FEP-CRR Correspondence: A Working Exploration

Observed Mathematical Patterns Between
Free Energy Principle and Coherence-Rupture-Regeneration

Research Notes — November 2025

Note: This document presents observed correspondences between FEP and CRR frameworks. These are working conjectures based on mathematical patterns, simulation behavior, and cross-domain analysis. Consider this a collaborative exploration tool rather than established proof.

Contents

1 Core Correspondences

1.1 State Variables

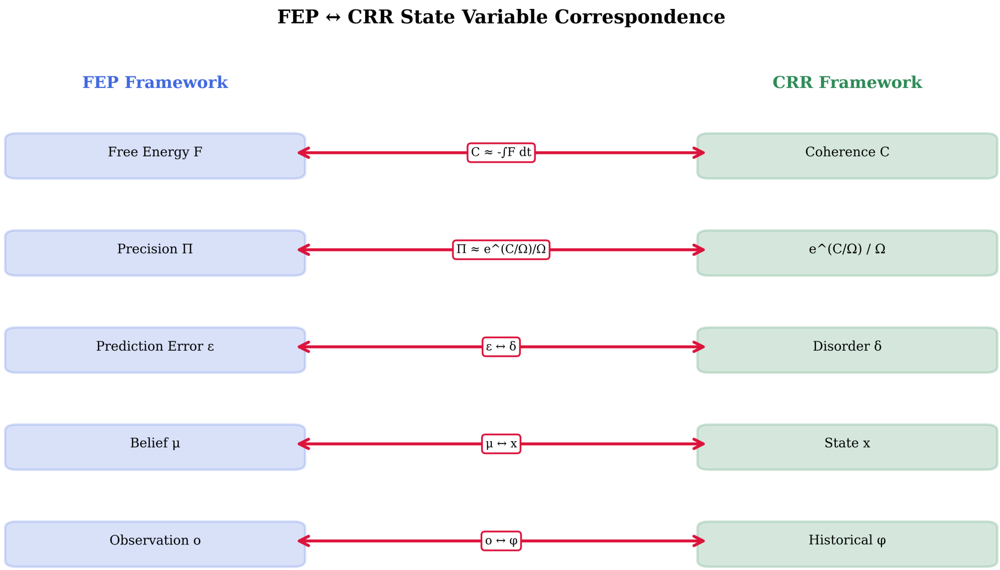

Figure 1: FEP and CRR state variable mappings

State Variable Mapping

$$\textbf{FEP:}\quad \text{Free Energy } F(t) \quad \leftrightarrow \quad \text{Coherence } C(t) \quad \textbf{:CRR} \tag{1}$$

$$\textbf{FEP:}\quad \text{Surprise } -\ln P(o|\mu) \quad \leftrightarrow \quad \text{Memory Density } -L(x,t) \quad \textbf{:CRR} \tag{2}$$

$$\textbf{FEP:}\quad \text{Precision } \Pi(t) \quad \leftrightarrow \quad \frac{1}{\Omega}\cdot e^{C(t)/\Omega} \quad \textbf{:CRR} \tag{3}$$

$$\textbf{FEP:}\quad \text{Prediction Error } \varepsilon(t) \quad \leftrightarrow \quad \text{Disorder } \delta_{\text{local}}(t) \quad \textbf{:CRR} \tag{4}$$

1.2 Fundamental Relation: Coherence as Integrated Free Energy Reduction

FEP: Variational Free Energy

$$F = \mathbb{E}_{Q(\mu)}[\ln Q(\mu) - \ln P(o,\mu)] = D_{KL}[Q(\mu)\|P(\mu|o)] - \ln P(o) \tag{5}$$

Where:

- $Q(\mu)$: Recognition density (internal beliefs)
- $P(o,\mu)$: Joint probability of observations and states
- D_{KL}: Kullback-Leibler divergence

CRR: Coherence Accumulation

$$C(x,t) = \int_0^t L(x,\tau)\, d\tau \quad \text{where} \quad L(x,\tau) = \frac{dC}{d\tau} \tag{6}$$

Where:

- $C(x,t)$: Accumulated coherence (integrated memory)
- $L(x,\tau)$: Memory density (rate of coherence change)

Observed Correspondence

$$\boxed{L(x,t) = -\frac{dF}{dt} \quad \Rightarrow \quad C(x,t) = F(x,0) - F(x,t) + C_0} \tag{7}$$

Interpretation: Coherence accumulation rate equals free energy reduction rate. Systems that minimize surprise (FEP) accumulate memory (CRR).

