*Regulation of Synthetic Ion Channels Enhances Cognitive Plasticity in Virtual Rodent Models*

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**Abstract**  
The modulation of synaptic transmission via artificial ion channels represents a frontier in neuroadaptive engineering. We report the design and simulation of a novel class of voltage-gated synthetic ion channels (VG-SICs) that dynamically alter conductance profiles based on predicted cognitive demand in silico. Using the *RodentMind v2.5* simulation framework, we introduced VG-SICs into layer V pyramidal neurons and monitored performance across virtual maze navigation tasks.

Cognitive plasticity was assessed using adaptive learning rates derived from Hebbian feedback loops (Chen et al., 2021). Results demonstrated a 48% enhancement in task acquisition speed compared to control networks (p < 0.001), with VG-SIC activity correlated to theta phase locking (Gao & Walters, 2019). These findings were further supported by gradient-based interpretability analyses which revealed upregulation of metaplastic subnetworks during critical learning windows (Ramanathan et al., 2023).

Interestingly, long-term simulation revealed emergent oscillatory phenomena consistent with biologically observed sharp-wave ripples, suggesting partial biorealism (De Wilde & Franco, 2020). While hardware deployment remains a challenge, the proposed VG-SIC system paves the way for neuromorphic co-processors that flexibly adapt to real-time cognitive loads.

**References**

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