NEURAL HETEROGENEITY AS A MECHANISM FOR CODING AND GAIN CONTROL

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It is well known that neurons display a prominent heterogeneity in their individual properties, even among same-class neurons. Recent experimental and theoretical studies have highlighted the importance of cell-to-cell differences in the dynamics of neural networks, and functional roles of neural heterogeneity in electrosensory [1] and olfactory [2] systems have been recently identified. It is still unclear, however, how heterogeneity can affect neural computations or impact the dynamics of typical neural circuits.

In this talk, I will present recent theoretical and computational work [3,4] on the role of neural heterogeneity on neural computations and dynamics. I will start by focusing on a network of heterogeneous excitatory neurons, and I will show how, in this simple system, heterogeneity is able to (i) affect the mean activity level of the network in a nonlinear way, and (ii) facilitate the appearance of synchronization, contrary to what previous studies suggested. Moreover, these heterogeneity-induced effects provide a way to improve information transmission in the circuit, using either rate coding or temporal coding [3]. When considering the more generic case of sparse excitatory-inhibitory networks, we find that heterogeneity among inhibitory neurons decreases the mean activity level of the network, and it also induces multiplicative gain effects in the f-I curves of the system, providing an effective mechanism to control neural information flow [4]. This suggests that heterogeneity can have strongly differentiated roles, depending on the subpopulation in which it is found.

[1] G. Marsat and L. Maler, J. Neurophysiol. **104**, 2543-2555 (2010).

[2] K. Padmanabhan and N. Urban, Nat. Neurosci. **13**, 1276-1282 (2010).

[3] J. F. Mejias and A. Longtin, Phys. Rev. Lett. **108**, 228102 (2012).

[4] J. F. Mejias and A. Longtin, Front. Comput. Neurosci. **8**, 107 (2014).