CRC 1461

Self-Organized Criticality in the Brain

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Self-organized criticality (SOC) refers to the ability of complex systems to evolve towards a second-order phase transition at which interactions between system components lead to scale-invariant events beneficial for system performance. For the last two decades, considerable experimental evidence has accumulated that the mammalian cortex with its diversity in cell types, interconnectivity, and plasticity might exhibit SOC. Here we review experimental findings of isolated, layered cortex preparations to self-organize towards the four dynamical motifs of up-states, oscillations, neuronal avalanches, and coherence potentials. During up-states, the synchronization observed for nested theta/gamma-oscillations embeds scale-invariant neuronal avalanches identified by robust power law scaling in avalanche sizes with a slope of -3/2. This precise dynamical coordination can be tracked in negative transients of the local field potential (nLFP), emerges autonomously in superficial layers of organotypic cortex cultures, is homeostatically regulated, exhibits separation of time scales, and reveals unique size vs. quiet time dependencies. A subclass of avalanches, the coherence potential, exhibits precise maintenance of temporal precision in propagated local synchrony. Avalanches emerge in superficial cortex layers under conditions of strong external driving. The balance of excitation and inhibition (E/I) and neuromodulators such as dopamine establish powerful control parameters for avalanche dynamics. This rich dynamical repertoire is not observed in dissociated cortex cultures, which lack the differentiation into layered components, suggesting that SOC in cortex requires essential components found in superficial layers of cortex. The precise interaction between up-states, nested oscillations and avalanches in layered cortex provides

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Invited by Hermann Kohlstedt
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