2 Precision-Temperature Correspondence

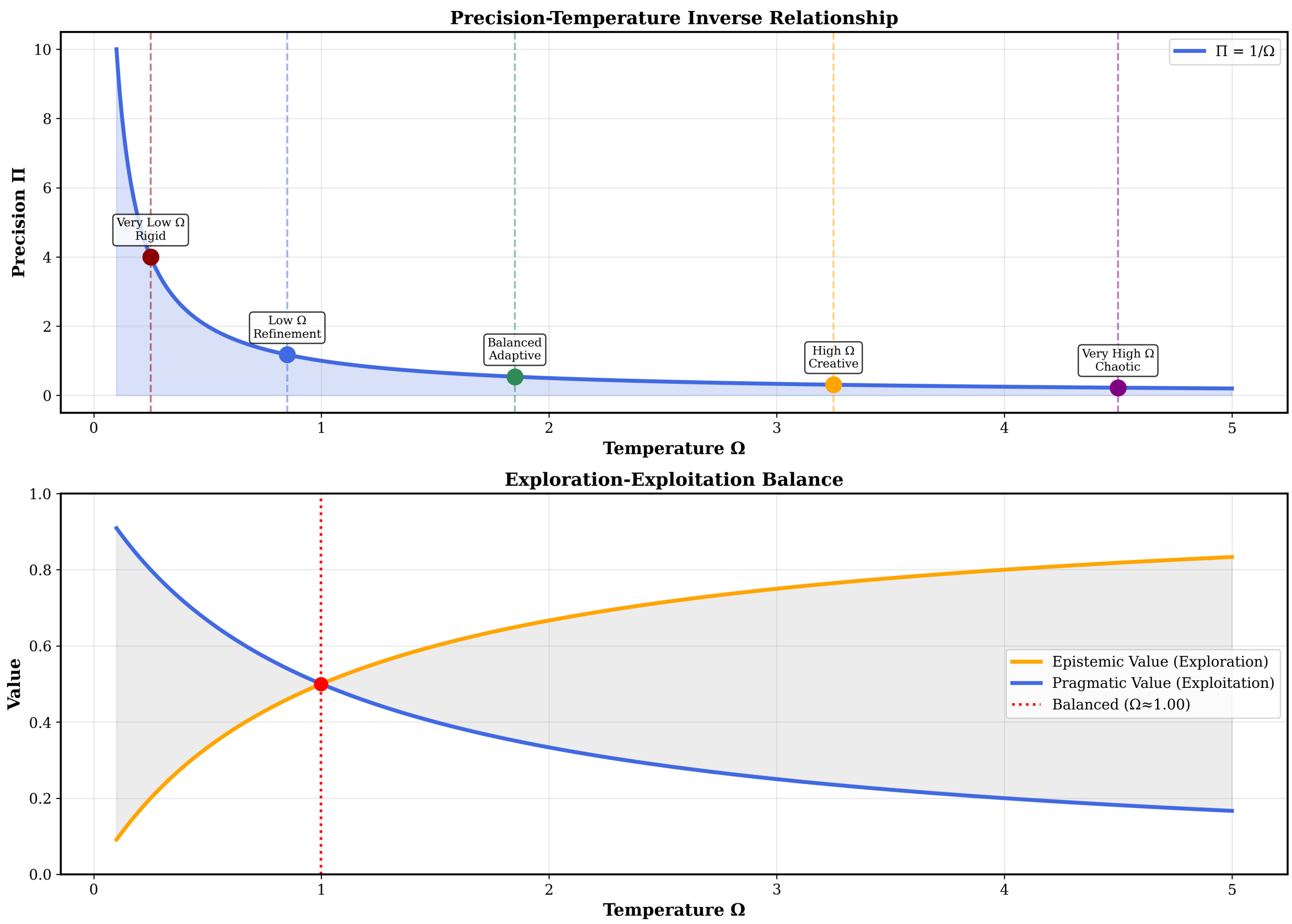

Figure 2: The Omega-Precision relationship across exploration-exploitation spectrum

2.1 Precision in FEP

Precision Π quantifies confidence in predictions:

$$\Pi = \frac{1}{\sigma^2} = \text{(inverse variance of prediction errors)} \tag{8}$$

Belief updates are precision-weighted:

$$\frac{d\mu}{dt} = -\frac{\partial F}{\partial \mu} = \Pi \cdot \varepsilon \tag{9}$$

Where $\varepsilon = o - g(\mu)$ is prediction error and $g(\mu)$ is the generative prediction.

2.2 Temperature (Omega) in CRR

Temperature Ω controls memory weighting:

$$R[\chi](x,t) = \int_0^t \phi(x,\tau) \cdot e^{C(x,\tau)/\Omega} \cdot K(t-\tau)\, d\tau \tag{10}$$

Future states regenerate from exponentially-weighted past:

$$\text{Weight}(\tau) = \exp\left(\frac{C(\tau)}{\Omega}\right) \tag{11}$$

2.3 Observed Equivalence

Precision

$$\boxed{\Pi(t) \approx \frac{e^{C(t)/\Omega}}{\Omega} \quad \text{or equivalently} \quad \Omega \approx \frac{C(t)}{\ln(\Pi(t) \cdot \Omega_{\text{ref}})}} \tag{12}$$

Rationale:

$$\text{High } C \text{ (learned)} \Rightarrow \text{High precision (confident)} \tag{13}$$
$$\text{High } \Omega \text{ (hot)} \Rightarrow \text{Low effective precision (uncertain)} \tag{14}$$
$$\Pi \propto \exp(C/\Omega) \quad \text{(exponential growth with learning)} \tag{15}$$

