Title

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Journal

New Mathematics and Natural Computation, 05(01)

ISSN

1793-0057 1793-7027

Author

WRIGHT, J. J.

Publication Date

2009-03-01

DOI

10.1142/S1793005709001210

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J. J. WRIGHT, *New Math. and Nat. Computation*, **05**, 159 (2009). DOI: 10.1142/S1793005709001210

CORTICAL PHASE TRANSITIONS: PROPERTIES DEMONSTRATED IN CONTINUUM SIMULATIONS AT MESOSCOPIC AND MACROSCOPIC SCALES

J. J. WRIGHT
Liggins Institute, and Department of Psychological Medicine, Faculty of Medicine and Health Sciences, University of Auckland, Grafton Road, Auckland, New Zealand
Brain Dynamics Centre, University of Sydney, Acacia House, Westmead Hospital, Hawkesbury Road, Westmead NSW 2145, Australia

Continuum simulations of cortical dynamics permit consistent simulations to be performed at different spatial scales, using scale-adjusted parameter values. Properties of the simulations described here accord with Freeman's experimental and theoretical findings on gamma synchrony, phase transition, phase cones, and null spikes. State equations include effects of retrograde action potential propagation into dendritic trees, and kinetics of AMPA, GABA, and NMDA receptors. Realistic field potentials and pulse rates, gamma resonance and oscillation, and $1/f^2$ background activity are obtained. Zero-lag synchrony and traveling waves occur as complementary aspects of cortical transmission, and lead/lag relations between excitatory and inhibitory cell populations vary systematically around transition to autonomous gamma oscillation. Autonomous gamma is initiated by focal excitation of excitatory cells and suppressed by laterally spreading trans-cortical excitation. By implication, patches of cortex excited to gamma oscillation can mutually synchronize into larger fields, self-organized into sequences by mutual negative feedback relations, while the sequence of synchronous fields is regulated both by cortical/subcortical interactions and by traveling waves in the cortex — the latter observable as phase cones. At a critical level of cortical excitation, just before transition to autonomous gamma, patches of cortex exhibit selective sensitivity to action potential pulse trains modulated in the gamma band, while autonomous gamma releases pulse trains modulated in the same band, implying coupling of input and output modes. Transition between input and output modes may be heralded by phase slips and null spikes. Synaptic segregation by retrograde action potential propagation implies state-specific synaptic information storage.

Keywords: Gamma activity; synchronous oscillation; cortical self-regulation; EEG; phase cones; null spikes