Unexpected impact of inhibitory cells in different brain states

Alain Destexhe, PhD
Paris-Saclay Institute of Neuroscience (NeuroPSI)
CNRS UMR 9197, Gif sur Yvette, France

We review here some unexpected roles of inhibition in the thalamo-cortical system during wake and sleep states. A first surprising effect of inhibition is the inhibitory rebound response, as typically found in thalamic neurons. Experiments and computational models show that this property is fundamental to explain the thalamic pacemakers, as well as the long-range synchrony of thalamic-generated oscillations. In cerebral cortex, conductance measurements have shown another surprising effect of inhibition, that it can drive spikes in excitatory neurons, through the strong impact of inhibitory fluctuations in awake animals. Indeed, spikes are more correlated to changes of inhibition compared to excitation. Computational models have shown that this can be explained by the intense and sustained synaptic bombardment in the waking state, but only with strong inhibitory conductances. More recently, the activity of inhibitory neurons could be extracted from human recordings, which also revealed other surprising roles of inhibition. Inhibitory cells can show remarkable correlations across large distances in cortex, a feature which was never seen among excitatory neurons. Inhibitory neurons can also show unexpected behavior during seizures. Finally, some pairs of inhibitory cells become correlated over large distances, but specifically during slow-wave sleep. This unexpected - and so far unexplained - observation shows that inhibitory neurons seem to also play a key role during sleep. In conclusion, inhibition clearly plays active roles in all brain states, such as wakefulness, sleep, and epileptic seizures, where its impact is often larger than expected.

Supported by the CNRS, ANR (PARADOX) and the E.U. (Human Brain Project)