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Synaptic conductances of pre-Bötzinger complex respiratory neurons in vitro and in situ

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Abstract:
The brainstem pre-Bötzinger complex (pre-BötC), an essential component of the respiratory rhythm-generating circuitry in mammals, can operate in multiple modes of rhythmic pattern generation under different physiological and pathophysiological conditions. In the intact brainstem respiratory network, where the pre-BötC interacts with numerous other neuron populations including the pons, RTN, and Bötzinger complex, the activity of different pre-BötC neurons reflects synaptic interactions underlying the 3-phase pattern of rhythmic activity in the respiratory network. When isolated from these inputs in vitro, the pre-BötC generates a more primitive rhythmic pattern of inspiratory (I) activity. The network interactions that occur during these different patterns of respiratory activity are poorly understood. We therefore reconstructed temporal patterns of excitatory and inhibitory postsynaptic conductances in pre-BötC respiratory neurons in vitro in slices from neonatal rats that isolate the pre-BötC circuits, and in functionally more intact in situ perfused brainstem-spinal cord preparations of mature rats. The results based on in vitro whole-cell recording experiments showed that inspiratory neurons exhibited strong excitatory conductances (Ge) during the I phase, which rapidly increased at I onset and were maximal during the first half of the I phase. Inhibitory conductances (Gi) were also present and observed during the first half of the I phase as well as throughout the E phase with lower magnitude. Expiratory neurons in vitro exhibited Gi during I and Ge throughout the E phase with lower magnitude. In contrast, in situ intracellular recording experiments showed that inspiratory neurons (e.g. pre-I neurons) exhibited strong Ge that increased during the second stage of expiration (E2) and peaked at the end of the I phase. Gi was maximal at the I-E transition and decreased throughout the first half of the E phase. In expiratory neurons (e.g. post-I neurons) in situ, Gi increased during the E2 phase and rapidly declined at I termination. Ge in post-I spiking neurons was observed primarily during the post-I period. These patterns of synaptic inputs in the various types of pre-BötC respiratory neurons indicate the functional synaptic interactions involved in the different modes of rhythmic respiratory pattern generation in vitro and in situ. The different patterns of synaptic inputs found between in vitro and in situ conditions are generally consistent with the circuit architectures proposed in our previous models to account for the different modes of pre-BötC network operation when isolated and in more intact states of the respiratory network.