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Biological mechanisms for learning: experiments and mathematical questions

Biological neural systems excel at fast and adaptable learning. Our experiments with computational models of the moth olfactory network suggest this learning depends on a triad of sparsity, Hebbian plasticity, and neuromodulatory signals. We also find that a bug brain can outperform machine learning methods in certain rapid-learning regimes. So given sufficient mathematical characterization, these biological mechanisms could yield high-value tools applicable to machine learning and especially neural nets. We'll describe some experimental results, and point to some current gaps in the mathematical analysis of these mechanisms.