3 Expected Free Energy and Action Selection

3.1 Expected Free Energy Decomposition

FEP: Expected Free Energy

Policy π selected to minimize expected future surprise:

$$G(\pi) = \underbrace{\mathbb{E}_Q[\ln Q(s_\tau|\pi) - \ln Q(s_\tau|o_\tau,\pi)]}_{\text{Epistemic Value (Information Gain)}} - \underbrace{\mathbb{E}_Q[\ln P(o_\tau|C)]}_{\text{Pragmatic Value (Goal Achievement)}} \tag{16}$$

Simplifies to:

$$G(\pi) = -I[s_\tau; o_\tau|\pi] + \mathbb{E}_Q[-\ln P(o_\tau|C)] \tag{17}$$
$$= \text{Ambiguity} - \text{Expected Utility} \tag{18}$$

CRR: Expected Coherence Gain

Action selection maximizes expected coherence accumulation:

$$\pi^* = \arg\max_{\pi} \mathbb{E}\left[\int_t^T L(x(\tau), \pi)\, d\tau\right] = \arg\max_{\pi} \mathbb{E}[\Delta C(\pi)] \tag{19}$$

Decompose by exploration vs. exploitation:

$$\mathbb{E}[\Delta C(\pi)] = \underbrace{\int_t^T I[x(\tau); \text{past}|\pi] \cdot e^{C(\tau)/\Omega} d\tau}_{\text{Epistemic Coherence Gain}} + \underbrace{\int_t^T \ln P(\text{preferred}|\pi)\, d\tau}_{\text{Pragmatic Coherence Gain}} \tag{20}$$

Action Selection Mapping

$$\boxed{\begin{array}{ccc} \text{Minimize } G(\pi) & \leftrightarrow & \text{Maximize } \mathbb{E}[\Delta C(\pi)] \\ \text{Epistemic value} & \leftrightarrow & \text{Exploration (high } \Omega) \\ \text{Pragmatic value} & \leftrightarrow & \text{Exploitation (low } \Omega) \end{array}} \tag{21}$$

Effective Policy Weighting:

$$\text{Score}(\pi) = \Omega \cdot \text{Epistemic Gain}(\pi) + \frac{1}{\Omega} \cdot \text{Pragmatic Gain}(\pi) \tag{22}$$

