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Criticality in the brain: A synthesis of neurobiology, models and cognition

Short title: Criticality and brain

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Highlights

- Criticality is a wide-spread phenomenon in natural systems
- Criticality provides a unifying framework to model and understand brain activity and cognitive function
- Substantial evidence now supports the hypothesis that the brain operates near criticality
- We review the role of criticality in healthy and pathological brain dynamics
- Caveats and pitfalls regarding the assessment of criticality in the brain are discussed

Abstract

Cognitive function requires the coordination of neural activity across many scales, from neurons and circuits to large-scale networks. As such, it is unlikely that an explanatory framework focused upon any single scale will yield a comprehensive theory of brain activity and cognitive function. Modelling and analysis methods for neuroscience should aim to accommodate multiscale phenomena. Emerging research now suggests that multi-scale processes in the brain arise from so-called critical phenomena that occur very broadly in the natural world. Criticality arises in complex systems perched between order and disorder, and is marked by fluctuations that do not have any privileged spatial or temporal scale. We review the core nature of criticality, the evidence supporting its role in neural systems and its explanatory potential in brain health and disease.

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