Tata Institute of Fundamental Research
Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad – 500 046

Webinar

Inspiratory rhythms in the preBötzinger Complex emerge through synchrony driven cell assemblies

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Mammalian breathing is robust, virtually continuous throughout life, and yet is exceptionally labile to i) respond rapidly to increases in metabolic demands for oxygen, e.g., fleeing a predator or chasing prey; ii) change pattern for essential reflexes, e.g., cough, sigh; and sync with non-ventilatory behaviours, e.g., vocalization, swallowing. The neuroanatomical core of the breathing circuit is the preBötzinger Complex (preBötC) located in the brainstem. However, decades after its discovery, the mechanisms underlying the generation and control of breathing patterns remain elusive. In this talk, I will present evidence from experimental and computational studies that reveal that the inspiratory activity in every breath cycle is generated by spike-synchronization of rhythmogenic preBötC neurons. This synchronization is gated by the excitation-inhibition balance in the preBötC network that modulates its rhythmicity. Furthermore, the preBötC inspiratory burst generation is an all-or-none phenomenon –a manifestation of attractor dynamics in neuronal networks. I will show that such dynamics impart robustness to the breathing rhythm while allowing for the necessary flexibility to respond to external inputs that coordinate breathing with behaviours such as chewing, swallowing, phonation, and the emotional and cognitive control of breathing. The robustness and lability of the preBötC network are effectuated by a fat-tailed synaptic strength distribution, as observed in the network models constructed from experimentally derived neuronal and network parameters. Such connectivity strategy in this vital rhythmogenic network augments neuronal synchronization and attractor dynamics through coincident convergent inputs, contributing to its reliability and responsiveness. These analyses reveal that the fat-tailed synaptic strength distribution, observed in several brain regions, provides a unified mechanism to balance the contrasting requirements underlying input sensitivity and response reliability for vital microcircuit operations. Understanding neuronal and network mechanisms underlying the preBötC attractor dynamics is crucial to study widespread pathologies caused by breathing malfunction and explore their solutions.

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