Basis Odor Model for Perceived Odor Intensity and Air Quality Assessments

Jana Panaskova, Frank Bitter and Dirk Müller

Technical University of Berlin, Germany

Corresponding email: jana.panaskova@tu-berlin.de

SUMMARY

This paper shows first results of an ongoing research project, which aims to develop a transfer model to link the odor intensity with the perceived air quality assessments. This model is based on basis odors, which were in this research project selected according to the primary odors defined by Amoore. Each basis odor measurement of the perceived intensity and air quality establish a transfer function between the intensity and the acceptability values. The basis odor samples are generated by using the saturation method and a dilution process with clean air. The experiments include the examination of single basis odors as well as mixtures of basis odors. Additionally, the influence of the relative humidity of the air on the perceived intensity and acceptability is part of the investigations. First results of the experiments show different correlations between perceived intensity and acceptability for all basis odors.

INTRODUCTION

A well known method developed by Fanger determines the perceived air quality with a sensory panel judging the acceptability of the air quality [1]. A category scale is used for the assessments with no absolute reference. Inherent to the acceptability assessments is a high standard deviation between the individual assessments of the panelists and therefore a large panel of subjects is required for statistically significant results. Bluyssen applied a group of trained panel members for air quality assessments using a comparative scale [2]. The training and the comparison with a reference reduces the standard deviation and a smaller panel size can be used.

Up to now it is very difficult to compare the results of both assessment methods. The influence of the thermal state of the air on the assessments is different for the acceptability method and for the method using a comparative scale. Studies [3, 4] show that the acceptability of air is decreased with increasing specific enthalpy. Results from a panel using a comparative scale indicate that the specific enthalpy is not important as long as the relative humidity stays constant. This discrepancy reveals that both methods appear to detect different measures of the odor perception. The use of a comparative scale forces all panel members to concentrate on the perceived intensity. Thus, a comparative scale cannot be used to measure the perceived air quality in terms of the acceptability and may be used for perceived intensity assessments only.

Subjects who are asked for the acceptability of the air quality do not differentiate between the hedonic tone and the intensity level of the odor impression and assess a combined impression instead. On the one hand, the perceived air quality in terms of the acceptability is an appropriate measure concerning the comfort in indoor environment, but on the other hand the perceived intensity judgments are more reliable because of the common reference of the

comparative scale. A transfer model which relates the intensity to the acceptability assessments enable to use the smaller panel size and the more precise intensity assessments to evaluate the perceived air quality.

In this study the correlation between acceptability and perceived intensity assessments for defined basis odors is investigated. The basis odor transfer model should close the gap between intensity and acceptability measures. The dependence of the hedonic impression on perceived intensity and acceptability can be extracted from the measured data which gives more insight in the structure of the interrelationship. Seven odors, which are defined as primary odors in the stereochemical theory of Amoore [5], are used for the investigations on the transfer model. Each odor is characterized by reference substances some of which were substituted by other substances with similar odor characteristics due to safety reasons. Later on, the investigation of the influence of the relative humidity on this relationship will be part of the research project as well as the investigation of the combinations of the basis odors which shed light into the interaction of the transfer functions of the basis odors.

SENSORY ASSESSMENTS

Samples of the basis odors are presented in the air quality laboratory of the Hermann-Rietschel-Institute. The laboratory is constructed mainly of glass and stainless steel and ventilated with a high air change rate which provides an odorless measurement environment.

The subjects for the assessments of the acceptability (assessments without the use of the comparative scale) are selected without any specific criteria except the absence of any respiratory diseases or known anosmia. The panel consists of 30-40 persons, mainly students. 45% of the subjects are women and 77% declared themselves as no smokers. The mean age of the panelists is 24. The subjects are asked for the acceptability using a scale divided into 20 steps ranging from -10 (clearly not acceptable) up to 10 (clearly acceptable) [1] and for the hedonic impression a scale from -4 (extremely unpleasant) to +4 (extremely pleasant) [6].

