Location of modulatory inputs affects the "scaling competence" of the NMDA channel

Recordings from cortical neurons indicate that their responses to "classical" sensory inputs can be multiplicatively and divisively scaled by various types of modulatory inputs. The neural mechanisms that underlie response scaling remain poorly understood, however. Using a compartmental model of a neocortical pyramidal cell, we previously showed that subthreshold response scaling based on voltage-dependent NMDA currents could be both accurate and precise over a substantial range of scaling factors (Jadi & Mel, Society for Neuroscience Abstracts, 2007, 2008). Here we show that a neuron's "scaling competence" depends heavily on the NMDA/AMPA ratio of its synapses, and that near optimal single trial scaling results can be attained by time-averaging the responses of a small population of (10) neurons in as little as 100 ms. We then considered the scaling competence of a pyramidal cell model operating in the more realistic spike rate regime (rather than subthreshold voltage). We found that response scaling improved dramatically when the classical inputs were delivered on distal basal dendrites while the modulatory inputs were delivered on proximal basal dendrites, in contrast to cases with co-localized inputs, or cases where the modulatory inputs terminated distally. Our findings supports the proposal of Behabadi et al. (Society for Neuroscience Abstracts, 2007) that multiplicative attentional, contextual and other modulatory inputs may target more proximal regions of neocortical basal dendrites.