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An in-silico framework to study the cholinergic modulation of the neocortex

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Neuromodulators control information processing in cortical microcircuits by regulating the cellular and synaptic physiology of neurons. Computational models and detailed simulations of neocortical microcircuitry offer a unifying framework to analyze the role of neuromodulators on network activity. In the present study, to get a deeper insight in the organization of the cortical neuropil for modeling purposes, we quantify the fiber length per cortical volume and the density of varicosities for catecholaminergic, serotonergic and cholinergic systems using immunocytochemical staining and stereological techniques. The data obtained are integrated into a biologically detailed digital reconstruction of the rodent neocortex (Markram et al, 2015) in order to model the influence of modulatory systems on the activity of the somatosensory cortex neocortical column. Simulations of ascending modulation of network activity in our model predict the effects of increasing levels of neuromodulators on diverse neuron types and synapses and reveal a spectrum of activity states. Low levels of neuromodulation drive microcircuit activity into slow oscillations and network synchrony, whereas high neuromodulator concentrations govern fast oscillations and network asynchrony. The models and simulations thus provide a unifying in silico framework to study the role of neuromodulators in reconfiguring network activity.

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