Integrating Enactivism and the Free Energy Principle with RSVP Mathematics

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1 Integrating Enactivism and the Free Energy Principle with RSVP

The free energy Principle (FEP) posits that cognitive systems minimize variational free energy to align internal generative models with sensory observations, reducing surprise and enabling adaptive behavior (**?**). enactivism frames cognition as a dynamic, embodied coupling between organism and environment, rejecting purely representational views (**??**). The RSVP framework models collective information dynamics through semantic density $\Phi(\mathbf{x}, t)$, attention flow $\mathbf{v}(\mathbf{x}, t)$, and entropy $S(\mathbf{x}, t)$. This section integrates these frameworks, aligning FEP's predictive mechanisms with enactivism's sensorimotor loops within RSVP's field equations, and explores implications for the vanity press economy.

1.1 Free Energy Principle: Mathematical Foundations

The FEP defines variational free energy $\mathcal{F}$ for an agent with internal model parameters μ, sensory data s, and hidden environmental states ψ:

$$\mathcal{F} = \mathbb{E}_{q(\psi)}[-\ln p(s, \psi \mid \mu)] - \mathbb{E}_{q(\psi)}[-\ln q(\psi)],$$

where $q(\psi)$ is an approximate posterior over hidden states, and $p(s, \psi \mid \mu)$ is the

generative model. Minimizing $\mathcal{F}$ approximates Bayesian inference:

$$\mathcal{F} = \mathrm{KL}[q(\psi) \parallel p(\psi \mid s, \mu)] - \ln p(s \mid \mu),$$

where KL is the Kullback-Leibler divergence, and $-\ln p(s \mid \mu)$ is the surprise. Agents minimize $\mathcal{F}$ by updating μ (perception) or acting to change s (active inference).

1.2 Enactivism: Embodied Coupling

enactivism posits that cognition emerges from sensorimotor interactions, co-defining organism and environment (**?**). Abstract thinking, per Gallagher, is a skilled practice using cognitive affordances (e.g., diagrams) grounded in bodily action (**?**). This aligns with FEP's active inference, where actions sample sensory data to reduce prediction errors, but enactivism emphasizes non-representational, dynamic coupling over internal models.

1.3 RSVP Framework Recap

RSVP models collective cognition via:

$$\frac{\partial \Phi}{\partial t} + \nabla \cdot (\Phi \mathbf{v}) = -\lambda_{\Phi S} S,$$

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla)\mathbf{v} = -\nabla \Phi + \eta_{vS} \nabla S - \nu |\mathbf{v}|^2 \mathbf{v},$$

$$\frac{\partial S}{\partial t} = \alpha \nabla^2 S + \beta (\nabla \cdot \mathbf{v})^2 - \gamma \Phi + \mu (\nabla S)^2,$$

where Φ is semantic density (meaning potential), $\mathbf{v}$ is attention flow (sensorimotor engagement), and S is entropy (information disorder). Decelerationism introduces damping (μ, ν) to stabilize dynamics.

1.4 Integration Framework

To integrate FEP and enactivism with RSVP, we map FEP's variational inference to RSVP's fields and align enactivism's sensorimotor coupling with RSVP's attention flows.

1.4.1 FEP in RSVP: Free Energy as Semantic Lagrangian

Define a local free energy density within RSVP, associating each spatial point $\mathbf{x}$ with a generative model $p(s(\mathbf{x},t) \mid \psi(\mathbf{x},t), \mu(\mathbf{x},t))$:

$$\mathcal{F}(\mathbf{x},t) = \mathbb{E}_{q(\psi(\mathbf{x},t))}[-\ln p(s(\mathbf{x},t), \psi(\mathbf{x},t) \mid \mu(\mathbf{x},t))] - \mathbb{E}_{q(\psi(\mathbf{x},t))}[-\ln q(\psi(\mathbf{x},t))].$$

Relate $\mathcal{F}$ to RSVP fields by defining Φ as the negative log-likelihood of the generative model, reflecting semantic coherence:

$$\Phi(\mathbf{x},t) = -\ln p(s(\mathbf{x},t) \mid \mu(\mathbf{x},t)).$$

The attention flow $\mathbf{v}$ drives active inference, adjusting sensory inputs s to minimize $\mathcal{F}$:

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla)\mathbf{v} = -\nabla \mathcal{F} + \eta_{vS} \nabla S - \nu |\mathbf{v}|^2 \mathbf{v}.$$

Entropy S quantifies model uncertainty:

$$S(\mathbf{x},t) = -\mathbb{E}_{q(\psi)}[\ln q(\psi(\mathbf{x},t))],$$

linking to FEP's entropic term. The RSVP continuity equation becomes:

$$\frac{\partial \Phi}{\partial t} + \nabla \cdot (\Phi \mathbf{v}) = -\lambda_{\Phi S} S + D \nabla^2 \Phi,$$

where $D\nabla^2\Phi$ accounts for diffusive updates to the generative model, aligning with FEP's perceptual optimization.