4 Exploration-Exploitation Spectrum

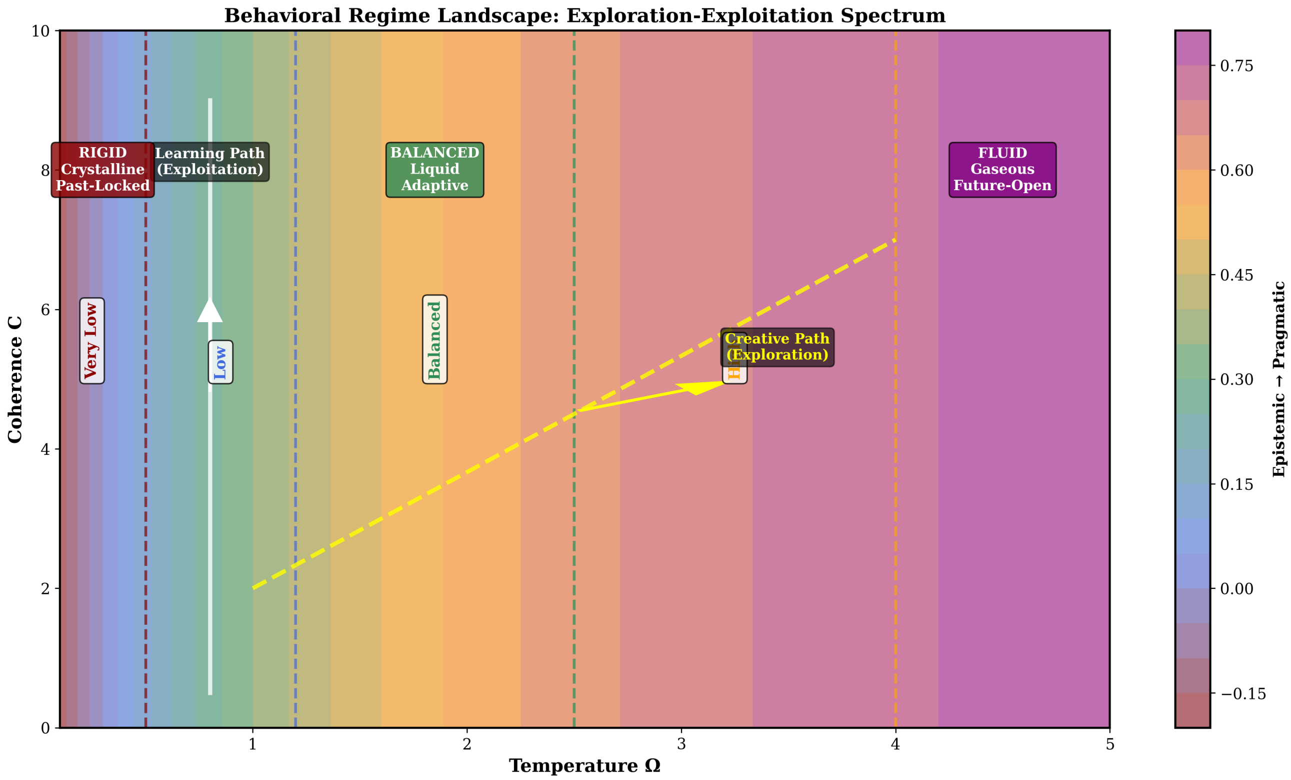

Figure 3: Behavioral regimes across Omega/Precision parameter space

Table 1: Omega Regimes: Observed Phenomenology from Simulations

Ω Range	Π Range	Epistemic	Pragmatic	Behavior	Metaphor
< 0.5	> 4.0	0.3	0.9	Rigid	Crystalline
$0.5 - 1.2$	$2.0 - 4.0$	0.5	0.7	Refinement	Structured
$1.2 - 2.5$	$0.8 - 2.0$	0.6-0.7	0.5	Balanced	Liquid
$2.5 - 4.0$	$0.4 - 0.8$	0.7-0.8	0.3	Creative	Fluid
> 4.0	< 0.4	> 0.8	< 0.2	Chaotic	Gaseous

Observed Pattern:

- Low Ω (high precision): Past dominates → Exploitation → "Memory chains me to certainty"
- High Ω (low precision): Future open → Exploration → "Formless potential, structure dissolves"
- Balanced Ω: Adaptive switching → "Experience guides, curiosity propels"

5 Rupture as Model Switching

5.1 Model Inadequacy in FEP

Model m becomes inadequate when variational bound loses tightness:

$$D_{KL}[Q(\mu|m)\|P(\mu|o,m)] > D_{\text{crit}} \tag{23}$$

Triggers model selection:

$$m^* = \arg\max_m \ln P(o|m) \approx \arg\min_m F(m) \tag{24}$$

Signature: Gradient explosion in free energy landscape:

$$\|\nabla_\mu F\|^2 \to \infty \quad \text{(no minimum exists under current model)} \tag{25}$$

5.2 Rupture in CRR

Rupture event as Dirac delta discontinuity:

$$\delta(t - t_0) \quad \text{where} \quad \int_{t_0^-}^{t_0^+} \delta(t - t_0)\, dt = 1 \tag{26}$$

Triggered when:

$$C(x,t) \geq C_{\text{crit}} \quad \text{or} \quad \frac{\partial^2 C}{\partial t^2} > \text{threshold (acceleration)} \tag{27}$$

Post-rupture coherence reset:

$$C(t_0^+) = \alpha \cdot C(t_0^-) \quad \text{where } \alpha \in [0,1] \tag{28}$$

Rupture Correspondence

$$\boxed{\begin{aligned} \text{Rupture Condition:} \quad & F(m_{\text{current}}) > F_{\text{threshold}} \\ & \updownarrow \\ & C(t) \geq C_{\text{crit}} \\ \\ \text{Model Switch:} \quad & m \to m' \\ & \updownarrow \\ & \text{Coherence Reset: } C \to \alpha C \\ \\ \text{Mechanism:} \quad & \text{Bayesian Model Selection} \\ & \updownarrow \\ & \text{History-Weighted Regeneration} \end{aligned}} \tag{29}$$

6 Regeneration as Bayesian Model Averaging

6.1 Bayesian Model Evidence

Evidence for model m given data $\mathcal{D}$:

$$P(m|\mathcal{D}) \propto P(\mathcal{D}|m) \cdot P(m) \tag{30}$$

Since $P(\mathcal{D}|m) = \exp(-F_m)$:

$$P(m|\mathcal{D}) \propto \exp(-F_m) \tag{31}$$

Model averaging:

$$\mathbb{E}[x] = \sum_m P(m|\mathcal{D}) \cdot x_m \tag{32}$$

6.2 CRR Regeneration Operator

Future state reconstructed from weighted historical states:

$$R[\chi](x,t) = \int_0^t \phi(x,\tau) \cdot \underbrace{e^{C(x,\tau)/\Omega}}_{\text{Evidence Weight}} \cdot K(t-\tau)\, d\tau \tag{33}$$

Where:

- $\phi(x,\tau)$: Historical field (past states)
- $e^{C(\tau)/\Omega}$: Exponential coherence weighting (model evidence)
- $K(t-\tau)$: Memory kernel (temporal decay)

Regeneration Mapping

$$\boxed{e^{C_m(\tau)/\Omega} \quad \leftrightarrow \quad P(\mathcal{D}|m) = e^{-F_m}} \tag{34}$$

Interpretation:

$$\text{High } C_m \Rightarrow \text{High evidence weight} \tag{35}$$

$$\text{Low } F_m \Rightarrow \text{High model probability} \tag{36}$$

$$R[\chi] = \text{Weighted average over historical models} \tag{37}$$

Implication: Regeneration implements Bayesian model averaging where "models" are past system states weighted by their prediction accuracy (coherence).

