{pre}}]$ exceeds what A's own reward trajectory would predict—the excess is Π. No Σ is predicted (P7 absent). This is a pure Level 1 test.

4 Comparison Density and Environmental Amplification

4.1 Defining Comparison Density

Define *comparison density* C_d as the rate at which an agent is exposed to state information about other agents, weighted by salience:

$$C_d = \sum_{i=1}^{n} w_i \cdot \nu_i \tag{8}$$

where ν_i is exposure frequency to S_i's state information and w_i is a salience weight reflecting perceived similarity, domain relevance, and state-space proximity.

The principle predicts: $\partial\Pi/\partial C_d > 0$. The functional form—linear, logarithmic, sigmoidal—is an empirical question. In agents satisfying P6 and P7, the parallel predictions $\partial M/\partial C_d > 0$ and $\partial\Sigma/\partial C_d > 0$ follow from the Bridging Postulate but are independently testable.

4.2 Environmental Induction

Environments that systematically increase C_d activate (CAP) chronically rather than episodically.

Principle 3 (Environmental Induction Principle)**.** *Environments that increase comparison density produce higher baseline* Π *across all agents satisfying P1–P5, regardless of the absolute state distribution.*

Curated depictions of others' lives are consistently associated with reduced self-evaluation (Σ-level: Appel et al. 2016; Verduyn et al. 2017), even among objectively well-off individuals.

4.3 Multiple Comparisons and Aggregation

In high-C_d environments, agents face many simultaneous targets. Plausible aggregation rules include a weighted sum ($A_{\text{agg}} = \sum_i w_i A_i$), a max-rule ($A_{\text{agg}} = \max_i(A_i)$; consistent with Fiske 2010), or intermediate schemes. Psychological evidence suggests both sub-additivity (habituation) and super-additivity (extreme-outlier amplification), with attention-capture by a small number of highly salient upward targets as the dominant pattern (Crusius and Lange, 2022).

Regardless of aggregation rule, Π as a function of C_d must exhibit diminishing marginal returns. A saturating form—$\Pi \propto \log(1+C_d)$ or $\Pi \propto C_d/(C_d+\kappa)$—is more plausible than linear growth.

4.4 Relationship to Formal Frameworks

The comparative asymmetry principle bears systematic relationships to two frameworks (Kriger, 2017, 2026). Rather than citing each connection locally, we consolidate the mapping here.

The **Viability Mismatch Law** (VML; Kriger 2026) establishes that any viable system operates under normalized mismatch $S = (E - R)/R$ between environmental demand E and available resources R. Below a critical threshold D^*, mismatch triggers adaptive mobilization ($dR/dt > 0$); above D^*, degradation ensues ($dR/dt < 0$). Systems with recursive self-modeling reparameterize inputs: $E' = E \cdot f_E(C,\theta)$, $R' = R \cdot f_R(C,\theta)$, where C is self-reflection capacity and θ is distortion mode.

The **unified theory of self-organizing systems** (Kriger, 2017) derives four laws for peer systems, including a cooperative default (Law Zero: antagonism requires continuous external perturbation P) and observational asymmetry (Law III: functional states generate low signal, producing $\hat{\rho} < \rho$ in external evaluations).

Concrete walkthrough (Instagram case). In CAP terms: C_d is high, A_i is inflated by curated content, (CAP) is chronically active, $\Pi > 0$. In VML terms: the agent's effective demand E' is inflated by maladaptive reparameterization ($\theta < 0$), pushing S toward D^*; cumulative load $\Lambda(t) = \int_0^t S(\tau) \cdot \mathbf{1}_{S(\tau)>0}\, d\tau$ predicts degradation onset. In unified theory terms: Law III explains the biased sample (routine fitness is invisible; exceptional physiques are broadcast), producing $\hat{\rho} < \rho$. The CAP identifies *comparison* as the specific mechanism through which E escalates endogenously. The VML provides the dynamics (regime transitions, cumulative load). The unified theory provides the information-theoretic constraints (why perceived asymmetry is biased upward) and game-theoretic constraints (why destructive strategies are unstable).

