


Unequal partitioning of AMPA and NMDA conductances leads to robust temporal order sensitivity

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NMDA and AMPA receptors coexist at most glutamatergic synapses in the CNS, and are frequently described as having a synergistic interaction: AMPA channels provide the major depolarization needed to relieve NMDA channels of their voltage-dependent Mg^{2+} block, which can lead under certain conditions to highly nonlinear regenerative events such as NMDA spikes. With compartmental modeling and analysis, we systematically studied the conditions required to achieve two-input summation that is at once

1. strongly superlinear (i.e. "synergistic"),
2. temporal order-dependent (i.e. "causal"),
3. stable despite fluctuations in synaptic parameters (i.e. "robust").

We found that all three desirable properties can be simultaneously achieved, but only with (1) an unequal allocation of NMDA and AMPA conductances between the two input pathways, and (2) fast-spiking voltage-dependent sodium channels in the dendritic membrane. Our results could serve as a basis for understanding time-dependent contextual modulation effects.