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Decorrelation of neural-network activity by inhibitory feedback

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Correlations in spike-train ensembles can seriously impair the encoding of information by their spatio-temporal structure. An inevitable source of correlation in finite neural networks is common presynaptic input to pairs of neurons. Recent theoretical and experimental studies demonstrate that spike correlations in recurrent neural networks are considerably smaller than expected based on the amount of shared presynaptic input. By means of a linear network model and simulations of networks of leaky integrate-and-fire neurons, we show that shared-input correlations are efficiently suppressed by inhibitory feedback. To elucidate the effect of feedback, we compare the responses of the intact recurrent network and systems where the statistics of the feedback channel is perturbed. The suppression of spike-train correlations and population-rate fluctuations by inhibitory feedback can be observed both in purely inhibitory and in excitatory-inhibitory networks. The effect is fully understood by a linear theory and becomes already apparent at the macroscopic level of the population averaged activity. At the microscopic level, shared-input correlations are suppressed by spike-train correlations: In purely inhibitory networks, they are canceled by negative spike-train correlations. In excitatory-inhibitory networks, spike-train correlations are typically positive. Here, the suppression of input correlations is not a result of the mere existence of correlations between excitatory (E) and inhibitory (I) neurons, but a consequence of a particular structure of correlations among the three possible pairings (EE, EI, II).

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