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Representing Information with Correlated Neural Populations[1]

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Using a multi-electrode array, we can record simultaneously from up to 50 ganglion cells, the output neurons of the retina, while stimulating with varied visual images generated on a computer monitor. We find that nearby ganglion cells, the output neurons of the retina, have spatial receptive fields that overlap significantly, leading to correlated firing and redundancy in the visual information that cells encode. Although the strength of correlations among pairs of cells is weak (~10%), the effect in larger populations is dramatic: patterns of spiking and silence in groups of just 10 cells can occur with a probability ~100,000-fold different from that predicted from statistical independence. We show that these strong network correlations can be explained by a model that includes all pairwise correlations, but no higher-order statistics. This model is identical to the Ising model, and predicts that larger populations may exhibit a form of freezing transition that allows for robust error correction. We have begun to explore these error-correcting properties in simple visual discrimination tasks using large populations of ganglion cells. We find that the correlations among neurons can dramatically reduce the discrimination error.

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