Introduction

The role of correlated firing for representing information has been a subject of much discussion. Several studies in areas including retina, visual cortex, somatosensory cortex, and motor cortex, have suggested that it plays only a minor role, carrying less than 10% of the total information carried by the neurons [3.5.7]. A limiting factor of these studies, however, is that they were carried out using pairs of neurons, how the results will extend to large populations isn’t clear.

Recently, new methods for modeling network firing patterns have been developed [8]. These open the door to answering this question for more complete populations of neurons. Pillow et al. [9] used this approach to study the importance of correlations in primate retina. Using a binary checkerboard stimulus, their group decoded ganglion cell responses and found correlations were important.

Their results showed that 32 +/- 0.5% of the information about the stimulus could be obtained when correlations were included, and 27.2 +/- 0.5% when they were not. While this constitutes a gain, the gain is several fold smaller than what might be expected from extrapolations using the pairwise data [see Ref. 8, Fig. 59 or attachment to this poster]. Here we performed the same analysis on mouse retinal ganglion cells, using cells with correlations as high as those found in primate retina [8]. The results showed that 25.5 +/- 1.35% of the information about the stimulus could be obtained when correlations were included, and 22.6 +/- 1.45% when they were not. An even smaller difference was found when the same analysis was performed on natural scenes.

These results suggest generalization. The pairwise analysis may even be more accurate. The analysis of large populations show a similar result, that correlations still account for a small fraction of the total information.

Figures 1 and 2 show the reliability of the data, that is, that our cells in our datasets are clearly and consistently driven by the stimulus.

Fig. 2. Typical Spike Triggered Averages (STAs) from 6 different ON cells from 2 retinas. The spatial component of the full STA which contains the peak of the STA is shown.

Fig. 3. Typical cross-correlograms for pairs of mouse ganglion cells from 2 retinas. A cross-correlogram gives the firing rate of one cell relative to spikes generated by the other. Black, the raw cross-correlogram; blue, the shifted (stimulus) cross-correlogram; red, the noise cross-correlogram. The stimulus cross-correlogram gives the correlations produced only by the stimulus and is generated by presenting the stimulus multiple times and cross-correlating the responses of the cells when they ‘see’ the stimulus at different times. The noise cross-correlogram is the raw cross-correlogram minus the stimulus cross-correlogram.

Figures 3-5 show the properties of the correlations in our model system, the mouse retina: For large populations of neurons, the importance of correlations in primate retina. Using a binary checkerboard stimulus, their group decoded ganglion cell responses and found correlations were important.

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Discussion

Previous work has shown that correlations among mouse retinal ganglion cells add little information above what can be obtained from the independent responses [3-7]. However, this work was done with pairs of neurons. Now, with the aid of a neuronal population model [9] we were able to address this question for much larger populations. We tested this with both binary checkerboard and natural scenes. The results show that, for the white noise stimulus, there was only a small information increase, and, for the natural scenes, there was no clearly detectable increase.

Some caveats should be taken into account when interpreting this result. First, the analysis was done with a model’s output rather than direct measurements (although the model was clearly reflecting the correlations as shown in Figures 5 and 6). Second, for the white noise stimulus, information was measured using a Gaussian assumption, although a binary stimulus was used. Third, the natural scene decoding performance was estimated using a discrete entropy calculation with a lower stimulus entropy than the white noise, and hence may not be directly comparable.

References


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