Unique membrane properties and enhanced signal processing in human neocortical neurons

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Abstract:

The advanced cognitive capabilities of the human brain are often attributed to our recently evolved neocortex. However, it is not known whether the basic building blocks of the human neocortex, the pyramidal neurons, possess unique biophysical properties that might impact on cortical computations. Here we show that layer 2/3 pyramidal neurons from human temporal cortex (HL2/3 PCs) have a specific membrane capacitance (Cm) of ~0.5 mF/cm2, half of the commonly accepted ‘universal’ value (~1 mF/cm2) for biological membranes. This finding was predicted by fitting in vitro voltage transients to theoretical transients then validated by direct measurement of Cm in nucleated patch experiments. Models of 3D reconstructed HL2/3 PCs demonstrated that such low Cm value significantly enhances both synaptic charge-transfer from dendrites to soma and spike propagation along the axon. This is the first demonstration that human cortical neurons have distinctive membrane properties, suggesting important implications for signal processing in human neocortex.

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