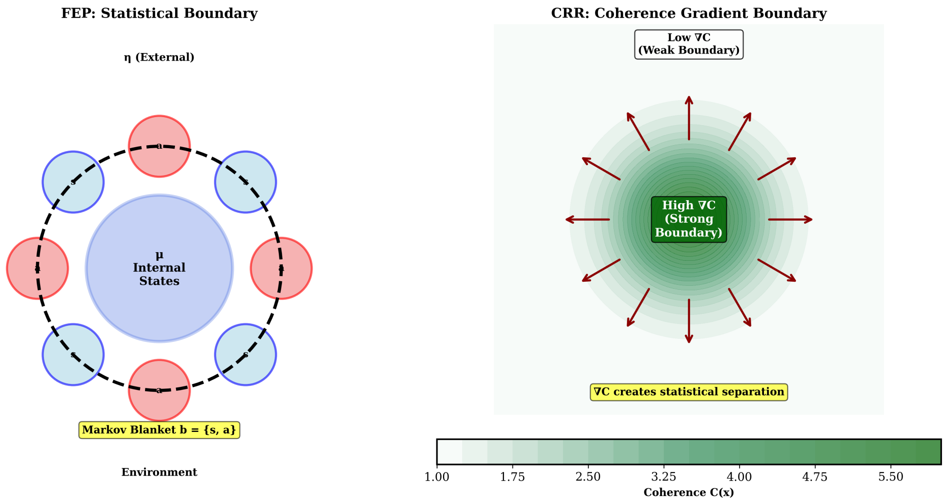

Figure 4: Markov blanket as coherence boundary

7 Markov Blankets and Boundaries

7.1 Markov Blanket in FEP

Statistical boundary rendering internal (μ) and external (η) states conditionally independent:

$$P(\mu, \eta | s, a) = P(\mu | s, a) \cdot P(\eta | s, a) \tag{38}$$

Where:

- s: Sensory states (affected by external, affect internal)
- a: Active states (affected by internal, affect external)
- Blanket $b = \{s, a\}$ mediates all coupling

Existence Condition: Sparse coupling in dynamical system maintains conditional independence.

7.2 Coherence Field as Boundary

Coherence field $C(x, t)$ defines statistical separation:

$$\text{Gradient } \nabla C \text{ creates "memory terrain"} \tag{39}$$

High $|\nabla C|$ regions = strong boundaries (system maintains identity)
Low $|\nabla C|$ regions = weak boundaries (system merges with environment)
Boundary Maintenance:

$$\frac{\partial C}{\partial t} = L(x, t) = \text{rate of boundary reinforcement} \tag{40}$$

Boundary Correspondence

$$\boxed{\begin{array}{rcl} \text{Markov Blanket } b & \leftrightarrow & \text{High-}\nabla C \text{ Surface} \\ \text{Blanket Maintenance} & \leftrightarrow & L(x,t) > 0 \\ \text{Blanket Dissolution} & \leftrightarrow & L(x,t) < 0 \end{array}} \tag{41}$$

Insight: Markov blankets are not static—they require active maintenance. CRR's coherence accumulation ($L > 0$) corresponds to FEP's free energy minimization maintaining the blanket.

8 Non-Markovian Memory Structure

8.1 Markovian vs. Non-Markovian Dynamics

Standard FEP (Markovian)

Present state sufficient for prediction:

$$P(x_{t+1}|x_t, x_{t-1}, \ldots, x_0) = P(x_{t+1}|x_t) \tag{42}$$

Belief update depends only on current state:

$$\frac{d\mu}{dt} = f(\mu_t, o_t) \tag{43}$$

CRR (Non-Markovian)

Entire history matters through coherence integral:

$$C(t) = \int_0^t L(\tau)\, d\tau \quad \Rightarrow \quad \text{Future depends on full past} \tag{44}$$

Regeneration creates path-dependence:

$$R(t) = \int_0^t \phi(\tau) \cdot e^{C(\tau)/\Omega} K(t-\tau)\, d\tau \tag{45}$$

Observed Pattern: Systems transition from Markovian → Non-Markovian as coherence accumulates:

$$\text{Effective Memory Depth} = \int_0^t e^{C(\tau)/\Omega}\, d\tau \tag{46}$$

- $C \approx 0$: Depth $\approx t$ (memoryless, Markovian)
- $C \gg \Omega$: Depth $\propto e^{C/\Omega}$ (deep memory, non-Markovian)

