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Learning olfactory codes using matrix factorization on 2DG uptake patterns from rats

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Recent studies based on both the analysis of odor descriptors [1] and psychophysical studies [2] have suggested that olfactory perception is mainly dominated by odor pleasantness. In contrast, findings on the sensory side [3] as well as on the perceptual side [4] indicate an odor perception space that is spanned by about 30 dimensions. On the way to understand the basic principles in the decoding of olfactory information from the single molecular compounds, we are focusing in this study on the first level of information processing in the sense of smell: The olfactory bulb (OB). We know that the olfactory epithelium is separated into four regions [5] of olfactory receptor protein expression and we expect a similar organization in the olfactory bulb [6]. With 2-DG-uptake-images, Johnson et al. [7] measured odorant-specific activity patterns, covering 98% of the bulbar surface with a resolution of one glomerulus per pixel. Using a database of 143 such bulbar activity fingerprints, we propose the so called non-negative matrix factorization [8] to decompose the data into a set of common features. These features can be best described as the coding alphabet while the uptake images of single molecular compounds resemble natural occurring code words. Interestingly, we can achieve three meaningful alphabets with a different size: 4, 6, and 9 digits. Only the last one is suitable for actually coding the compounds, as a single compound is evoking activity of only about 1/8 of the bulbar surface, with an average code word length of two to three digits. The other two decompositions might reflect the superglomerular organization of the receptor neurons in the bulb, like e.g. the above mentioned expression patterns and neuronal subnetworks that directly result from the targeting mechanisms guiding the neurons from the OE to the OB. We argue that the proposed decompositions are not only reflecting the chemotopic organization of the bulbus but rather giving a first hint on the coding scheme underlying olfactory perception.

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