The Fragmentation Problem in the Sciences of Mind and Society: A Minimal Unified Framework

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Abstract

Despite major advances in neuroscience, psychology, artificial intelligence, and social science, no unified model currently explains how human intelligence, identity, and society arise from common foundational principles. This paper formalizes the "fragmentation problem"—the lack of a bridge between neural mechanism and social phenomenon—and proposes a minimal unified framework. We posit that complex human phenomena emerge from five interacting principles: **Prediction** (free energy minimization), **Feedback** (active inference), **Attention** (precision weighting), **Self-Modeling** (hierarchical integration), and **Social Coupling** (alignment of generative models). This framework provides a continuous mathematical and logical path from the neuron to the nation-state.

1 Introduction: The Fragmentation Problem

The current state of the sciences of mind is characterized by explanatory gaps. Neuroscience describes the *mechanism* (synaptic efficacy, firing rates) but lacks a theory of *meaning*. Psychology catalogs *behavior* (biases, traits) without a unified causal core. Social science analyzes *structure* (institutions, markets) without deriving them from *cognition*.

We propose that these are not distinct domains but distinct scales of a single information-processing imperative. To unify them, we must identify the invariant rules that operate across scales.

2 The Formal Framework

We define the human cognitive-social system S as a function of five recursive operations.

2.1 Principle I: Prediction (Free Energy Minimization)

The fundamental imperative of the cognitive system is to maintain homeostasis by minimizing the divergence between its internal model of the world and sensory reality. Formally, this equates to minimizing **Variational Free Energy** (F). The system does not passively receive data; it projects a generative model (G) onto the world.

$$F \approx -\ln p(o|m) + D_{KL}[q(s)||p(s|m)] \tag{1}$$

Where:

- o is sensory observation.
- m is the internal model.
- $q(s)$ is the approximate posterior belief about external states.
- D_{KL} represents the complexity cost of updating beliefs.

2.2 Principle II: Feedback (Active Inference)

To minimize F, the system has two, and only two, options:

1. **Perceptual Learning:** Update internal beliefs (m) to match sensory data (o).
2. **Active Inference (Action):** Act upon the environment to change sensory data (o) to match internal predictions.

$$\dot{a} = -\frac{\partial F}{\partial a} \tag{2}$$

Action (a) is simply a reflex to eliminate prediction error. Behavior is not "willed" in a vacuum; it is a calculated effort to confirm the system's priors.

2.3 Principle III: Attention (Precision Weighting)

Not all prediction errors are equal. The system must assign a "weight" or confidence level to incoming signals. This is **Precision** (Π).

$$\xi = \Pi \cdot (o - g(m)) \tag{3}$$

Where ξ is the weighted prediction error.

- **High Precision:** The system trusts the senses (Attention).
- **Low Precision:** The system trusts the prior (Inattention/Dreaming).

2.4 Principle IV: Self-Modeling (Hierarchical Control)

To minimize F efficiently, the system must predict its own future states. The brain constructs a high-level abstraction—the **"Self"**—as a control variable in its generative model.

$$S_{self} \subset m \tag{4}$$

The "Self" is a statistical compression used to organize agency and accountability. It is an interface, not a homunculus.

2.5 Principle V: Social Coupling (Synchronization of Priors)

When two predictive agents (i and j) interact, they become part of each other's environment. To minimize their respective F, they must predict each other.

$$F_{joint} \approx F_i(o_j) + F_j(o_i) \tag{5}$$

The most efficient way to minimize mutual prediction error is to synchronize generative models ($m_i \approx m_j$). This synchronization emerges as **Language**, **Culture**, and **Law**.

3 Derivations: From Cognition to Society

Using these five rules, we can mathematically derive complex human phenomena without introducing new auxiliary hypotheses.

3.1 Derivation A: Anxiety (The Precision Failure)

Anxiety can be formalized as an inability to minimize Free Energy (F) regarding future states, coupled with hyper-active Precision (Π) on negative outcomes.

If the agent's generative model (m) predicts a high probability of threat, but the environment (o) is ambiguous, the agent cannot resolve the error term ($o - g(m)$).

$$\xi_{anxiety} = \Pi_{high} \cdot (o_{uncertain} - g(m_{threat})) \tag{6}$$

Because action (a) cannot easily resolve the uncertainty of the future, the system enters a loop of "worry"—simulating potential actions to reduce F without physical success. This creates a persistent high-energy state (stress) driven purely by the internal requirement to minimize expected error.

3.2 Derivation B: Political Polarization (Social Free Energy Minimization)

Polarization is a collective strategy to minimize processing costs. A complex social environment introduces massive entropy (unpredictability). To reduce this, agents form clusters with shared generative models (m_{group}).

When Agent i (Group A) encounters Agent j (Group B), the prediction error is high:

$$F_{interaction} = \text{High} \quad \text{since} \quad m_A \neq m_B \tag{7}$$

To minimize F without the caloric cost of rewriting their entire internal model (m_A), Agent i employs **active inference** to suppress the source of error. This manifests as:

1. **Epistemic Isolation:** Reducing precision ($\Pi \to 0$) on data from Group B (ignoring the other side).

2. **Active Suppression:** Acting to remove Agent j from the environment (cancel culture, censorship, or conflict).

Thus, polarization is not a moral failing but a mathematical stability requirement for systems trying to protect their generative models.

4 Conclusion

This framework offers a non-dualistic solution to the mind-body-society problem. By viewing human reality as a multi-scale system of predictive processing, we bridge the gap between the firing of a neuron and the formation of a government. The five principles—Prediction, Feedback, Attention, Self-Modeling, and Social Coupling—are sufficient to generate the observable complexity of the human condition.

References

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