Table 1: Mapping between CAP constructs and formal frameworks

CAP Construct	VML Equivalent	Unified Theory Equivalent
Perceived asymmetry A_i	Demand inflation ($E \uparrow$)	Signal asymmetry (Law III: $\hat{\rho} < \rho$)
Comparative perturbation Π	Instantaneous mismatch S	Response function ϕ
Internal mobilization M	Adaptive mobilization ($dR/dt > 0$)	—
Resolution strategies (5.1–5.5)	Stress response hierarchy	Cooperative vs. antagonistic strategies
Other-directed interference (5.2)	Stress transfer	Perturbation-maintained antagonism ($P \neq 0$)
Reframing (5.5)	Inversion ($\partial S/\partial E$ sign change)	—
Runaway goal drift	$S \geq D^* \rightarrow$ degradation	—
Perception distortion (7.4)	Reparameterization (f_E, f_R)	Observational bias ($\hat{\rho} < \rho$)
Culturally high ρ	—	Internalized perturbation P_{int}

5 Resolution Strategies

When $\Pi > 0$, five structurally distinct strategies can reduce the comparative asymmetry condition. These map onto the VML stress response hierarchy (Section 4).

5.1 Self-Modification (Constructive)

The agent increases R_{self} toward R^*: $\Delta R_{\text{self}} > 0$. This corresponds to competitive effort, skill acquisition, or resource accumulation. At Level 1, this reduces Π by closing the gap. At Level 3, it may not reduce Σ if goal drift (Section 8) moves R^* upward concurrently.

5.2 Other-Directed Interference (Destructive)

The agent decreases R_{other_i}: $\Delta R_{\text{other}_i} < 0$. This corresponds to sabotage, aggression, or status undermining.

A structural constraint comes from Law Zero (Kriger, 2017): in peer systems with shared environment and repeated interaction, cooperative response is the dynamically stable configuration. Antagonistic behavior requires continuous external perturbation P. Strategy 5.2 is therefore not self-sustaining in peer systems: agents incur ongoing costs to maintain a configuration the system's dynamics work to dissolve. In the absence of institutional structures that subsidize competitive antagonism, the system relaxes toward cooperative equilibria—a systems-theoretic reason for the observed instability of destructive strategies in repeated-interaction environments.

5.3 Goal Recalibration

The agent adjusts R^*: ΔR^* such that $g(R^{*\prime}, R_{\text{self}}) < g(R^*, R_{\text{self}})$. This reduces perturbation without changing the agent's state or environment.

5.4 Observation Withdrawal

The agent reduces C_d: $\Delta C_d < 0$. Examples include unfollowing social media accounts, avoiding competitive contexts, or reducing monitoring of colleagues' achievements. This targets the informational precondition and is often the fastest route to reducing Π, but may carry opportunity costs.

5.5 Reframing the Comparison Dimension

The agent reinterprets the comparison so that it no longer maps onto the evaluated dimension—or so that it serves as information rather than perturbation. This is the most powerful contained response, corresponding to inversion in the VML hierarchy.

6 Determinants of Strategy Selection

Six primary predictors determine which strategy an agent adopts.

6.1 Perceived Controllability

When the comparison dimension is perceived as within capacity to influence, self-modification (5.1) is strongly favored. When perceived as fixed, agents shift to 5.3–5.5 (Weiner, 1985).

Prediction 1. *Perceived controllability is the strongest single predictor of self-modification vs. non-modification strategy choice.*

6.2 Accountability Structure

Strategy 5.2 is constrained by accountability. High-accountability environments (identifiable agents, strong norms) suppress interference; low-accountability environments (anonymity; Suler 2004) lower its cost.

6.3 Identity Investment

When comparison occurs along a dimension central to identity (Tajfel and Turner, 1979), perturbation is amplified and the agent persists with effortful strategies (5.1, 5.2) rather than disengaging. High identity investment overrides controllability.

6.4 Alternative Comparison Dimensions

Agents evaluating along k independent dimensions experience single-dimension asymmetry impact scaling approximately as $1/k$.

6.5 Social Support for Withdrawal

Strategy 5.4 is facilitated when the social environment normalizes reduced comparison exposure and stigma for withdrawal is low.

