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