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DISSERTATION SUMMARY

Subcellular information processing: placement and effect of GABAergic synapses, gap junctions and hyperpolarization-activated ion channels on cortical neurons

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Synaptic integration and information processing is highly affected by the placement of synaptic inputs on the somato-dendritic surface of cortical neurons. Distinct interneuron populations innervate perisomatic and dendritic regions of cortical cells and have significant role in governing neuronal activity at behaviorally relevant frequencies.

Perisomatically terminating GABAergic inputs are effective in timing postsynaptic action potentials, and basket cells synchronize each other via gap junctions combined with GABAergic synapses at γ frequency (Tamas et al. 2000).

Regular spiking nonpyramidal cells (RSNPs) innervate dendritic shafts and spines and occasionally somata. Combined GABAergic and gap junctional connections produce synchronous activity of the coupled RSNPs, however strong electrical coupling can also synchronize presynaptic and postsynaptic activity at β and γ frequency (Szabadics et al. 2001).

Inhibition in the cerebral cortex consists of fast $GABA_A$ and slow $GABA_B$ receptor mediated inhibitory postsynaptic potentials (IPSPs). Most neuron classes elicit IPSPs through $GABA_A$ receptors, but possible distinct sources of slow inhibition remained unknown. We identified a class of GABAergic interneuron, the neurogliaform cells, that in contrast to other GABAerg cells, elicited combined $GABA_A$ and $GABA_B$ receptor mediated responses and predominantly targeted dendritic spines of pyramidal neurons. Slow inhibition evoked by a distinct interneuron in spatially restricted postsynaptic compartments could locally and selectively modulate cortical excitability (Tamas et al. 2003).

Hyperpolarizing the dendritic membrane, IPSPs evoked by GABAergic inputs can activate hyperpolarization-activated cation channels that can influence the summation of synaptic inputs and determine how sub-and supratreshold events propagate to soma. However, the functional role of an ion-channel depends, to a large extent, on its location and density on the surface of nerve cells. Using high-resolution immunolocalization we determined the subcellular distribution of the hyperpolarization-activated and cyclic-nucleotide-gated channel subunit 1 (HCN1). Quantitative comparison of immunogold densities showed a domain-, distance- and subcellular compartment dependent distribution of HCN1, revealing the complexity in the cell surface distribution of a voltage-gated ion-channel, and predict its role in increasing the computational power of single neurons via subcellular domain and input specific mechanisms (Lorincz et al. 2002).

References

Tamás G, Lőrincz A, Simon A, Szabadics J (2003) Identified sources and targets of slow inhibition in the neocortex. Science 299:1902-1905.

Lőrincz A, Notomi T, Tamás G, Shigemoto R, Nusser Z (2002) Polarized and compartment-dependent distribution of HCN1 in pyramidal cell dendrites. Nature Neurosci 5:1185-1193.

Szabadics J, Lőrincz A, Tamás G (2001) Beta and gamma frequency synchronization by dendritic GABAergic synapses and gap junction in a network of cortical interneurons. J Neurosci 21:5824-5831.

Tamás G, Buhl EH, Lőrincz A, Somogyi P (2000) Proximally targeted GABAergic synapses and gap junctions synchronize cortical interneurons. Nature Neurosci 3:366-371.

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