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Empirical and Neuroinformational Bounds on Human Verification Bandwidth: Defining C_{bio}

Douglas H. M. Fulber

Institute for Hybrid Cybernetics

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The Theory of Hybrid Stability relies on a critical parameter: the biological channel capacity for semantic verification, denoted as C_{bio}. While literature often cites reading speeds of 200-400 wpm ($\approx$ 50 bits/s), verification requires active error detection, which imposes a higher cognitive load. This paper synthesizes evidence from cognitive psychology (Miller, Sweller), information theory (Pierce, Shannon), and neurophysiology to derive a rigorous bound for C_{bio}. We distinguish between Passive Reception Flux (Φ_{Rx}) and Active Verification Flux (Φ_{Ver}), demonstrating that for high-entropy tasks (e.g., code review, hallucination detection), the effective capacity drops to the range $C_{bio} \in [10^1, 20]$ bits/s. This finding reinforces the necessity of "Thermodynamic Throttling" in Human-AI interfaces.

In Hybrid Cybernetics, the stability of a coupled system $\mathcal{H} \circ \mathcal{M}$ is conditional on the Bandwidth Constraint:

$$\mathcal{F}(\Phi_{out}) \leq C_{bio}$$

If C_{bio} is overestimated, the filter $\mathcal{F}$ will fail, leading to saturation and error divergence. Therefore, establishing a physically defensible value for C_{bio} is not a detail, but a safety-critical requirement.

I. THEORETICAL BOUNDS

A. The Shannon Limit of Language

Shannon (1951) estimated the entropy of English text H_{eng} to be ≈ 1.5 bits/letter. For a reading speed of 250 words/minute (≈ 20 letters/s):

$$R_{shannon} \approx 20 \times 1.5 = 30 \text{ bits/s}$$

This represents the *maximum reception rate* for native text.

B. The Psychometric Limit (Hick-Hyman Law)

Verification is a decision process. The time T to verify a bit of information follows the Hick-Hyman Law: $T = b \cdot \log_2(n+1)$. For binary verification (True/False) per semantic unit, the processing cost is non-negligible.

II. EMPIRICAL EVIDENCE

A. Code Review Studies

Studies on software engineering (e.g., Cohen et al.) show that code review effectiveness drops precipitously after **400 LOC/hour**. Assuming 1 line $\approx$ 50 bits of entropy:

$$R_{review} = \frac{400 \times 50}{3600} \approx 5.5 \text{ bits/s}$$

This suggests active verification is an order of magnitude slower than passive reading.

B. The "Invisible Gorilla" Effect

When flux increases ($\Phi \gg 10$ bits/s), the brain engages heuristic filters (System 1). In this mode, "hallucinations" (plausible but false statements) become invisible because they fit the heuristic pattern. Detecting a semantic error requires switching to System 2 (Analytical), which has a metabolic cost and requires $T_{switch} \approx 200$ms.

III. DERIVED BOUNDS FOR C_{BIO}

We propose a tri-level classification for C_{bio}:

Regime	Flux (Φ)	Mechanism	Reliability
Scanning	~ 50 bits/s	Pattern Matching	Low (σ^2_{high})
Reading	~ 30 bits/s	Semantic Reconstruction	Medium
Verification	$\sim 5-10$ bits/s	Logical Falsification	High ($\sigma^2 \to 0$)

IV. IMPLICATIONS FOR AI INTERFACE DESIGN

The naive assumption that "Humans can read AI output at 300 wpm" is dangerous. For **Safety-Critical Tasks**, the interface must throttle the AI output to the **Verification Bandwidth** (~10 bits/s), not the Reading Bandwidth. This implies that **High-Speed Chat Interfaces** are structurally unsafe for debugging or fact-checking.

V. CONCLUSION

We define the operational parameter C_{bio} for Hybrid Cybernetics as:

$$C_{bio}^{safety} \approx 10 \text{ bits/s}$$

Any system pushing flux beyond this limit without algorithmic pre-filtering is thermodynamically unstable.

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