Finite size effects in a network of rate neurons

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In a first approximation, neurons can be described by rate equations that quantify the frequency of the spiking activity exchanged among them. Another important feature of the brain is noise, that is able to reduce the reliability of the spike train making it a probabilistic process. In our work, we have developed a perturbative analysis in terms of the three sources of randomness of this kind of network: the noise intensity, the uncertainty in the initial conditions and the uncertainty in the distribution of the synaptic weights. This analysis can be performed for many topologies of the connectivity matrix and for an arbitrary finite number of neurons, and reveals three important results. The first is the formation of a stochastic synchronization, and therefore of strong correlations, between the neurons: this is uniquely related to the spectrum of the connectivity matrix, and therefore makes a mean-field description of the network impossible. The second result is the reduction of correlation by an increasing of the network's input, while the third result is that correlation decreases also when we increase the number of connections between the neurons. Since this analysis allows to find the full correlation structure of the network, we think it could help to shed light on the relation between the structural and functional connectivities of the system, a problem which is currently intensively investigated.