THE ARCHITECTURE OF CACHE SATURATION: Landauer Erasure Inefficiency and Global Sensory Overload

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ABSTRACT

Sensory Processing Disorder (SPD) has long been framed as a qualitative over-responsivity or under-responsivity to environmental stimuli. This paper presents a complete thermodynamic reconstruction of isolated sensory overload, introducing the Architecture of Cache Saturation within the HEPOE framework. We isolate the information erasure variable ($W_{erasure}$) as the primary site of global hardware failure. Based on Landauer's Principle, resetting neural buffers to discard irrelevant ambient data requires active thermodynamic work ($k_B\, T \ln 2$). In this architecture, global clearance mechanisms, specifically astrocytic clearing and GABAergic desensitization, are highly inefficient, drastically raising the thermal cost of data erasure. To avoid catastrophic localized Joule heating, the system leaves the sensory buffers un-cleared. This induces an immediate, global cache saturation where background noise is permanently retained, forcing the Predictive Solvency Equation $S(t)$ into an acute state of environmental overload.

Keywords: HEPOE Framework. Sensory Processing Disorder (SPD). Cache Saturation. Landauer's Principle. Thermodynamic Erasure. Predictive Solvency.

1. INTRODUCTION: THE THERMODYNAMIC COST OF FORGETTING

In any advanced computational system, information retention is bounded by erasure capacity. In 1961, Rolf Landauer demonstrated that erasing a single bit of information always dissipates a minimum structural amount of heat, formalized as $\Delta Q = k_B T \ln 2$. The human brain, as a biological prediction engine, faces this constraint continuously. To sample new environmental data $H(E)$, it must constantly flush its short-term sensory buffers, erasing background noise (such as the texture of clothing or low-frequency ambient sounds). This paper details the Architecture of Cache Saturation, a native configuration where the physical cost of information erasure ($W_{erasure}$) is unsustainably elevated, turning the desensitization process into a catastrophic energy drain.

2. BIOPHYSICAL BREAKDOWN OF THE ERASURE PUMP

At the hardware level, sensory desensitization is an energy-intensive filtering operation executed via global interneuronal networks and astrocytic maintenance. In the Cache Saturation phenotype, the biophysical infrastructure for resetting membrane potentials and absorbing extracellular neurotransmitters is compromised. Hypofunctional global GABAergic pathways and sluggish glymphatic/astrocytic clearance loops mean that the system requires double the standard ATP allocation to clear an information bit from the sensory cortex.

When exposed to a standard multi-sensory environment, the brain attempts to erase the irrelevancies. However, because its internal $W_{erasure}$ is highly inefficient, this clearance process generates intense localized thermal dissipation (Joule heating). To protect the physical neural architecture from thermal degradation, the system halts the erasure protocol. The sensory cache remains full, leaving the background noise active, un-cleared, and directly competing for processing bandwidth.

3. MATHEMATICAL INTEGRATION INTO THE HEPOE EQUATION

We formalize this erasure deficit directly within the core HEPOE Predictive Solvency Equation, mapping its global impact on the informational load parameters:

$$S(t) = S_0 + \int_0^t [\Phi(t) - (H(E)_t + \Delta P_t + W_{erasure,t}) \cdot \Omega] \, dt$$

In this architecture, the physical resistance within the astrocytic clearance pathways forces the erasure work term ($W_{erasure}$) to exponentially increase. Because the energy required to force data deletion becomes prohibitive, the system alters its operational mode to permit un-cleared noise to accumulate in the active data matrix:

$$H(E)_{active} = H(E)_{environment} + H(E)_{noise\_cache}$$

Table 1. Thermodynamic Bounding in Cache Saturation

Variable Component	Biophysical Reality in Cache Saturation	Thermodynamic Consequence
Elevated $W_{erasure}$	Sluggish astrocytic/interneuronal clearance of short-term sensory buffers.	Extreme localized thermal dissipation during erasure attempts.
$H(E)_{noise\_cache}$	Permanent retention of background noise within active sensory channels.	Structural reduction of available processing bandwidth.

Source: Authors (2026).

4. SENSORY OVERLOAD AS AN IRREVERSIBLE CACHE OVERFLOW

Clinical "Sensory Overload" is thus completely stripped of behavioral subjectivity. It is defined as a mechanical cache overflow. Because the background noise cannot be erased, the incoming environmental entropy ($H(E)_{environment}$) collides with a buffer that is already saturated by old data. The system experiences immediate data congestion. The parallel processing networks lock, prediction errors (ΔP) skyrocket globally, and the resynthesis pump (Φ) fails to keep pace. The meltdown or shutdown states of Sensory Processing Disorder are emergency thermodynamic maneuvers designed to force a zero-entropy input state, allowing the inefficient erasure pump time to clear the cache without total systemic insolvency.

5. CONCLUSION: THERMODYNAMIC ISOLATION OF SPD

By defining Sensory Processing Disorder as the Architecture of Cache Saturation, the HEPOE framework separates it from the high global resistance of Autism or the modulatory shifts of ADHD. It represents a clean, independent hardware configuration where the core restriction is the thermodynamic cost of erasing information. This framework demands a revolution in environmental engineering: treating sensory accommodation not as a behavioral preference, but as a mandatory thermodynamic boundary requirement to prevent structural cache failure.

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