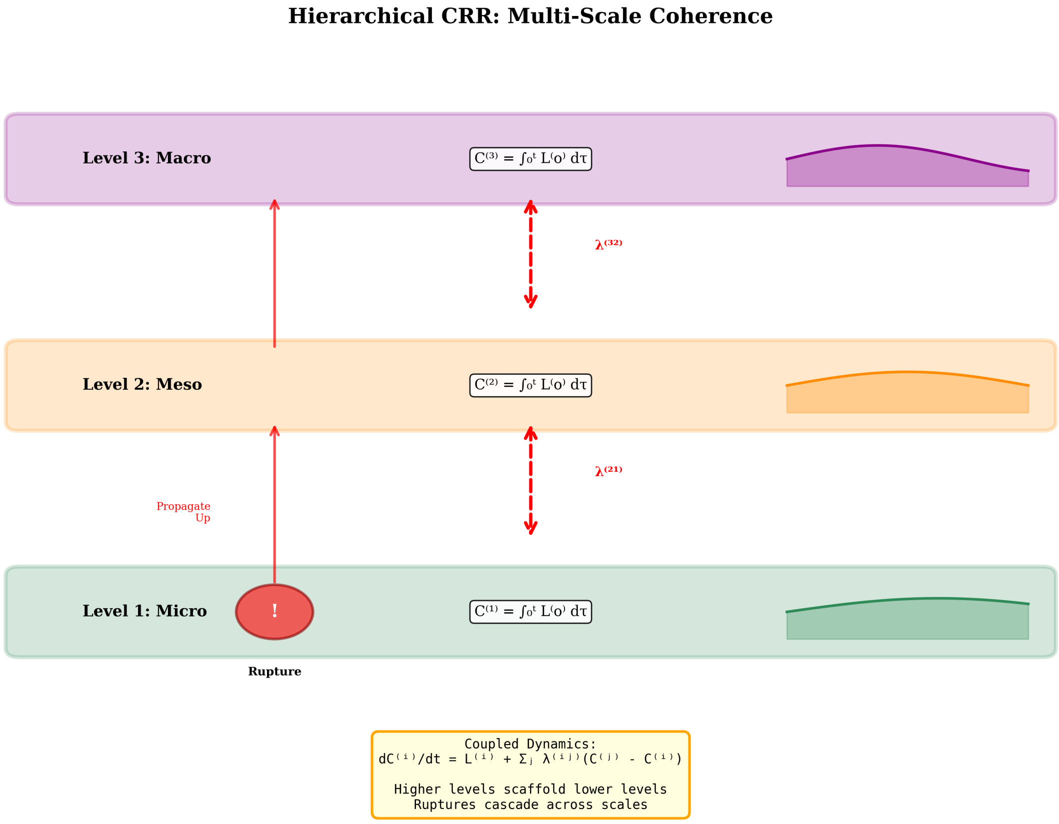

Figure 5: Multi-scale CRR with cross-level coherence coupling

9 Hierarchical Structure

9.1 Hierarchical Active Inference

Multi-level generative model with hierarchical prediction errors:

$$\text{Level } i: \quad F^{(i)} = \mathbb{E}[\ln Q(\mu^{(i)}) - \ln P(s^{(i-1)}, \mu^{(i)} | \mu^{(i+1)})] \tag{47}$$

$$\text{Error}^{(i)}: \quad \varepsilon^{(i)} = s^{(i-1)} - g^{(i)}(\mu^{(i)}) \tag{48}$$

$$\text{Update}^{(i)}: \quad \dot{\mu}^{(i)} = \Pi^{(i)} \varepsilon^{(i)} + \Pi^{(i+1)} \varepsilon^{(i+1)} \tag{49}$$

9.2 Multi-Scale CRR

Coherence at each scale with cross-scale coupling:

$$C^{(i)}(t) = \int_0^t \left[L^{(i)}(\tau) + \sum_{j \neq i} \lambda^{(ij)} (C^{(j)}(\tau) - C^{(i)}(\tau)) \right] d\tau \tag{50}$$

Where:

- $L^{(i)}$: Local coherence accumulation at scale i
- $\lambda^{(ij)}$: Coupling strength between scales
- Cross-scale term: Higher levels scaffold lower levels

Rupture Propagation:

$$\text{If } C^{(i)} > C^{(i)}_{\text{crit}} \Rightarrow \begin{cases} \text{Propagate up if } \Delta F^{(i)} > \Delta F^{(i+1)} \\ \text{Propagate down via top-down predictions} \end{cases} \tag{51}$$

10 Parameter Identification Methodology

10.1 Extracting Ω from System Observations

General Methodology (from original document)

To determine Ω for a given system:

1. Identify Memory Density $L(x, t)$:

- What increases system integration/memory?
- What decreases coherence/causes forgetting?

Examples Across Domains:

$$\text{Ocean waves:} \quad L = \frac{v_{\text{orbital}}}{10} \cdot \frac{E_{\text{wave}}}{1000} \tag{52}$$

$$\text{Hurricanes:} \quad L = \left(0.2 + 0.8 \frac{v_{\text{wind}}}{220}\right) \times f_{\text{env}} \tag{53}$$

$$\text{Bees:} \quad L = r_{\text{nectar}} + a_{\text{learning}} - f_{\text{fatigue}} \tag{54}$$

$$\text{Neural:} \quad L = \text{synaptic integration} + \text{attention} - \text{fatigue} \tag{55}$$

FEP-Guided Parameter Extraction

Step-by-Step Process:

