

The Quest for the Emergent Brain

Abstract

The past decades have witnessed an explosive growth in the knowledge of the molecular and cellular mechanisms underlying brain structure and its chemical and electrical signaling. How these mechanisms give rise to learning, memory and cognitive functions, is still poorly understood. According to one school of thought in theoretical neuroscience, neural information processing and cognitive functions are emergent properties of the neuronal and synaptic dynamics of large neuronal circuits. A hallmark of emergence is the existence of phase transitions, namely, sharp boundaries between different dynamical and functional states of the neuronal circuits. I present examples from models of cognitive functions such as memory, learning, and sensory processing, as well as from the theory of chaos and excitation/inhibition balance in cortical networks. I discuss implications of the emergent nature of brain dynamics and function on the understanding of brain diseases and the role of stimulation.