T 53/4

Models of Electrocortical Dynamics

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Abstract

Computational and continuum models of electrocortical activity are developed in order to better understand the genesis and significance of the major mammalian cerebral rhythms.

The computational model was developed to investigate the relationship between individual neuron behaviour and population electrical dynamics. Networks of multicompartment excitatory and inhibitory neurons incorporating "fast" synaptic transmission were coupled together using an anatomically derived scheme of asymmetric intracortical axosynaptic connectivity. Results showed that such networks are capable of oscillating at frequencies frequently observed in mammalian electroencephalogram (EEG). The relationship of individual neuron behaviour to mean network activity was investigated by generating *Conditional Pulse Probability Surfaces*. Derived results exhibited a near linear relationship between the probability of a pyramidal cell firing and the extant value of the local field potential (LFP), similar to that seen in experimental studies involving cortical neurons.

In contrast the continuum model considered neural tissue to be a continuous one-dimensional chain of excitatory and inhibitory neurons interacting by way of short (intra-cortical) and long (isotropic cortico-cortical) fibres. The defining non-linear integral equations were linearised such that Fourier-Laplace techniques could be applied to investigate potential solutions. Numerical solutions revealed the prescence of, spatially, weakly damped travelling waves at or near the frequencies of mammalian alpha (8-13 Hz). Biasing the excitatory cell population was shown to have a dominant effect in determining spatio-temporal damping of travelling wave solutions, whereas applying bias to the inhibitory cell population had a dominant effect in specifying the corresponding spatio-temporal frequencies. The possibility that such bias may be due to, and regulated by, subcortical efferents is discussed. Finally it is suggested that the alpha rhythm may be an important synchronising agent for coordinating widespread cortical activity.

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Contents