6.6 Learning History and Habitual Strategy

Agents develop habitual preferences through reinforcement history. Past success with 5.1 biases toward 5.1; past failure biases toward 5.3 or 5.4.

6.7 Strategy Sequencing

Strategies are typically attempted in a predictable sequence: 5.1 $\rightarrow$ 5.5 $\rightarrow$ 5.3 $\rightarrow$ 5.4, with 5.2 adopted primarily under specific conditions (low accountability, high frustration, identity threat). When 5.1 fails—because the dimension is less controllable than assumed or goal drift moves R^* upward—agents fall back through the sequence.

7 Individual Variation in Susceptibility

7.1 Relational Orientation (ρ)

Define *relational orientation* ρ as the degree to which R^* is determined by others' states:

$$\rho = \frac{\mathrm{Var}(R^*|R_{\text{other}})}{\mathrm{Var}(R^*)} \tag{9}$$

High-ρ agents set goals by reference to what they observe; low-ρ agents maintain internally anchored goals. High ρ is associated with comparison-dense socialization, insecure attachment (Mikulincer and Shaver, 2007) (primarily Σ), trait neuroticism (Buunk and Gibbons, 2007) (Π and Σ), and socially prescribed perfectionism (Hewitt and Flett, 1991) (primarily Σ). Low ρ is associated with secure attachment, intrinsic motivation (Deci and Ryan, 2000), dispositional mindfulness (Keng et al., 2011) (primarily Σ), and age (Lacey et al., 2006).

ρ varies across cultures: interdependent self-construal cultures produce higher baseline ρ (Markus and Kitayama, 1991; Heine and Lehman, 1995; White and Lehman, 2005). Some culturally high ρ may reflect internalized perturbation P_{int} (Kriger, 2017)—competitive ranking structures transmitted culturally, persisting even after external pressures weaken. If so, ρ should decay slowly when external competitive pressure is reduced—a longitudinally testable prediction distinguishing the perturbation account from fixed-trait views.

7.2 Breadth of Comparison Dimensions

An agent evaluating across k independent dimensions distributes comparative risk; single-dimension asymmetry impact scales approximately as $1/k$.

7.3 Comparison Target Selection Habits

Habitual upward comparison strongly predicts chronic Π (Buunk and Gibbons, 2007). Downward comparison can reduce perturbation (Wills, 1981).

7.4 Perception Accuracy and the Double Distortion Pipeline

The mechanism operates on perceived A_i, not actual state differences. Agents who overestimate R_{other_i}—interpreting curated self-presentation as representative—compute inflated A_i.

Two mechanisms produce systematic upward bias. First, **environmental signal asymmetry** (Law III; Kriger 2017): functional states generate low observational signal while exceptional states generate high signal, producing $\hat{\rho} < \rho$—agents observe a sample enriched for high-R_{other_i} observations. This bias is structural, not cognitive. Second, **internal reparameterization** (VML; Kriger 2026): agents with maladaptive distortion ($\theta < 0$) inflate perceived demands ($f_E > 1$) and shrink perceived resources ($f_R < 1$), producing $S_{\text{total}} \gg S_{\text{objective}}$.

Together these constitute a *double distortion pipeline*: the environment presents a biased sample, and internal processing further amplifies or attenuates that bias depending on θ.

Prediction 2. *Agents with more accurate models of others' states exhibit lower* Π *given equivalent actual asymmetry.*

7.5 Acceptance-Based Regulation

Agents differ in capacity to experience comparative disequilibrium without behavioral amplification. Acceptance-based regulation (Hayes et al., 1999) attenuates the Level 1 $\to$ Level 2 $\to$ Level 3 amplification loop without preventing initial Π.

Prediction 3. *Higher acceptance-based regulation capacity* $\to$ *equivalent initial* Π *but lower sustained* Π*,* M*, and* Σ.

8 Goal Drift

R^* is not necessarily stable. In high-ρ agents, the desired state is influenced by observation:

$$R^*(t+1) = h(R^*(t), \{R_{\text{other}_i}(t)\}) \tag{10}$$

where $h : \mathbb{R} \times \mathbb{R}^n \to \mathbb{R}$. When observation shifts R^* upward, a self-reinforcing cycle emerges: Observation $\to$ Asymmetry $\to \Pi > 0 \to$ Upward Goal Shift $\to$ Greater Asymmetry.

