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Evidence for a neural model to evaluate symmetry in V1

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50 years ago Hubel and Wiesel discovered simple and complex cells in V1, but there is still no consensus on their functional roles. It is agreed that complex cells are more often selective for direction of motion than simple cells, that there are differences in the way they combine information within their receptive fields, and that complex cells probably receive most of their input from simple cells, but what this serial hierarchy achieves is not understood. There is another puzzling dichotomy that we think is related, namely that of cross-correlation, which is widely accepted as the operation performed on the input image by simple cells, and auto-correlation, which some think underlies the perception of Glass patterns, and possibly motion. We propose the hypothesis that complex cells signal auto-correlations in the visual image, but to evaluate them they require the preliminary analysis done by simple cells, and also pinwheels - structures intervening between simple cells and complex cells that were quite unknown to Hubel and Wiesel. We shall first present psychophysical evidence, using a new kind of random dot display, which suggests that both cross-correlation and auto-correlation are performed in early vision. We then point to recent evidence on the micro-circuitry of pinwheels, and mappings of their intrinsic activity, which shows how pinwheels might enable complex cells to respond selectively to autocorrelations in the input image that activates the simple cells. Auto-correlation is a powerful tool for detecting symmetry, and many may be surprised by evidence that such an abstract property is detected so early in visual perception.

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