# Scale-invariance and near-critical behavior in neural systems

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The brain is in a state of perpetual reverberant neural activity, even in the absence of specific tasks or stimuli. Shedding light on the origin and functional significance of such a dynamical state is essential to understanding how the brain transmits, processes, and stores information. An inspiring, albeit controversial, conjecture proposes that some statistical characteristics of empirically observed neuronal activity can be understood by assuming that brain networks operate in a dynamical regime with features, including the emergence of scale invariance, resembling those seen typically near phase transitions.

Here, we present a data-driven analysis based on simultaneous recordings of the activity of thousands of individual neurons in various regions of the mouse brain [1]. To analyze these data, we construct a unified theoretical framework that synergistically combines a phenomenological renormalization group approach and techniques that infer the general dynamical state of a neural population, while designing complementary tools. This strategy allows us to uncover strong signatures of scale invariance that are quasiuniversal across brain regions and experiments, revealing that all the analyzed areas operate, to a greater or lesser extent, near the edge of instability. These results are then replicated on a minimal computational model to uncover the essential ingredients involved in the emergence of this scale-invariance phenomenon. To wrap-up, we move beyond biological systems to show that even artificial neural networks operating near the edge-of-instability, where optimal performance is achieved for an image-classification task, show similar scaling behavior when subject to the aforementioned phenomenological renormalization group analysis.

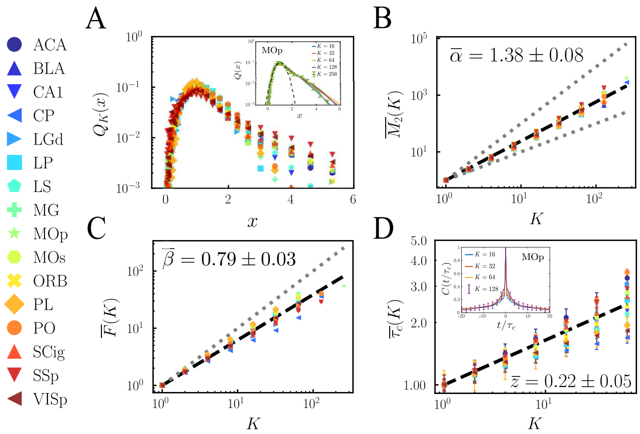


Fig. 1. Results of the phenomenological RG analyses of brain activity measured in 16 different mouse brain areas, showing the existence of a non-trivial quasi-universal scaling across regions.

[1] G. B. Morales, S. di Santo, and M. A. Muñoz, *Quasiuniversal scaling in mouse-brain neuronal activity stems from edge-of-instability critical dynamics*, Proceedings of the National Academy of Sciences **120(9)** (2023).