Spike synchronization is population specific in the respiratory pattern generator

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Introduction

Breathing accounts for only a small fraction of basal metabolism, and its motor pattern is highly efficient mechanically [1]. While this view is widely accepted, no one understands whether this property is malleable and whether it can be utilized to attenuate respiratory failure as well as to facilitate weaning from artificial ventilation. Several factors influence muscle force including firing rate and recruitment of pre-motor and motoneurons (MNs), which increase energy consumption. Another factor is the synchronization of spikes of MNs, which increases muscle force in an energy efficient manner, preserving rather than increasing the firing frequency of active motor units. In line with Otis' findings, we hypothesized that the respiratory control network uses synchrony to generate an efficient inspiratory pattern, minimizing the work of diaphragm contraction, chest wall expansion and lung inflation.

Methods

To test our hypothesis, we recorded ensembles of respiratory neurons in perfused *in situ* preparations (Sprague-Dawley/Harlan rats) that produces a ramping breathing pattern spontaneously (for details on preparation see [2]). A 16-channel microelectrode array placed 8 tungsten electrodes (10-12 MΩ) on either side of the spinal cord or brainstem. The design allowed for simultaneous bilateral recording of spinal motor or brainstem pre-motor neurons, and those of the pre-Bötzinger complex. The independent depth adjustment of each electrode optimized the yield of isolated high signal-to-noise activity. In a typical experiment, we are able to record an ensemble of 6 to 16 neurons. Spike-synchrony between neurons was calculated as reported somewhere else [3].

Results

Simultaneous recordings from neurons in and around the rostral-ventral respiratory group (inspiratory pre-motor area) have been processed and converted to spike trains in order to assess their temporal relationships (Fig. 1A). While expiratory and non-respiratory modulated cells show a low level of coordination, the pre-motor inspiratory cells exhibit significant spike-synchrony levels in eupneic-like breathing conditions (Fig. 1A, bottom and Fig. 1B).

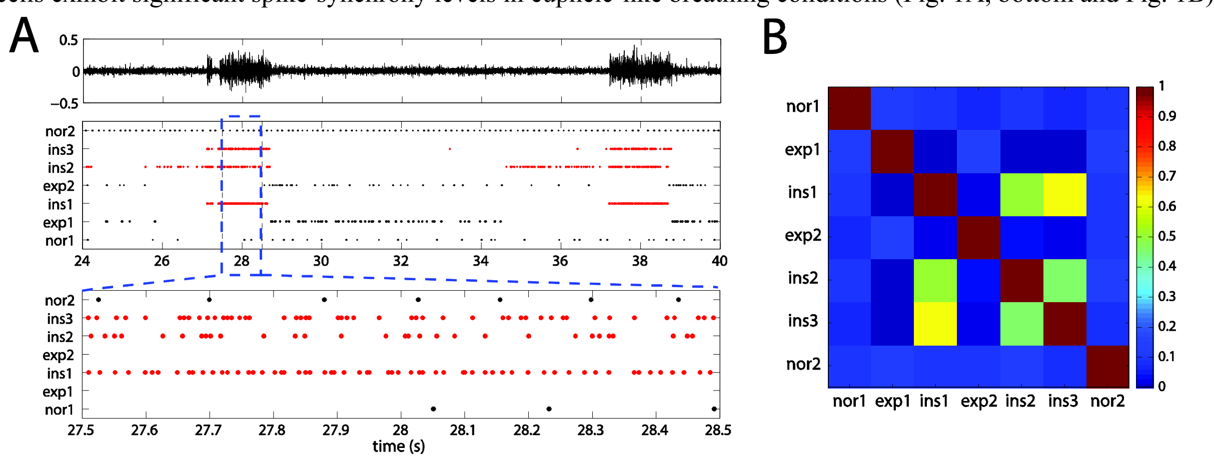

Figure 1: Pairwise synchrony is specific to pre-motor inspiratory neurons. **A:** Simultaneous recordings of phrenic nerve activity showing inspiratory bursts (top) and of pre-motor neurons (raster plots), including inspiratory (ins), expiratory (exp) and neither inspiratory nor expiratory (nor) neurons. **B:** Spike synchrony between cell pairs (normalized between 0 and 1) is only significant among inspiratory neurons.

Acknowledgements

This work has been supported by the American Heart Association (SDG 0735037N, DMB), the National Institutes of Health (HL-080318 & HL-007887, TED), and The Mount Sinai Health Care Foundation (RFG).

References

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