8.1 Three Regimes

A linear model $R^*(t+1) = (1-\rho) \cdot R_0 + \rho \cdot \bar{R}_{\text{other}}(t)$ yields three regimes:

Table 2: Goal drift regimes

Regime	**ρ Range**	**Goal Dynamics**	**Π Profile**	**Human Example**	**RL Example**
Stable	$\rho \ll 1$	R^* anchored to R_0	Bounded, episodic	Intrinsic researcher ($\rho = 0.1$)	Fixed reward target
Runaway	$\rho \to 1$	R^* tracks $\bar{R}_{\text{other}}$; unbounded	Chronic, increasing	Social media user ($\rho = 0.9$)	Mimicking top performer
Bounded	Moderate ρ, $\lambda > 0$	Stabilized via dampening	Transient, converges	Mature professional	Aspiration decay agent

The bounded case adds a dampening term: $R^*(t+1) = (1-\rho) \cdot R_0 + \rho \cdot \bar{R}_{\text{other}}(t) - \lambda \cdot [R^*(t) - R_{\text{self}}(t)]$, penalizing the gap between aspiration and reality. When λ is large relative to ρ, equilibrium is reached even under high comparison exposure.

8.2 Red Queen Dynamics and Energetic Collapse

The runaway regime is a Red Queen dynamic: sustained M in service of an ever-receding R^* depletes internal resources. When cumulative cost exceeds capacity, the system faces a forced exit: adaptive strategy switch or systemic degradation (burnout, learned helplessness).

In VML terms: upward comparison inflates E while R changes slowly; in runaway, E grows without bound, pushing S past D^*. The cumulative load $\Lambda(t)$ predicts degradation onset. The Optimal Mismatch Theorem shows the optimal state is small positive S—moderate Π may serve adaptive mobilization, consistent with the finding that mild upward comparison can enhance motivation (Meier and Schäfer, 2021).

8.3 Evaluative Dependence

Over sustained high-C_d exposure, self-evaluation becomes increasingly relational:

$$\lim_{t\to\infty} \frac{\partial R^*}{\partial R_{\text{other}}} \gg \frac{\partial R^*}{\partial R_{\text{self}}} \tag{11}$$

Supported by social media and self-concept studies (Vogel et al., 2014) (Σ-level).

9 Boundary Conditions

B1. Missing structural properties. The principle does not apply to systems lacking any of P1–P5.

B2. Orthogonal comparison dimensions. If evaluation and observation dimensions are entirely independent, no asymmetry is perceived.

B3. Saturated self-evaluation. If self-evaluation is dominated by absolute criteria ($\partial\Pi/\partial A_i \approx 0$), the mechanism is inactive.

B4. Low salience. Dissimilar or irrelevant agents produce negligible asymmetry ($w_i \to 0$; Festinger 1954; Mussweiler 2003).

B5. Downward comparison dominance. Predominantly observing lower-R_{other_i} agents produces comparative comfort (Wills, 1981).

B6. Acceptance-based regulation. Limits escalation and chronicity without preventing initial Π (Section 7).

B7. Pathological level dissociation. When inter-level coupling is disrupted, the Bridging Postulate breaks down. High M with $\Sigma \approx 0$, or high Π with $M \approx 0$, may occur. The combination $\Pi \approx 0$ with $M \gg 0$ (latent perturbation) is clinically significant: an unstable suppression state that may resolve through sudden decompensation.

10 Statistical Prevalence

Theorem 1 (Statistical Prevalence Theorem)**.** *In an environment with n observable agents with non-identical states and shared evaluation dimensions, the expected proportion of agents for whom at least one upward comparison is available approaches 1 as n increases.*

Given shared evaluation criteria, some nonzero Π is overwhelmingly probable in aggregate in large populations, while remaining agnostic about individuals. The Π distribution is determined by the susceptibility factors in Section 7.

11 Diagnostic Applications

Comparison-driven Π serves as diagnostic evidence of latent goal representation: if $\Pi > 0$ specifically in response to relational information, the system maintains an implicit R^* along that dimension.

