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# From Tangled Object Manifold to Temporal Relation Manifolds

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## **Abstract**

In this paper, we extended the DiCarlo & Cox 2007 tangled object manifold framework of object recognition to better address the unsupervised nature of category learning. We developed a novel Markov chain-based similarity metric that formally connects aspects of manifold untangling with trace learning. Using these developments, we replaced unobservable labels and artificial category boundaries with our observable Markov chain walk based similarity metric as a theoretically grounded target for unsupervised category untangling. Further, we developed a new rationale for how neuronal input windows should be chosen for an untangling algorithm using this new framework. This new framework for manifold untangling and trace learning allowed us to synthesize aspects of simple cell learning, complex cell learning, and axonal development theories, into a high-level theory of how the visual cortex learns to separate object categories at a computational level.