Cortical Spiral Traveling Waves Model

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Complex spiral traveling waves occur in the cortex across different organisms. The underlying mechanisms of how local cortical neuronal populations interact to produce emergent spiral dynamics during cognitive tasks remains unknown. Therefore, to understand and bridge this gap, a spatiotemporal cortical field model of local neural microcircuits, composed of excitatory pyramidal (PYR) population and three distinct time scale inhibitory populations namely parvalbumin, somatostatin, and vasoactive intestinal peptide, (PV, SST, VIP) is proposed. Such local neural circuit motifs occur quite frequently across L2/3 and L5 layers in mice and humans with different connectivity strengths [1]. This model is extended to a two-dimensional cortical sheet, consisting of both nonlinear local interactions and global diffusive spatial coupling. Simulation results indicate mixed-mode oscillations occur in the local circuits, which may represent the coexistence of multiple rhythms and show the emergence of complex rotating spirals patterns undergoing annihilation events. Spiral waves respond differentially to the strength of the grating input stimulus and exhibit working memory-like characteristics [2]. Also hypothesize that local patterns, such as planar, source, sink, or concentric waves across the cortex, might be an inherent integral part of the rotating spiral state dynamics.

[1] Campagnola et al., Science, 375 (6585), 2022
[2] G. Singh et al., bioRxiv, 2026.01. 06.698037, 2026