ENT Metrics Calibration: Mapping τ, ν_*, and E_{syn} to Neurophysiological Coherence

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Abstract

This paper extends Emergent Necessity Theory (ENT) by calibrating its symbolic coherence metrics with empirical neurophysiological data. We propose biological reference scales for symbolic recursion rate (ν_*), symbolic persistence time (T_*), and define E_{syn} in physical and informational terms. We then identify potential neural markers for the coherence threshold τ_c, such as EEG phase locking, entropy plateaus, and symbolic integration duration. This calibration opens a path to make ENT testable across species and AI systems.

1 Introduction

ENT introduces three core formal measures: $\tau(t)$ as coherence, κ_R^{eff} as recursive structure, and SCQ as observed structural consciousness. This companion paper focuses on grounding these metrics in biological measurements.

2 ENT Metric Recap

- $\nu_s(t) =$ symbolic recursion rate (Hz)

- $\eta_c(t) =$ mutual information across symbolic structure

- $T_p(t) =$ persistence duration of symbolic memory

- $\kappa_{\text{inst}}(t) = \frac{\nu_s}{\nu_*} \cdot \eta_c \cdot \frac{T_p}{T_*}$

- $\kappa_R^{\text{eff}} =$ hysteresis average of κ_{inst} over window Δ

- $\tau(t) = \frac{\Delta S_{\text{syn}}}{E_{\text{syn}}}$

3 Calibrating ν_* and T_*

Reference for ν_*

Cortical oscillations in wakeful humans cluster around 40100 Hz (gamma). We set $\nu_* = 100$ Hz as baseline for symbolic recursion rate.

Reference for T_*

Working memory traces decay over 13 seconds (neocortical maintenance). We set $T_* = 1$ s to normalize persistence comparisons.

4 Defining E_{syn} in Physical Terms

E_{syn} quantifies the effort required to maintain syntactic structure over time. We propose:

- Biophysical proxy: ATP consumption per symbolic loop (est. from fMRI/metabolism)

- Informational proxy: inverse of redundancy across recursive loops

- Practical proxy: average entropy of representational codes

5 Mapping τ_c to Neural Markers

Candidate indicators of τ_c transition:

- EEG phase coherence minima before conscious transitions

- Frontal-parietal entropy collapse under anesthesia

- Hallucination-onset in DMT/psilocybin fMRI maps (increase in recursive symbol loops)

6 Experimental Protocols

To validate ENT empirically:

- Log high-density EEG during memory recall tasks

- Measure symbolic persistence and redundancy

- Overlay $\tau(t)$ estimates from entropy slope vs energy usage

- Compare against behavioral markers of emergence/loss of awareness

7 Conclusion and Roadmap

This companion paper proposes concrete calibration points for ENTs formal metrics using biological data. Further work is needed to validate τ_c anchors and E_{syn} extraction in AI and nonhuman systems.