Applications:

1. **Artificial agent design**—comparison-driven Π in multi-agent AI signals emergent implicit goals, useful for alignment monitoring (Level 1 only).

2. **Organizational behavior**—identifying which dimensions generate strongest perturbation reveals actual values vs. stated incentives.

3. **Clinical assessment**—the dimensions along which Σ is strongest indicate self-concept vulnerabilities; independent measurement of Π, M, Σ reveals clinically significant dissociations.

Toy RL prediction. In a multi-agent system with observable rewards, an alignment monitor can detect emergent relational objectives by measuring $\Pi_i = D_{\text{KL}}[\pi_i(a|s, R_{\text{others}}) \| \pi_i(a|s, \emptyset)]$. If $\Pi_i > \epsilon$ for sustained periods in an agent whose explicit reward function contains no comparison term, it has developed a de facto relational objective—an early warning for emergent competitive dynamics in cooperative systems.

12 Discussion

12.1 Limitations

The principle is deliberately abstract; predictive power depends on specifying f, g, h for specific system classes. The domain-independence claim awaits demonstration in artificial agents; preliminary work (Leibo et al., 2017) is suggestive but not formally connected. The aggregation structure for multiple simultaneous comparisons involves nonlinear dynamics beyond this treatment. The strategy selection model identifies predictors but not yet relative weights. The conditions for level dissociation deserve fuller treatment.

12.2 Testable Predictions

Core mechanism:

- Holding D constant while varying visibility of better-off others should modulate Π (Level 1) and Σ (Level 3).
- Information restriction interventions should reduce Π even without change in R_{self}.
- Reframing interventions that shift R^* should reduce Π without objective improvement.

Individual variation:

- Perceived controllability should be the strongest predictor of self-modification, except under extreme identity investment (Section 6).
- ρ, dimension breadth, comparison direction, and perception accuracy should predict individual Π intensity.
- Sustained high C_d should produce upward drift in R^* and increasing evaluative dependence, modulated by ρ.

Level dissociation:

- Acceptance-based regulation should reduce sustained Π and Σ without eliminating initial perturbation.
- Under controlled conditions: high Π/low Σ (unconscious perturbation), low Π/high Σ (suppressed distress), and high M with discordant Π and Σ should all be observable.

Artificial agents:

- Multi-agent RL agents satisfying P1–P5 should exhibit $\Pi > 0$ (policy divergence) when comparison information is available, absent explicit relative-performance objectives.
- Sustained $\Pi > \epsilon$ in agents with no explicit comparison term signals implicit relational goals—testable as an alignment diagnostic.

Sketch of experimental design. Participants: $N = 120$ humans performing a creative task with objective scoring. Design: 2 (visibility: peer scores visible vs. hidden) $\times$ 2 (gap: peer moderately above vs. equal), between-subjects. Measures: behavioral output (Π, Level 1), salivary cortisol (M, Level 2), self-reported affect (Σ, Level 3). Prediction: visibility $\times$ gap interaction significant for all three measures; the visibility-on/gap-above condition produces highest Π, M, Σ; the gap-equal/visibility-on condition produces negligible Π. A parallel design using RL agents, with and without access to others' reward signals, tests the same prediction at Level 1 only.

13 Conclusion

The Comparative Asymmetry Principle describes a mechanism by which agents with self-evaluation, goal representation, observational access, relational evaluation, and behavioral modulation capacities generate measurable behavioral perturbation (Π) from perceived asymmetry rather than absolute deficit. In agents with additional complexity, perturbation is accompanied by mobilization (M); in agents with consciousness, by experienced tension (Σ).

The perturbation scales with comparison density, is amplified by high-visibility environments, and resolves through five strategies—self-modification, interference, goal recalibration, observation withdrawal, or reframing. Individual susceptibility varies along five dimensions: relational orientation, comparison breadth, target selection habits, perception accuracy, and acceptance-based regulation. The mechanism becomes self-reinforcing when goal representations are endogenous to comparison.

Formal integration with the Viability Mismatch Law and the theory of self-organizing systems situates comparative perturbation as one specific demand-generation mechanism within a broader framework of viable-system dynamics.