1.4.2 Enactivism in RSVP: Sensorimotor Flows

Enactivism's dynamic coupling maps to $\mathbf{v}$, which represents sensorimotor interactions navigating environmental affordances. The gradient $-\nabla\Phi$ (or $-\nabla\mathcal{F}$) directs $\mathbf{v}$ toward

regions of high semantic potential, embodying enactivist action-perception loops. For example, in collaborative coding, $\mathbf{v}$ synchronizes across agents, reducing joint $\mathcal{F}$:

$$\mathcal{F}_{\text{joint}} = \sum_i \mathcal{F}_i + \sum_{i,j} J_{ij}(\Phi_i - \Phi_j)^2,$$

where J_{ij} couples agents' semantic fields, reflecting social enactivism (**?**).

Abstract thinking, as a skilled practice, is modeled as a hylomorphism on RSVP fields:

$$\mathsf{hylo}_F = \mathsf{cata}_F \circ \mathsf{ana}_F,$$

where cata_F folds environmental data into Φ (embodied understanding), and ana_F unfolds Φ for exploration, aligning with FEP's generative model updates.

1.4.3 Unified Dynamics

The integrated system modifies RSVP equations to incorporate FEP's free energy minimization and enactivism's embodied coupling:

$$\frac{\partial \Phi}{\partial t} + \nabla \cdot (\Phi \mathbf{v}) = -\lambda_{\Phi S} S + D\nabla^2 \Phi,$$

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla)\mathbf{v} = -\nabla \mathcal{F} + \eta_{vS} \nabla S - \nu |\mathbf{v}|^2 \mathbf{v},$$

$$\frac{\partial S}{\partial t} = \alpha \nabla^2 S + \beta (\nabla \cdot \mathbf{v})^2 - \gamma \Phi + \mu (\nabla S)^2,$$

$$\mathcal{F}(\mathbf{x}, t) = \Phi(\mathbf{x}, t) + S(\mathbf{x}, t) + \mathrm{KL}[q(\psi(\mathbf{x}, t)) \parallel p(\psi(\mathbf{x}, t) \mid s(\mathbf{x}, t))].$$

The Lagrangian becomes:

$$\mathcal{L} = \frac{1}{2}|\nabla \Phi|^2 + \frac{1}{2}|\mathbf{v}|^2 + \mathcal{F} - \kappa(\nabla \cdot \mathbf{v})S + \mu(\nabla S)^2 - \nu |\mathbf{v}|^4.$$

This unifies FEP's predictive dynamics, enactivism's sensorimotor coupling, and RSVP's collective fields. The $\mathcal{F}$ term drives perception and action, $\mathbf{v}$ enacts embodied interactions, and Φ and S balance meaning and uncertainty.

1.5 Stability and Convergence

Linearizing around a steady state $(\Phi_0, \mathbf{v}_0, S_0, \mathcal{F}_0)$:

$$\omega(k) = i(\alpha k^2 - \lambda_{\Phi S} - Dk^2) \pm \sqrt{-\gamma + \eta_{vS} k^2 - \partial_\Phi \mathcal{F}},$$

stability requires $\alpha k^2 + Dk^2 \geq \lambda_{\Phi S}$, $\eta_{vS} k^2 \leq \gamma + \partial_\Phi \mathcal{F}$. The damping terms (μ, ν) ensure convergence, preventing runaway entropy from platform-driven acceleration.

1.6 Implications for the Vanity Press Economy

In the vanity press economy, platforms disrupt enactivist coupling by replacing affordance-rich interactions with tokenized rewards, increasing S without reducing $\mathcal{F}$. computational seigniorage extracts value from user-generated data, inflating $\mathcal{F}$ via prediction errors:

$$\mathcal{S}(t) = \int_\Omega \big(v_{\text{market}}(\tau) - c_{\text{production}}(\tau)\big) \rho(\tau, t)\, d\tau,$$

where $\rho(\tau, t)$ is skewed by platform algorithms. The Decelerationism Compression Commons counters this by rewarding reductions in Kolmogorov complexity (ΔK), aligning with FEP's goal of minimizing $\mathcal{F}$:

$$R_{\text{creator}}(t) = \tau_c C_{\text{total}}(t) \frac{\Delta K}{K_{\text{baseline}}},$$

ensuring creators are incentivized for novel, embodied contributions. Sousveillance, inspired by Brin's transparent society (**?**), monitors platform algorithms to reduce KL-divergence, restoring enactivist agency.

1.7 Numerical Implementation

Simulate the integrated system using finite-difference methods, updating $\mathcal{F}$:

$$\mathcal{F}_{i,j}^{t+\Delta t} = \Phi_{i,j}^t + S_{i,j}^t + \sum_\psi q(\psi_{i,j}^t) \ln \frac{q(\psi_{i,j}^t)}{p(\psi_{i,j}^t \mid s_{i,j}^t)}.$$

Parameters: $\lambda_{\Phi S} = 0.1$, $\eta_{vS} = 0.02$, $\alpha = 1.0$, $\beta = 0.2$, $\gamma = 0.05$, $\mu = 0.05$, $\nu = 0.01$, $D = 0.1$, grid spacing $h = 0.02$, $\Delta t = 10^{-3}$.

1.8 Conclusion

This integration casts FEP's free energy minimization as a driver of RSVP's semantic and attention dynamics, with enactivism's embodied coupling shaping $\mathbf{v}$. In the vanity press economy, it counters computational seigniorage by aligning incentives with meaningful, embodied interactions, formalized through ΔK and $\mathcal{F}$. Future work could explore ecological costs and compression aesthetics within this unified framework.