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The Drift Law

The Temporal Stimulation Theorem - A Rate-Dependent Model of Perceptible Versus Cumulative Harm in Biological Systems

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Abstract

Biological systems maintain stability through homeostatic regulation, counteracting deviations from equilibrium via compensatory mechanisms. This paper introduces the Temporal Stimulation Theorem (TST), which formalizes how the rate of stimulation governs the visibility of harm, while cumulative damage depends on the time-integrated deviation from baseline. The framework explains why fast-acting stimulants produce immediate and perceptible harm, whereas slow, repeated stimulation results in concealed baseline erosion and dependency through normalization rather than acute collapse. The model is presented using a minimal dynamical system and does not depend on the legal, cultural, or chemical classification of the stimulus.

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Introduction

Substances and behaviors that stimulate the central nervous system are commonly classified by social acceptability, legality, or delivery mechanism. However, biological regulation does not distinguish between such categories. From a physiological perspective, the nervous system responds only to the magnitude, frequency, and rate of perturbation.

This mismatch between biological dynamics and social framing leads to a systematic blind spot: slow, repeated stimulation is often normalized despite producing substantial cumulative harm.
This paper presents a simple mathematical framework explaining this phenomenon.

System Definition

Let:

- $S(t) \in R$ denote the instantaneous physiological or neural regulatory state
- $S0 \in R$ denote the natural homeostatic baseline
- $I(t) \in R$ denote external stimulant input
- $\tau > 0$ denote the recovery time constant
- $k > 0$ denote sensitivity to stimulation

We model the system using a first-order linear differential equation:

$$\frac{dS(t)}{dt} = kI(t) - \frac{S(t) - S_0}{\tau} \qquad (1)$$

The first term represents imposed disturbance, while the second term represents homeostatic correction.

Fast Stimulation Regime

Fast stimulation is characterized by high amplitude and short duration relative to recovery time.
A representative input is:

$$I(t) = Ae^{-t/\epsilon}, \quad \epsilon \ll \tau \qquad (2)$$

This produces a rapid excursion of S(t) away from S0 before compensatory mechanisms can respond effectively.
The result is:

- large peak deviation
- delayed correction
- overshoot and rebound
- immediate subjective perception of harm

Such harm is highly visible and typically provokes alarm and intervention.

Slow Stimulation Regime

Slow stimulation is characterized by low amplitude, repeated exposure with inter-dose intervals shorter than recovery time.
A representative input is:

$$I(t) = a \sum_{n=1}^{N} H(t - nT), \quad a \ll A,\ T < \tau \qquad (3)$$

Here, recovery remains incomplete between exposures. Solving the recurrence reveals convergence to a shifted equilibrium:

$$\lim S(t) = S_0 - \Delta, \quad \Delta > 0 \qquad (4)$$

$t \to \infty$

This phenomenon is referred to as baseline drift. Harm is distributed across time rather than expressed as an acute event.

Cumulative Harm Functional

$$H = 7. \int_0^T |S(t) - S_0|\, dt \qquad (5)$$

These functional captures both magnitude and duration of displacement. Fast stimulation produces a large peak with short duration; slow stimulation produces small deviations sustained over long periods. Both can yield equal or greater cumulative harm.

Craving as Error Correction

Craving arises when:

$$S(t) < S0 \quad (6)$$

The system seeks to minimize error:

$$\min|S(t) - S_0| \quad (7)$$

Because relief coincides temporally with the most recent stimulus, the system falsely attributes correction to the stimulus itself. This is termed misattributed homeostatic relief.

The Temporal Stimulation Theorem

Theorem 1 (Temporal Stimulation Theorem). In a homeostatic biological system, the perceptibility of harm is inversely proportional to the rate of stimulation, while cumulative harm is proportional to the time-integral of deviation from baseline.

Formally:

$$\text{Visibility} \propto \frac{1}{\text{rate}(I(t))}, \qquad \text{Harm} \propto \int |S(t) - S_0|\, dt \qquad (8)$$

Corollaries

Corollary 1 (Visibility–Rate Inversion). As stimulation rate decreases, harm visibility decreases even when cumulative impact increases.
Corollary 2 (Baseline Drift). Repeated sub-threshold stimulation prevents full recovery and establishes a new, lower baseline perceived as normal.
Corollary 3 (Misattributed Relief). Dependence arises when endogenous correction is falsely attributed to the disturbing stimulus.

Discussion

Fast perturbations generate fear and regulation because harm is immediate. Slow perturbations evade scrutiny because harm is distributed and normalized. Biology integrates both identically through cumulative deviation.

The distinction between "safe" and "dangerous" stimulation is therefore temporal rather than mechanistic.

Conclusion

The Temporal Stimulation Theorem provides a unified explanation for why slow, normalized stimulation can be more deceptive and potentially more damaging than fast, overt disruption. The nervous system integrates deviation over time, independent of cultural framing, legality, or intent [1-4].

Key insight: Harm is not determined by peaks, but by area under the curve.

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