Measuring perceived odor quality

L. Zheng
Institute of Environmental Medicine, Karolinska Institute & Department of Psychology, Stockholm University. SE106 91 Stockholm, Sweden, lzg@psychology.su.se

All we know, is that we can discriminate a large numbers of odors, but mechanism to try to describe odor quality is complicated. The perception of odor quality is a homogeneous perception, according to the definition of odor quality, it is "a characteristic of an odor", which we lack a specific language for odor quality. Many studies have been conducted to try to measure the difference between odors. The most efficient way is measure the similarity or dissimilarity between odors. Hedonic factor plays an important role in odor classification and in individual differences found in odor quality studies. Multidimensional scaling has been proved as the most useful method to define odor quality space.

The psychological study of odor quality has been gone through different "trying" steps, the following are some most applied approaches, which were used for measuring the perceived odor quality: (1) *Classification* – group odors by qualitative resemblance [8]. Categorization can be hierarchical which expressed by scheme of odor "primaries"[1]. (2) *Sorting* – sort odors by qualitative resemblance. Subjects sort odors into different numbers of group according to their similarity [11, 12, 15]. (3) *Profiling* – match odor with related word/fixed descriptors [5, 6,13] or with reference odorants [18, 19]. A list of words describing "odor quality" to be attributed to the odor of the inhaled odorants. The attributions are either "objects" and/or "characteristics". (4) *Direct comparison* – judge odors (reference odors and target odors) directly by using free or range of numerical rating of similarity for all pair-wise odors combination [2, 4, 14, 17].

Various statistical measures can be derived from the direct comparison odor/profile data, which were then presented on an odor classification space, each odor represent a point, similar odor stick together form a cluster, the distances (Euclidian distance) between odor points related to the sensory differences between the odors. These measures usually based on two modeling: one is content model, which use principal component analysis (PCA) of similarity and with a vector solution; another one is distance model, multidimensional scaling (MDS) or INDSCAL analysis of 2 way or 3 way [10] data matrices dissimilarity for odor-odor, odor-profile, profile-profile. For sorting data (odorants in groups), the frequencies of the paring of odorants summed over all subjects, those pairings that occur most frequently are considered to have the most similar odors, and least frequency have the least similar odors. This can be used as input for cluster analysis, which can support the MDS solution [11]. The modeling of perceptual structure by the method of multidimensional scaling (MDS) is becoming highly developed and widespread, many applications [2, 4, 7, 11, 14, 15, 17, 18] have been reported Multidimensional scaling (MDS) of similarity judgments provides an ideal method to generate a nonverbal representation of odor quality

The other type of sensory process, which involved in person's perceived odor qualities are: (1) *Odor mixtures*. Independent of type of mixture percept, the mixture quality frequently seems to be intermediate to the quality of its component odors when presented separately [3, 13]. (2) *Adaptation & cross-adaptation*. Repeated exposure will decrease person's ability to discern the differences in odor quality [3]. (3) *Odor intensity*. Concentration changes may also be perceived as odor quality difference [9, 15]. Psychophysical functions, self-adaptation functions, across-adaptation functions and mixture models can measure these effects. The constant of functions used as indicators of "similarity" in odor quality.

Differences in culture, context, social conventions and semantics are known to influence the labeling of odor qualities [15]. Researches on roles of learning in odor perception and on cross-culture differences in odor perception support the same conclusion that experience effects the perceived quality of an odor as well as how much it is like [16].

We use iterative changeover between a top down (perception to molecule) and bottom up approach (molecule to perception) approach to define an odor space. The top down approach is used for determining human ability to differentiate odor quality among single odorous substances, mixtures and complex air mixtures (the question is why are they all different perceived qualities?). The bottom up approach used for selecting reference odor substance (type of molecules or well-controlled mixtures), which together cover the potential odor space. Using this process, we can build up an odor space, which give hierarchical ordinal information on dendrogram, reference odors will define subspaces for repeated testing of new samples of target odorants. Odor space represents an n-dimensional metric space of odor quality.

References

1. Amoore, J.E. (1964). Current status of the steric theory of odor. Ann. NY Acad. Sci., **116**, 457-476.
2. Berglund, B., Berglund, U., Engen, T., & Ekman, G. (1973). Multidimensional analysis of twenty-one odors. *Scand J. Psychol*.,**14**, 131-137.
3. Berglund, B. (1974). Quantitative and qualitative analysis of industrial odors with human observers. Ann. NY Acad. Sci., **237**, 35-51.
4. Davis, R. G. (1979). Olfactory perceptual space models compared by quantitative methods. *Chemical Senses and Flavour*, **4(1)**, 21-33.
5. Dravnieks, A. (1982). Odor quality: semantically generated multidimensional profiles are stable. *Science*, 218, 799-801.
6. Dravnieks, A., Bock, F. C., Powers, J. J., Tibbetts, M., & Ford, M. (1978). Comparison of odors directly and through profiling. *Chemical Senses and Flavour*, **3(2)**, 191-225.
7. Gregson, R. A. M., & Mitchell, M. J. (1974). Odor quality similarity scaling and odor word profile matching. *Chemical Senses and Flavor*, **1**, 95-101.
8. Harper, R., Bate Smith, E.C. & Land, D.G. (1968). *Odour Description and Odour Classification*. American Elsevier, New York.
9. Gross-Isseroff, R., & Lancet, D. (1988). Concentration-dependent changes of perceived odor qulity. *Chem.Senses*, **13**, 191-204.
10. Kruskal, J.B. (1964). Nonmetric multidimensional scaling. A numerical method. *Psychometrika*, **29**, 1-27, 115-129.
11. Lawless, H. T. (1989). Exploration of fragrance categories and ambiguous odors using multidimensional scaling and cluster analysis. *Chemical Senses*, **14(3)**, 349 -360.
12. MacRae, A. W., Rawcliffe, T., Howgate, P., & Geelhoed, E. N. (1992). Patterns of odour similarity among carbonyls and their mixture. *Chemical Senses*, **17(2),** 119 -125.
13. Moskowitz, H.R., & Barbe, C.D. (1977). Profiling of odors components and their mixtures. *Sens.Process*., **1**, 212-226.

14. Moskowitz, H. R., & Gerbers, C. L. (1974). Part I. Functional properties of the olfactory system: psychophysics: dimensional salience of odors. *Ann N Y Acad. Sci*., 237, 1-16.
15. Stevens, D. A., & O'Connell, R. J. (1996). Semantic-free scaling of odor quality. *Physiology & Behavior*, 60, 211-215.
16. Stevenson, R. J., & Boakes, R. A. (2003). A mnemonic theory of odor perception. Psychological *Review*, 110, 340-364.
17. Woskow, M.H. (1968). Multidimensional scaling of odors. In Tanyolac, N. (ed.), *Theories of Odor and Odor Measurement*. Robert College, Istanbul, pp. 147-191.
18. Wright, R.H., & Michels, K.M. (1964). Evaluation of infrared relations to odor by a standards similarity method. *Ann. NY Acad. Sci*., 116, 535-551.
19. Yoshida, M. (1975). Psychometric classification of odors. *Chem. Senses Flav*., 1, 443-464.