Supplementary Note S1 (Phase 2)
Why τ^* Is Not an Anthropic Parameter

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1 The objection has two versions

In the Phase 2 set, τ^* denotes a minimal persistence/retention threshold required for a record to count as event-like and history-supporting. A recurring objection is that τ^* is an *anthropic insertion*, implicitly tied to human integration timescales. This objection splits into:

- **Weak version (agent-specificity).** "If τ^* is around 100–300 ms for humans, then BCT is human-specific."
- **Strong version (why any threshold?).** "Even if τ^* varies by agent, why should there be any threshold at all, rather than a smooth continuum of record persistence with no special timescale?"

Phase 2 answers the weak version by design: τ^* is *agent-dependent*, not human-dependent. This note targets the strong version: why a threshold is conceptually forced by the Phase 2 identity framing.

2 Operational definition (non-anthropic by construction)

Fix an agent A with an integration window τ (the time over which A aggregates information into a stable internal state), and a record channel with an operational information target I_c and an error tolerance ϵ.

Definition. $\tau_A^*(\epsilon, I_c)$ is the minimal time such that a record in A's accessible record channel can be stabilized to carry at least I_c effective bit(s) with error probability $\leq \epsilon$, and remain accessible within the integration window τ.

This definition makes τ^* measurable per-agent (calibration of a real record channel) and removes any essential tie to human psychology.

3 Self-consistency: the iterated-identity condition

Phase 2 defines experience/identity via an agent-relative equivalence relation grounded in accessibility and stable records. For A to persist as "the same agent" across successive integration windows, A must share enough stable records across updates.

Let $R(t)$ be the set of stable, accessible records for A at time t. A minimal self-consistency requirement is that, from t_1 to $t_2 = t_1 + \tau$, the overlap of stable records does not collapse to (near) zero. Formally, there exists a (non-universal) threshold $\rho_{\min} \in (0, 1)$ such that:

$$\frac{|R(t_1) \cap R(t_2)|}{|R(t_1)|} \geq \rho_{\min}.$$

The exact value of $\rho_{\min}$ is not important here. What matters is the qualitative consequence: if record persistence times τ_p are shorter than the integration window τ, the overlap generically degrades and the equivalence-class identity becomes unstable across updates.

Key consequence. A necessary condition for iterated identity is that the record channel supports persistence on the order of τ:

$$\tau_p \gtrsim \tau \quad \Rightarrow \quad \tau_A^* \text{ must scale with } \tau \text{ (up to order-of-magnitude).}$$

This is not anthropocentrism; it is the minimal condition for the Phase 2 identity framing to be self-consistent.

4 τ^* is not decoherence time

A common confusion is to identify τ^* with a decoherence timescale τ_{dec}. Phase 2 uses distinct roles: decoherence may suppress interference in a reduced description, but BCT's threshold concerns *accessible record persistence* for agent A.

Operationally:

- τ_{dec}: environmental dephasing timescale (branch stability in reduced description);
- τ_{loss}: loss/overwrite timescale of the accessible record buffer;
- τ: integration window of A (identity update scale);
- τ^*: minimal persistence threshold for event-like records (Phase 2).

Decoherence can be necessary but is not sufficient for BCT collapse: the record must also be accessible and persist beyond the relevant integration/update scale.

5 Conservative physical bounds (optional, architecture-dependent)

We do not claim that τ^* is derivable uniquely from fundamental constants alone. However, any physical record channel faces bottlenecks that prevent arbitrarily fast, arbitrarily reliable stabilization at fixed resources. A conservative way to express this is via lower bounds from bandwidth, noise, and dissipation constraints, treated as calibration targets rather than derivations.

6 Predictions and falsifiers (what makes this non-circular)

BCT Phase 2 already commits to defeat conditions along the bridge: measurement-like interaction $\rightarrow$ record formation $\rightarrow$ record persistence $\rightarrow$ experienced definiteness. The τ^* framing strengthens that bridge with agent-scaling predictions.

P1. Scaling with integration window. Engineer two agents with substantially different integration windows $\tau_1 \ll \tau_2$, while holding which-way interaction and ordinary path dephasing controls fixed. Prediction: the onset of event-like definiteness (visibility loss / irreversibility) tracks the agent-dependent threshold and therefore scales with τ.

Falsifier F1. If both systems show identical persistence thresholds despite $\tau_1 \ll \tau_2$, the integration-window grounding of τ^* is undermined.

P2. Temperature dependence via τ_{loss} (when retention is temperature-tunable). If the record buffer has a temperature-dependent loss time $\tau_{\text{loss}}(T)$, Phase 2 predicts a near-threshold regime where visibility behavior correlates with retention metrics (under controls isolating the recording chain from path dephasing).

Falsifier F2. If visibility transitions occur at temperatures where the independently measured retention is far from the predicted near-threshold regime (in either direction), the persistence-threshold interpretation fails.

P3. Universality of role, not value. Not predicted: a universal numerical τ^* across substrates. Predicted: for each agent A, once τ_A^* is independently calibrated, event-like definiteness tracks the crossing $\tau_p \sim \tau_A^*$, regardless of substrate.

Falsifier F3. If stable records form well above the calibrated threshold while event-like definiteness systematically fails to appear under controlled tests, the Phase 2 operational bridge is falsified.

Why this is not circular. The calibration is independent: τ and record retention metrics can be measured without referencing "collapse"; then one tests whether visibility/irreversibility transitions align with the calibrated threshold when persistence is varied under controls.

7 Summary (one-line intuition)

τ^* is not an anthropic free parameter because it is constrained by (i) the agent's integration window τ (identity self-consistency) and (ii) the record-loss timescale τ_{loss} (hardware retention). A practical expectation is that τ_A^* scales like the dominant constraint in the agent's record chain (often summarized heuristically as "of order $\max(\tau, \tau_{\text{loss}})$"), while its role remains the same across substrates.