

# TROPHIC ANALYSIS: A METHOD FOR STUDYING HIERARCHY AND DIRECTIONALITY IN COMPLEX SYSTEMS

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Many complex systems—whether they involve genes, neurons, people, species, institutions or concepts—can be usefully described as directed networks. Over the past decade, trophic analysis has emerged as a powerful method for studying the hierarchical structure and overall directionality of such systems. In particular, trophic coherence has been related to properties like feedback, strong connectivity, stability, robustness, control, synchronisation, percolation and non-normality, often by using graph ensembles. Applications have been found in ecology, neuroscience, social systems, finance, epidemics, railways and deep learning, among others. For instance, networks based on brain images show that while a standard anti-depressant increases coherence, the hallucinogen psilocybin has the opposite effect—which may help us understand the mechanisms of action of these drugs. We describe how trophic analysis can be applied to any directed network, what kind of insights this methodology can reveal, and potential extensions to other descriptions of complex systems, such as linear operators.

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