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The brain as a complex system: plasticity at multiple scales and criticality TONY NG, PAUL MILLER, Brandeis University — As a complex system, a successful organism is one that can react effectively to environmental fluctuations. Not only should its response repertoire be commensurate with the number of independent conditions that it encounters, behavioral and environmental variations need to be matched at the appropriate scales. In the cortex, neuronal clusters, not individual cells, operate at the proper scale that is necessary to generate appropriate responses to external states of the world. Single neurons, however, serve on a finer scale to mediate interactions between neuronal assemblies. The distinction of scales is significant, as plasticity mechanisms can operate on various spatial and temporal scales. The brain has apparently evolved complex-system strategies to calibrate its own dynamics at multiple scales. This makes the joint study of local balance and global homeostasis fundamentally important, where criticality emerges as a signature of a computationally powerful system. We show via simulations how plasticity mechanisms at multiple scales are inextricably tied to spike-based neuronal avalanches, which are microscopic in origin and poorly predictive of animal behavior, and cluster-based avalanches, which are manifest macroscopically and are relevant to cognition and behavior.

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