Computational model of brain stem functions

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Brain stem is the key structure controlling many homeostatic processes, but also attention, action selection, overall arousal and the level of consciousness. It is also one of the least understood brain structures, with essentially no computational models available. As the first step towards comprehensive brain stem model neural rhythm generators controlling the upper and lower lung muscles responsible for breathing patterns are studied. This network consists of three interconnected groups of neurons in the dorsomedial brain stem: the Pontine Respiratory Group (PRG) that stabilizes and slows the respiratory patterns, the Dorsal Respiratory Group (DRG) that is sensitive to feedback from lungs, and the Ventral Respiratory Group (VRG) with inspiratory and expiratory neurons. Different types of breathing patterns generated by the model may be compared with types of patterns observed in brain spirography. The multilevel dynamics of neural networks creating rhythmic activations of muscles will be coupled with model of upper and lower lung muscles. The dynamical properties of such network are studied using non-linear dynamics techniques, including novel techniques for visualization of trajectories and fuzzy symbolic dynamics analysis. Calibration of the model is done using spirography data for a healthy group of individuals. Lesions to the model should replicate qualitative changes in the breathing rhythm patterns that result from specific neuroanatomical and neuropathological lesions. The major part of this investigation is to find different patterns of rhytmic activity that the model is capable of, and analyze modifications of these patterns resulting from the feedback from lung muscles. Such simulations should help to improve rehabilitation of patients after brain-stem strokes.

Extension of the brain stem model that includes reticular formation and controls arousal of major cortical and subcortical brain areas is being planned. This type of models may be used to study transition from normal conscious states to coma, persistent vegetative states and brain death.

Keywords: Brain Stem, Neural Network Model, Respiratory Centers, Central Pattern Generators, Consciousness

COST Action BM0605: Consciousness: A Transdisciplinary, Integrated Approach, WG4: Clinical, societal, and ethical implications