Modeling Recurrent Neural Networks in Serial Recall Paradigm With Dynamic Self-Excitation

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Abstract

This study explores recurrent on-center off-surround (OCOS) networks with time-varying self-excitation to model biological neural circuits in working memory. We derive analytical conditions for steady states and global stability, ensuring non-divergent dynamics. Linear stability analysis shows that activity levels and pattern separation depend on the balance between self-excitation (α), lateral inhibition (β), and passive decay (λ) through two distinct eigenmodes. Simulations reveal that lateral inhibition regulates co-active nodes, while dynamic self-excitation, specifically the ramp slope and decay time constant (τ), controls response amplification and memory persistence. In a serial recall paradigm, systematic variation of τ produces a continuum of serial position curves, transitioning between primacy and recency effects. Our statistical analyses quantify these relationships, linking microscopic network parameters to macroscopic cognitive phenomena. This framework explains how the excitation-inhibition balance manages the trade-off between memory maintenance and interference. These results provide practical guidelines for parameter selection in neural modeling and offer testable predictions for neurophysiological research into working memory mechanisms.

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