

Spike train analysis reveals cooperation between Area 17 neuron pairs that enhances fine discrimination of orientation

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We examined 22 pairs of neurons in Area 17 of cats that were paralyzed and anesthetized with Propofol and N₂O. We studied changes in ensemble responses for small (<10deg, 0.1c/deg) and large (>10deg, 0.1c/deg) differences in orientation (OR) and spatial frequency (SF). Examination of temporal resolution and discharge history revealed advantages in discrimination from both dependent (connectivity) and independent (bursting) interspike interval properties. For 12 pairs with at least moderate connectivity and enough data (>200 stimulus repetitions), we found the average synergy (information greater than that summed from the individual neurons) was 50% for fine discrimination of OR and 20% for SF; and <10% for gross discrimination of both OR and SF.

Dependency (Kullback-Leibler "distance" between the actual responses and two wholly independent responses) was measured between pairs of neurons while varying OR (10 pairs), SF (10 pairs) and contrast (9 pairs). In general, dependency was more selective to spatial parameters than was firing rate. Variation of dependence against SF corresponded to variation of burst rate, and was even narrower than burst rate tuning for OR (suggesting that burst length also influences dependency). Since there is no differential modulation of burst rate and average firing rate with contrast, dependency strength matched average firing rate. However, we found a gradual decline (adaptation) of dependency over time that is faster for lower contrasts which is likely a result of the decrease in isolated (non-burst) spikes. The results suggest that salient information is more strongly represented in bursts, but that isolated spikes also have a role in transferring this information between neurons. The dramatic influence of burst length modulation on both synaptic efficacy and dependency around the peak OR (where firing rate remains relatively constant) leads to significant cooperation that improves discrimination in this region.

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