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Voltage attenuation in reconstructed type-identified motor neurons as a constraint for reduced models

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Introduction

Attenuation of voltage in dendrites depends on the direction of propagation [1]: Direction Dependent Voltage Attenuation (DDVA). This study's **objectives** were to: 1) determine whether DDVA differed for motor neurons of different types (i.e. slow – fast), and 2) derive the cable parameters for reduced models that satisfy DDVA for the heteronymous properties of motor neurons in a pool.

Methods

The morphologies of six type-identified cat spinal motor neurons were downloaded from a public database [2] and imported into the NEURON simulation environment. Passive parameters were set to experimentally determined values from these same cells [3]. DDVA was characterized by calculating the voltage attenuation between the soma and all sites on the dendrites in both directions.

Results

Voltage attenuation changed rapidly with distance from the soma for central propagation (Fig 1 left) compared to the peripheral direction (Fig 1 right). The change in voltage attenuation with distance was well described by a single exponential function, fitting a voltage decay constant (VDC). A comparison of VDCs for S, FR and FF-type motor neurons did not reveal significant differences resulting from type-specific morphology. The input resistance of the six anatomical models was varied from 0.4 – 4.0 MOhm by changing passive parameters. All models had similar monotonic relationships between input resistance and VDC. These results were used to derive two-compartment models in which all cable parameters could be determined analytically by specifying the parameters of input resistance and distance between soma and dendrite compartments.

Discussion

Type-specific dendritic morphology had no obvious effect on DDVA. DDVA in spinal motor neurons was fully characterized by input resistance at the soma. The two-compartment models are the first to analytically solve for reduced cable parameters based on reconstructed neurons. This solution has important implications for the bistable firing behavior in these cells.

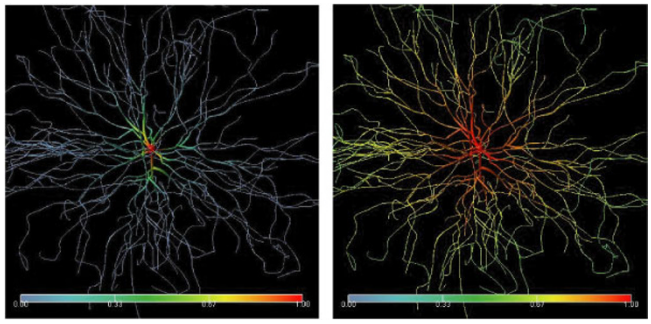

Figure 1
DDVA in an adult cat spinal cord motor neuron.

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