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the synergism between rate and stability**

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High metabolic demand in neural tissues: information and control theory perspectives on the synergism between rate and stability

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Abstract

Evolutionary process has selected for inherently unstable systems in higher animals that can react swiftly to changing patterns of threat or opportunity, for example blood pressure, the immune response, and gene expression. However, these require continual strict regulation: uncontrolled blood pressure is fatal, immune cells can attack 'self' tissues, and improper gene expression triggers developmental disorders. Consciousness in particular demands high rates of metabolic free energy to both operate and regulate the fundamental biological machinery: both the 'stream of consciousness' and the 'riverbanks' that confine it to useful realms are constructed and reconstructed moment-by-moment in response to highly dynamic internal and environmental circumstances. We develop powerful necessary conditions models for such phenomena based on the Data Rate Theorem linking control and information theories in the context of inherent instability. The synergism between conscious action and its regulation underlies the ten-fold higher rate of metabolic energy consumption in human neural tissues and implies a close, culturally-modulated relation between sleep disorders and certain psychopathologies.

Key Words: consciousness, control system, culture; Data Rate Theorem, information bottleneck, metabolic free energy, Rate Distortion Theorem, sleep disorders

1 Introduction

Why do neural tissues in humans consume metabolic free energy at ten times the rate of other tissues (Clarke and Sokoloff 1999)? A simplistic answer is

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