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Zipf's law and criticality in multivariate data without fine-tuning

DAVID SCHWAB, Princeton University, ILYA NEMENMAN, Emory University, PANKAJ MEHTA, Boston University — Recently it has become possible to directly measure simultaneous collective states of many biological components, such as neural activities or antibody sequences. A striking result has been the observation that the underlying probability distributions of the collective states of these systems exhibit a feature known as Zipf's law. They appear poised near a unique critical point, where the extensive parts of the entropy and energy exactly cancel. Here we present analytical arguments and numerical simulations showing that such behavior naturally arises in systems with an unobserved random variable (e.g., input stimulus to a neural system) that affects the observed data. The mechanism does not require fine tuning and may help explain the ubiquity of Zipf's law in disparate systems.

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