1. **Measure Time Series:** $\{o(t), \mu(t)\}$ (observations and inferred states)
2. **Fit Generative Model:** $P(o|\mu, \theta)$ using maximum likelihood
3. **Compute Free Energy:**

$$F(t) = -\ln P(o(t)|\mu(t), \theta) + H[Q(\mu)] \tag{56}$$

4. **Estimate Coherence:**

$$C(t) \approx F(0) - F(t) = -\int_0^t \frac{dF}{d\tau} d\tau \tag{57}$$

5. **Extract Precision:**

$$\Pi(t) = [\text{var}(\varepsilon(t))]^{-1} \quad \text{where } \varepsilon = o - g(\mu) \tag{58}$$

6. **Solve for Ω:**

$$\boxed{\Omega \approx \frac{C(t)}{\ln[\Pi(t) \cdot \Omega_{\text{ref}}]}} \tag{59}$$

7. **Identify C_{crit}:**

$$C_{\text{crit}} = \text{median}\{C(t_k) : \text{rupture at } t_k\} \tag{60}$$

8. **Fit Memory Timescale:**

$$\tau_m : \quad \langle R(t)R(t + \Delta t)\rangle \propto e^{-\Delta t/\tau_m} \tag{61}$$

10.2 Cross-Domain Omega Values

Table 2: Observed Ω values across systems (from simulations)

System	Ω Range	Regime	Behavior
Ocean waves	1.3-1.7	Balanced	Predictable with variation
Hurricanes	1.2-2.0	Balanced-High	Structured chaos
Neural development	0.5-2.5	Low-Balanced	Progressive stabilization
Bee colonies	1.5-2.5	Balanced-High	Adaptive foraging
Child development (stages)	0.5 $\rightarrow$ 2.0	Low $\rightarrow$ Balanced	Increasing abstraction
Mathematical life	0.3-4.0	Full range	Regime exploration

Observed Pattern:

- Physical systems (waves, weather): $\Omega \approx 1.2 - 2.0$ (balanced exploration-exploitation)
- Biological systems (learning, development): Ω increases with maturity (rigidity $\rightarrow$ fluidity)
- Cognitive systems: Dynamic Ω adjustment based on uncertainty

11 Master Equations

11.1 Unified Dynamics

Complete FEP-CRR Dynamical System

$$\begin{aligned}
\frac{dx}{dt} &= \underbrace{-\frac{\partial F}{\partial x}}_{\text{FEP Inference}} + \underbrace{\int_0^t \phi(\tau) e^{C(\tau)/\Omega} K(t-\tau) d\tau}_{\text{CRR Regeneration}} + \underbrace{\sum_i \rho_i(x)\delta(t-t_i)}_{\text{Ruptures}} \\
C(x,t) &= \int_0^t L(x,\tau)\, d\tau = -\int_0^t \frac{dF}{d\tau} d\tau \\
\Pi(t) &= \frac{e^{C(t)/\Omega}}{\Omega} \\
\text{Rupture:} &\quad \text{if } F > F_{\text{thresh}} \text{ or } C > C_{\text{crit}} \\
\text{Policy:} &\quad \pi^* = \arg\min_\pi \left[\int_t^T G(\pi,\tau) d\tau\right] \\
\text{where} &\quad G(\pi) = F(t|\pi) - \frac{C_{\text{expected}}(t|\pi)}{\Omega}
\end{aligned} \tag{62}$$

11.2 Decomposed Equations by Operator

Table 3: Core operator equations

Operator	**Equation**
Coherence	$C(x,t) = \int_0^t L(x,\tau) d\tau$ where $L = -dF/dt$
Rupture	$\delta(t - t_0)$ triggered when $\|\nabla_x F\|^2 >$ threshold
Regeneration	$R[\chi] = \int_0^t \phi(\tau) \cdot \Pi(\tau) \cdot K(t-\tau) d\tau$ where $\Pi = e^{C/\Omega}/\Omega$
Precision	$\Pi(t) = [\text{var}(\varepsilon)]^{-1} = e^{C(t)/\Omega}/\Omega$
Expected Free Energy	$G(\pi) = -I[s; o\|\pi] + \mathbb{E}[-\ln P(o\|C)]$
Policy Selection	$\pi^* = \arg\max_\pi [\Omega \cdot \text{Epistemic} + (1/\Omega) \cdot \text{Pragmatic}]$
Markov Blanket	Maintained when $L > 0$ (coherence builds boundary)
Memory Depth	$\tau_{\text{eff}} = \int_0^t e^{C(\tau)/\Omega} d\tau$

12 Thermodynamic Consistency

FEP: Non-Equilibrium Steady State

At NESS, system minimizes path-dependent free energy:

$$\mathcal{S}[q] = \int_0^T \left[\frac{1}{2} \left\| \frac{dq}{dt} \right\|^2 + F(q,t) \right] dt \tag{63}$$

Optimal path: $q^*(t) = \arg\min \mathcal{S}[q]$

CRR: Action Principle

CRR dynamics derivable from action:

$$\mathcal{S}_{\text{CRR}}[x, C, R] = \int_0^T [\mathcal{L}_{\text{kinetic}} + \mathcal{L}_{\text{coherence}} + \mathcal{L}_{\text{regen}}] \, dt \tag{64}$$

