Heterogeneity and Convergence of Olfactory First-Order Neurons Account for the High Speed and Sensitivity of Second-Order Neurons

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Résumé en anglais	In the olfactory system of male moths, a specialized subset of neurons detects and processes the main component of the sex pheromone emitted by females. It is composed of several thousand first-order olfactory receptor neurons (ORNs), all expressing the same pheromone receptor, that contact synaptically a few tens of second-order projection neurons (PNs) within a single restricted brain area. The functional simplicity of this system makes it a favorable model for studying the factors that contribute to its exquisite sensitivity and speed. Sensory information—primarily the identity and intensity of the stimulus—is encoded as the firing rate of the action potentials, and possibly as the latency of the neuron response. We found that over all their dynamic range, PNs respond with a shorter latency and a higher firing rate than most ORNs. Modelling showed that the increased sensitivity of PNs can be explained by the ORN-to-PN convergent architecture alone, whereas their faster response also requires cell-to-cell heterogeneity of the ORN population. So, far from being detrimental to signal detection, the ORN heterogeneity is exploited by PNs, and results in two different schemes of population coding based either on the response of a few extreme neurons (latency) or on the average response of many (firing rate). Moreover, ORN-to-PN transformations are linear for latency and nonlinear for firing rate, suggesting that latency could be involved in concentration-invariant coding of the pheromone blend and that sensitivity at low concentrations is achieved at the expense of precise encoding at high concentrations.

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