Cell assemblies of the basal forebrain exhibit beta-frequency dynamics.

David Tingley, Andrew Alexander, Sean Kolbu, Andrea Chiba, Douglas Nitz
University of California, San Diego

The basal forebrain (BF) consists of a heterogeneous population of cholinergic, GABAergic, and glutamatergic neurons having projections to most cortical regions. The importance of these projections for cognitive processing has been demonstrated in behavioral studies employing lesions of BF and in examining impairments in cognitive processing in patient populations (e.g., Alzheimers disease). In recent years, such work has been complemented by multiple single neuron recording studies demonstrating that BF cell populations: 1) form distinct activity patterns for all phases of a selective attention task; 2) consist of neuron populations having distinct inter-spike interval (ISI) patterns; 3) are responsive to salient sensory stimuli and rewards; and 4) exhibit complex task-phase-specific firing patterns paralleling those observed in their efferent targets (e.g., parietal cortex). These functional and anatomical features of the BF allow for the possibility of complex neural assemblies that integrate information, and modulate cortex, over a distinct time frame.

Specific groups of neurons with similar ISI histograms that represent either 'bursty' or tonic firing were found among a large population of BF neurons. These types become most active at different phases of a visual-spatial attention task, representing temporally, perhaps functionally, distinct cell assemblies. Such shifts in activity patterns could represent a switching mechanism between network attractor states coinciding with attentional shifts across phases of a complex behavioral task.

To further characterize interactions among BF neurons during task performance, spike firing patterns among pairs were examined in the context of the 'cell assembly' hypothesis. Using a generalized linear model, spike times of BF neurons were more accurately predicted by temporally smoothed spike time probabilities of simultaneously recorded peer neurons. Furthermore, BF neurons exhibited an optimal temporal window for synchronous spike generation of 30-80 ms. This indicates that BF cell assemblies are synchronized over a beta-frequency time scale which has been proposed as an optimal global synchronization frequency.

In addition to the anatomical connections between the BF and cortical regions, the electrophysiological properties of this region further suggest temporally precise integration, synchronization, and modulation of cortical targets during a task that demands visual-spatial attention. These preliminary findings suggest that the temporal dynamics of cell assemblies in the BF differ from previously explored brain regions, as does its functional and behavioral importance.