Predictive information in the retina

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Prediction is important for almost all modes of behavior and our research focuses on how a population of neurons implements predictive computations. We have examined how groups of retinal ganglion cells (the output neurons of the retina) encode predictive information in their collective firing patterns. The population response is represented as a binary word, indicating a spike or no-spike from each neuron in a small time window of size $\Delta t$. We can then ask how precisely a word at time $t$ specifies a future word at time $t + \Delta t$. This is the predictive information in the population firing. We next construct a synthetic neuron that receives these inputs, and gives as output a single bit (spike or no-spike). We ask how this downstream neuron, combining subgroups of its potential presynaptic cells, would learn to become maximally predictive of its inputs, in the sense that its output spiking would carry maximal information about its input pattern at the next time step. Can this output capture the available predictive information? What is the structure of the algorithm that maps inputs to predictive outputs? For four-cell subgroups, we can exhaustively search all possible deterministic rules for converting input responses into a binary output, and we use this to test our search strategies for larger groups. We find that the best rules can capture more than 95\% of the predictive information in the input firing. Rules which capture such a large percentage of the predictive information also retain a large amount of stimulus information about the visual world. These best rules can be reliably learned by a perceptron model, meaning that instantiating such a coding of predictive information in the brain might be biologically plausible.

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