CODING OF ODOUR QUALITY IN OLFACTORY RECEPTOR NEURONS

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ABSTRACT

Olfactory stimuli are complex chemical signals whose composition varies quantitatively and qualitatively in space and time. Olfactory receptor neurones (ORNs) can monitor these variations and convey raw data to the brain from which biologically meaningful information can be extracted. The primary purpose of this work is to investigate quantitatively how the qualitative properties of odours are encoded in the spike trains delivered by ORNs. To this end, we studied the responses of ORNs in the frog olfactory epithelium to four volatile compounds, anisole, camphor, isoamyl acetate and limonene, which are strongly and distinctively odorous for humans.

Because the quality of an odour stimulus cannot be studied independently from its temporal and intensitive aspects (the latter measured by odorant concentration in the air), all four odorants were applied as square pulses of 2-s duration at increasing concentrations [4]. So, only the time variable was kept identical through all experiments. The neural activity was recorded one neurone at a time with extracellular electrodes from an intact epithelium in order to minimize the modifications due to experimental conditions [3]. The spike train yielded by each stimulation was characterized by its latency, length (number of spikes), duration and median frequency.

The main conclusions drawn from these data regarding quality coding can be summarized as follows:

1. No neurone is sensitive to a single odorant. This means that odorant quality is coded by the whole neuronal population, not specialized ORNs different for each odour.

2. All four variables characterizing spike trains (latency etc.) depend on the odorant and its concentration. This means that coding of odorant quality is coded by all variables, so that, in practice, the four series of concentration vs. variable plots must be taken into account.

3. Latency can be described by a single function of the logarithm of concentration (a decreasing exponential). The same is true for duration, length (alpha function) and frequency (Hill function). For each plot the parameters of the function giving the best fit to the experimental data were determined.

4. The parameters of the concentration-response curves describe the position of the concentration-response curves along the concentration axis and their shape. These features can be quantified by their thresholds, width (dynamic range) and height (maximum), respectively. It follows that the qualitative information about odorants is entirely borne by these quantities.

5. Both position and shape characteristics depend on the odorant but in a different way. Position parameters of camphor are systematically lower than those of the other odorants. No such systematic trend can be found for shape parameters, although limonene tends to have extreme heights and widths, different from those of the other odorants.

6. In general, the thresholds, widths and heights of concentration-response curves are independent. Thus, they can appear in any combination. It follows that no global classification system of curves can be defined, neither based on odorants, nor on neurone types. For a given odorant, knowing, for example, that a neurone has a narrow dynamic range of frequency tells us nothing on the maximum response duration. Moreover, the curves of a given neurone for different odorants are as dissimilar as those in different neurones. This means that there is no evidence for different neuronal types.

7. Some of the response characteristics involved in quality coding can be interpreted in terms of molecular events (deactivation of odorant molecules, odorant-receptor interaction, transduction cascade) using a chemo-electrical model of the ORN and its environment [1,2].

Keywords: Quality coding; intensity coding; Dose response curves; Transduction

References

[1] Rospars, J.P., Lánsk_, P., Tuckwell, H.C. & Vermeulen, A. (1996) Coding of odor intensity in a steady-state deterministic model of an olfactory receptor cell neuron. *Journal of Computational Neuroscience*, **3**: 51-72.

[2] Rospars, J.P., Krivan, V. & Lansky, P. (2000a) Perireceptor and receptor events in olfaction. Comparison of concentration and flux detectors: a modeling study. *Chemical Senses*, **25**: 293-311.

[3] Rospars, J.P., Lánsk_, P., Duchamp-Viret, P. & Duchamp, A. (2000b) Spiking frequency vs. odorant concentration in olfactory receptor neurons. *BioSystems*, **58**: 133-141.

[4] Vigouroux, M., Viret, P. & Duchamp, A. (1988) A wide concentration range olfactometer for delivery of short reproducible odor pulses. *Journal of Neuroscience Methods*, **24**: 57-63.