Where:

$$\mathcal{L}_{\text{coherence}} = -L(x,t) + \lambda \left(C - \int_0^t L d\tau \right) \tag{65}$$

$$\mathcal{L}_{\text{regen}} = -R[\chi] \cdot \frac{dx}{dt} \tag{66}$$

Energy Conservation at Rupture:

$$\Delta H|_{t_0} = \underbrace{\rho(x(t_0))}_{\text{Rupture Energy}} + \underbrace{\int_0^{t_0} R[\chi] \cdot dx}_{\text{Accumulated Work}} \tag{67}$$

Interpretation: Discontinuous jumps conserve energy through history-weighted work terms. Ruptures are thermodynamically consistent.

13 Testable Predictions

Empirical Predictions from FEP-CRR Mapping

Prediction 1: Universal Precision-Coherence Relation

$$\ln \Pi(t) = \frac{C(t)}{\Omega} + \text{const} \tag{68}$$

Test: Measure neural spike precision and entropy across learning → should be exponentially related.

Prediction 2: Omega Scales with Metabolic Rate

$$\Omega_{\text{system}} \propto \frac{k_B T_{\text{eff}}}{\langle F \rangle} \tag{69}$$

Test: Compare Ω across species with different metabolic rates.

Prediction 3: Rupture Size Power Law

$$P(\Delta C) \propto (\Delta C)^{-3/2} \exp(-\Delta C/\Omega) \tag{70}$$

Test: Measure discontinuous transitions (neural avalanches, earthquakes, phase changes) → should follow Kramers statistics.

Prediction 4: Cross-Scale Coherence Synchronization

$$C^{(i+1)}(t) - C^{(i)}(t) = \text{const} \tag{71}$$

Test: Measure entropy across cortical layers → should maintain constant offsets.

Prediction 5: Learning Rate Scaling

$$\eta_{\text{optimal}} = \frac{\Omega}{\langle C \rangle} \tag{72}$$

Test: Optimal learning rates should decrease with accumulated coherence (explains age-related learning slowdown).

14 Quick Reference: Symbol Glossary

FEP Symbols

- F: Variational free energy
- Π: Precision (inverse variance)
- ε: Prediction error
- $Q(\mu)$: Recognition density
- $P(o, \mu)$: Generative model
- $G(\pi)$: Expected free energy
- μ: Internal states
- o: Observations
- s, a: Sensory, active states
- η: External states

CRR Symbols

- $C(x, t)$: Coherence functional
- $L(x, t)$: Memory density
- Ω: Temperature parameter
- $R[\chi]$: Regeneration operator
- $\delta(t - t_i)$: Rupture event
- $\phi(x, \tau)$: Historical field
- $K(t - \tau)$: Memory kernel
- τ_m: Memory timescale
- C_{crit}: Rupture threshold
- $\rho_i(x)$: Rupture amplitude

15 Visualization Guide

15.1 Reading the Diagrams

Figure 1: State Correspondence

- Shows parallel between FEP inference loop and CRR temporal flow
- Free energy minimization $\leftrightarrow$ Coherence accumulation
- Prediction errors $\leftrightarrow$ Local disorder

Figure 2: Omega-Precision Spectrum

- Horizontal axis: Ω (temperature) and Π (precision)
- Vertical axis: Epistemic (exploration) vs Pragmatic (exploitation) value
- Shows crossover from rigid to fluid behavior

Figure 3: Exploration-Exploitation Landscape

- Phase diagram showing behavioral regimes
- Low Ω: Past-dominated (crystalline structure)
- High Ω: Future-open (gaseous exploration)

Figure 4: Markov Blanket as Coherence Boundary

- Coherence gradient creates statistical separation
- High $|\nabla C|$: Strong boundary (Markov blanket maintained)
- Low $|\nabla C|$: Weak boundary (system merges with environment)

Figure 5: Hierarchical CRR

- Multi-scale coherence fields with cross-level coupling
- Ruptures propagate up/down hierarchy
- Higher levels provide scaffolding for lower levels

16 Usage Notes

How to Use This Cheat Sheet

For Theorists:

- Use equations to translate between FEP and CRR formalisms
- Master equations (Section 8) provide complete dynamics
- Parameter extraction (Section 7) bridges theory and data

For Experimentalists:

- Testable predictions (Section 9) suggest experiments
- Parameter identification (Section 7.1) guides data analysis
- Cross-domain table (Section 7.2) provides reference values

For Simulators:

- Implement unified dynamics (Section 8.1)
- Adjust Ω to explore regimes (Table in Section 4)
- Use thought bubble phenomenology to interpret behavior

Caveats:

- These are working conjectures, not proven theorems
- Some mappings are approximate (e.g., $\Pi \approx e^{C/\Omega}/\Omega$)
- Parameter values are system-dependent
- Rigorous proofs still needed for many correspondences

This is a living document. Corrections and refinements welcome.
Join the exploration at: `https://alexsabine.github.io/CRR/`