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On convexity and efficiency in semantic systems

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Abstract

There are two widely held characterizations of human semantic category systems: (1) they form convex partitions of conceptual spaces, and (2) they are efficient for communication. While prior work observed that convexity and efficiency co-occur in color naming, the analytical relation between them and why they co-occur have not been well understood. We address this gap by combining analytical and empirical analyses that build on the Information Bottleneck (IB) framework for semantic efficiency. First, we show that convexity and efficiency are distinct in the sense that neither entails the other: there are convex systems which are inefficient, and optimally-efficient systems that are non-convex. Crucially, however, the IB-optimal systems are mostly convex in the domain of color naming, explaining the main empirical basis for the convexity approach. Second, we show that efficiency is a stronger predictor for discriminating attested color naming systems from hypothetical variants, with convexity adding negligible improvement on top of that. Finally, we discuss a range of empirical phenomena that convexity cannot account for but efficiency can. Taken together, our work suggests that while convexity and efficiency can yield similar structural observations, they are fundamentally distinct, with efficiency providing a more comprehensive account of semantic typology. A preprint of this work is available at <https://doi.org/10.48550/arXiv.2602.08238>.