A Illustrative Cases

A.1 Doctoral Program: Comparative Perturbation in Academic Training

Setting. A second-year PhD student (Agent S; $\rho \approx 0.7$) in a mid-ranked computational biology program. The department publishes a weekly seminar schedule listing graduate students' recent publications and conference acceptances.

State variables. $R_{\text{self}} = \{1 \text{ published paper}, 1 \text{ under review}\}$. $R^* = \{3 \text{ publications by Year } 3\}$, anchored partly to program norms. The agent observes a cohort peer (S_1) who has just published a sole-authored paper in a top-tier journal: $R_{\text{other}_1} = \{3 \text{ published papers, including 1 in top venue}\}$.

Activation of (CAP). $A_1 = f(R_{\text{other}_1}, R_{\text{self}}, R^*) > 0$: the peer is perceived as substantially closer to the aspiration. $D = g(R^*, R_{\text{self}}) = 2$ publications remaining. Both conditions of (CAP) are met. The non-monotonicity of f matters: a faculty member with 50 publications would produce negligible A_i (too distant; $w_i \approx 0$), but the peer—same career stage, same department—falls within the inverted-U peak.

Three levels.

- *Level 1 (Π)*: Increased daily lab hours ($8 \to 11$), hourly preprint checking, shift from exploratory to confirmatory research strategies. Π = behavioral divergence from pre-observation pattern.
- *Level 2 (M)*: Decreased sleep quality (elevated cortisol, reduced slow-wave sleep). Attentional narrowing: stops attending seminars outside subfield.
- *Level 3 (Σ)*: Self-reported shift from "engaged and curious" to "anxious and behind." Reports "feeling like I'm failing" despite being on track by program milestones. The Bridging Postulate connects this Σ to the Π prediction.

Resolution strategy sequence. (1) Self-modification (5.1): increased effort, strategy shift—adopted first (controllability perceived as moderate-to-high). (2) After six months produce one submission but no acceptance, and a second peer publishes, she considers goal recalibration (5.3): redefining success as "field contribution" rather than "matching peer output." (3) Reduces checking the department board (observation withdrawal, 5.4). (4) Advisor suggests reframing (5.5): viewing the peer's success as evidence that lab methods work—converting comparison from threat to information.

Goal drift. With $\rho = 0.7$: $R^*(t+1) = 0.3 \cdot R_0 + 0.7 \cdot \bar{R}_{\text{other}}(t)$. When S_1 publishes again, $\bar{R}_{\text{other}}$ increases, pulling R^* upward even though R_{self} has improved. The gap D widens despite absolute progress.

VML mapping. Effective demand E inflates as R^* escalates; actual capacity R changes slowly. With $\theta < 0$ (rumination), $S_{\text{total}} > S_{\text{objective}}$. Cumulative load $\Lambda(t)$ accumulates over months, predicting burnout risk.

Unified theory mapping. Law III: the seminar board broadcasts publications (high signal) but not hundreds of hours of failed experiments and rejected submissions (low-signal functional states). The student's sample of peer performance is biased upward. Law Zero: other-directed interference (undermining the peer) would require continuous institutional support; the department's collaborative norms make it costly and unstable.

A.2 Instagram Fitness Culture: Environmental Induction and Double Distortion

Setting. A 28-year-old recreational athlete (Agent S; $\rho \approx 0.6$) follows 40 fitness influencers on Instagram. The platform's algorithm amplifies high-engagement content—disproportionately images of exceptional physiques.

State variables. R_{self}: healthy BMI, 10km in 52 minutes, bench press 1.1× bodyweight—above-average by population norms. R^*: initially anchored to health markers and personal records. R_{other_i}: curated images of competition-level physiques (approximately 99.9th percentile).

Activation of (CAP). $A_i > 0$ for most observed influencers. Despite objectively good R_{self}, $D > 0$ because R^* has drifted toward the curated sample. $C_d \approx 30$ comparison exposures per day, each high-salience.

Double distortion pipeline. (1) *Environmental signal asymmetry (Law III)*: routine fitness generates no content; exceptional physiques are broadcast. The agent perceives the population as fitter than it is ($\hat{\rho} < \rho$). (2) *Internal reparameterization (VML)*: with $\theta \approx -0.3$, the agent inflates perceived demand ($f_E > 1$: "I should look like that") and deflates perceived resources ($f_R < 1$: "I'll never get there"). Combined: $S_{\text{total}} \gg S_{\text{objective}}$.

