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Coding in the olfactory system: linking realistic and abstract models

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In general, theoretical models for the function of the olfactory system can be divided into two broad categories. In one, the seemingly diffuse and unstructured pattern of neuronal connections within the olfactory cortex have been interpreted to suggest that it functions like a kind of an autoassociative neural network [4,5,7,6]. An essential feature of autoassociative networks is their randomly structured connectivity and the special importance of the formation of connection weights in the process of its evolution [8,9]. On the other hand, a very different functional structure has recently been proposed based on a detailed biologically realistic network model of the olfactory cortex [11]. This work predicts that the olfactory cortex actually has a highly structured connectivity consisting of distinct different although highly spatially overlapping subnetworks, which are only sparsely connected to each other [11].

In a new collaboration (O'Connor and Steuber,University of Hertfordshire; Bower, University of Texas Health Science Center San Antonio; Metzner, University of Lübeck), we focus on linking models of the olfactory cortex [11] and the olfactory bulb [10] in order to test both the associative and subnetwork theories of olfactory coding.

In this presentation we will focus on a more abstract model, derived from the realistic model in order to apply information theoretic techniques to determine the coding potential of both forms of information representation. This new abstract fused model will follow along the lines of a previous effort to construct a more abstract representation of the original Wilson olfactory cortical model by Crook et al. [3,2,1]. In this approach interaction functions for a coupled oscillator model are derived from a biophysically detailed model accurately reflecting the properties of this model. The fact that the interaction functions are tightly linked to the experimentally grounded biophysical model, rather than chosen arbitrarily, enables this approach to make accurate predictions about the dynamical behaviour of the whole system and to apply new methods of mathematical and information theoretical analysis to more quantitatively compare the two different theories of olfactory cortical structure and function.

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