Inhibitory Circuitry Mechanisms for Cortical Processing and Dynamics

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Among the cellular constituents in many brain circuits, the interneuron that releases neurotransmitter γ-aminobutyric acid (GABA), occupying about 10-20% of total neuron population, generates the spatiotemporally rich and fine inhibitions through its stunning diversity in subtypes. These heterogeneous GABAergic cells play distinct and critical roles in establishing the functional balance, complexity, and computational architecture of brain circuits. Understanding the operation of inhibitory GABA circuits is therefore a key part to decipher the cellular and circuitry mechanisms of various brain functions. In the talk, I would present our previous and recent findings on some functional aspects of how the GABA inhibition regulates the cortical dynamic and processing. First, I would introduce our empirical derivation of a simple arithmetic rule for dendritic integration of inhibitory and excitatory synaptic inputs in a single principal cell. This rule is further On the basis of these experimental data, we further have generalized this rule to be a bilinear rule which could nicely estimate the spatiotemporal dendritic integration of multiple excitatory and inhibitory synaptic inputs in a single-compartment (point) neuron model. Our *in vivo* whole-cell recording in the rat auditory cortex further suggested the spatiotemporal integration of sensory input-activated excitatory and inhibitory information underlie the emergence of direction selectivity of auditory cortical cells responding to frequency-modulated sounds. Second, I would present our recent experimental evidence on the distinct regulatory roles of different sub-groups of inhibitory interneuron in cortical oscillatory activities in awaken animals, in which the most ubiquitous cortical oscillations are rhythms in the β- (12–35 Hz) and γ-frequency (35–90 Hz). Given inhibitory interneurons are generally believed to involve in the regulation of cortical oscillations, whether and how different sub-groups of interneuron are involved remain elusive. Using the combined approaches of optogenetics and multiple arrayed electrode recording in the primary visual cortex (V1) of awake mice, we find that inhibitory SST cells are exclusive for generating β-band oscillations while PV cells are preferentially involved in producing higher (γ)-frequency range oscillations in the cortex. Our results also suggest a dis-inhibition synaptic pathway between these two sub-groups, which is actively involved in the cortical dynamic regulation. Thus, our findings have revealed some important working mechanisms of inhibitory interneurons for the cortical processing and dynamics.