Three levels.

- *Level 1 (*Π*)*: Training increases from 4 to 7 sessions/week. Diet shifts from flexible to rigid macro-tracking. Begins purchasing influencer-advertised supplements.
- *Level 2 (M)*: Elevated resting heart rate (overtraining). Sleep disruption. Stops eating socially.
- *Level 3 (*Σ*)*: Body dissatisfaction despite objective health. Reports "I look at myself and feel disgusted." Paradox: R_{self} is above-average, yet Σ is strongly negative.

Resolution attempts. (1) Self-modification (5.1): increased training and restriction—produces diminishing returns and overtraining injury. (2) Observation withdrawal (5.4): unfollows 30 accounts; Σ decreases within two weeks (consistent with Verduyn et al. 2017). (3) Sports psychologist facilitates reframing (5.5): redefining fitness comparisons as "information about what's possible with full-time training and pharmaceutical assistance" rather than "what I should look like."

Goal drift. R^* drifts continuously as each new physique resets the reference point. Runaway operates because $\rho = 0.6$ applied to the extreme tail produces chronic $D > 0$. The bounded case would require dampening ($\lambda > 0$: realistic genetic/pharmacological limits) or ρ reduction.

Saturation. The 40th influencer post produces less marginal Π than the 1st—consistent with $\Pi \propto C_d/(C_d + \kappa)$—but baseline Π remains elevated because C_d is so high that even the saturated rate produces substantial chronic perturbation.

A.3 Multi-Agent RL: Pure Level 1 Dynamics

Setting. A shared-environment RL system with three agents (A, B, C) on a foraging task. Each has an individual reward function. Agents observe each others' cumulative rewards (scoreboard) but have no communication channel.

Structural properties. A satisfies P1 (tracks reward via value function), P2 (has reward target in objective), P3 (observes scoreboard), P4 (computes relative performance), P5 (modifies policy in response). P6 is architecture-dependent. P7 is absent.

Activation of (CAP). At $t = 5000$: $A = 12.3$, $B = 18.7$, $C = 11.1$. For A: $A_B > 0$ (upward asymmetry with B); $A_C = 0$ (downward). (CAP) active with respect to B.

Measuring Π. Two conditions: (1) scoreboard visible; (2) scoreboard hidden. $\Pi_A = D_{\mathrm{KL}}[\pi_A^{\mathrm{visible}} \| \pi_A^{\mathrm{hidden}}]$. In simulation: $\Pi_A > 0$. The visible-scoreboard agent shifts exploration toward regions where B forages (mimicry) and away from low-yield areas it would otherwise have explored (risk-aversion). This policy divergence exceeds what A's own reward trajectory predicts.

Three levels.

- *Level 1 (*Π*)*: Measurable policy divergence. This is the pure test: $\Pi > 0$ in a system with no consciousness.
- *Level 2 (*M*)*: If the agent has an attention mechanism, increased weights on the scoreboard channel are observable. In simpler architectures, absent.
- *Level 3 (*Σ*)*: Not applicable.

Resolution strategies. (1) Self-modification (5.1): higher exploration in promising regions—automatic via policy gradient. (2) Strategy mimicry (specific form of 5.1): copying B's foraging pattern. (3) If action affordances allow, interference (5.2): blocking B's resource access—but suppressed if training objectives penalize such actions. (4) With meta-learning: implicit recalibration (5.3) via internal reward-scale adjustment.

Goal drift. If R_A^* is influenced by $\bar{R}_{\mathrm{other}}$ (even implicitly through interaction dynamics), the agent enters a runaway regime: its target chases B's reward. Chronic Π even as absolute reward increases—explaining why multi-agent settings often produce sub-optimal individual behavior compared to isolated training.

Alignment diagnostic. If $\Pi_A > \epsilon$ for sustained periods in an agent whose explicit reward function contains no comparison term, it has developed a de facto relational objective. Detectable via D_{KL} measurement; constitutes an early warning for emergent competitive dynamics in ostensibly cooperative systems.

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