The panel using the comparative scale consists of 9-12 persons and is selected from subjects passing the training test. This test evaluates the capability to compare the odor intensities of the unknown samples with the comparative scale. In addition to the determination of the perceived intensity of the air samples the subjects are also asked to judge the hedonic impression using the same scale as the other sensory panel. At the Hermann-Rietschel-Institute acetone is used as a reference substance for the comparative scale. The perceived intensity is assessed in the unit pi, which was introduced by Müller [7]. Currently, the scale is constructed linearly in respect to the acetone concentration and an intensity step of one pi corresponds to a concentration step of 20 mg/m³. At an acetone concentration of 20 mg/m³ which is approximately the odor threshold the perceived intensity is defined to be zero. An odor perceived intensity value above zero should be detectable for most of the panel members.

For every air sample the arithmetic mean of the acceptability, the perceived intensity and the hedonic impression of both groups are calculated. The first set of experiments use seven reference substances, listed in Table 1. The reproducible and constant air samples are generated by newly developed dosing equipment (see Figure1) operating with a saturation method. Synthetic air is enriched with the substance in a wash bottle at room temperature. The air is cooled down to a defined temperature to reach a saturated substance-air mixture with constant concentration according to the vapor pressure. The saturated air is dosed in an air flow of clean air and is presented to the sensory panel through glass cone. The presented

concentrations of reference substances in air are selected considering safety rules and health considerations. The stability of the odor samples has a major impact on the quality of the results of the investigations since the assessments have to be done rather in sequence over a longer period than it can be done parallel. The developed dosing equipment fulfills this requirement adequately.

Table 1. Reference Substances

Odor classification	**Chemical substance**
Camphoraceous	Eucalyptol
Musky	15-pentadecenolide
Floral	Geraniol
Pepperminty	(-)-menthone
Ethereal	Diethyl ether
Pungent	Acetic acid
Putrid / fishy	Pyridine

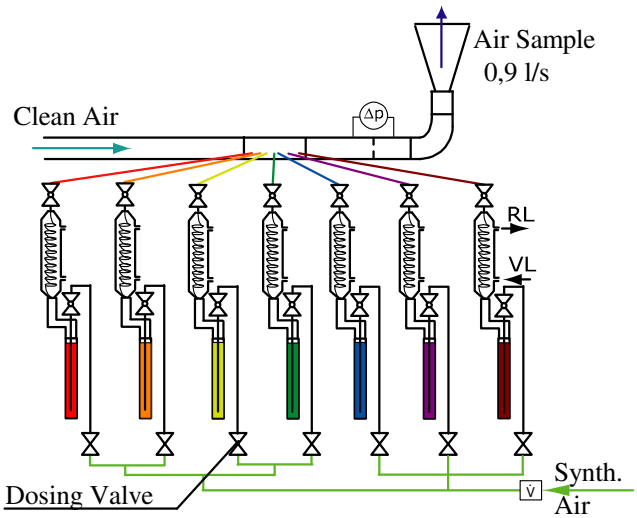

Figure 1. Schema of the dosing equipment

During the first set of experiments the relative humidity is 45% (± 5%) and the temperature of the air is 21.5 °C (± 1°C). The second set of experiments will be focused on the combination effects of different basis odors and the influence of temperature and relative humidity. The influence of the relative humidity will be determined for only three of the basis odors and for the relative humidity of 30% and 70%.

RESULTS

Comparison of acceptability and perceived intensity

Figure 2 shows the interrelationship of the assessments of the acceptability and the perceived intensity for the first set of experiments using the basis odors. The figure indicates that the acceptability values are generally decreased by increasing the perceived intensity. But the transfer functions are not completed yet. More measurements have to be done to cover a wider range of the odor intensity. By now it can be seen, that the seven odors can be separated in two groups, one of acceptable odors in the positive acceptability range and another one of unacceptable odors in the negative acceptability range.

Peppermint, floral and musky odors are almost for all considered concentration levels in the acceptable area. The gradients of floral and peppermint odor are very similar. The camphoraceous odor seems to change over from positive to negative acceptability values at higher intensity values. Ethereal, pungent and putrid odors do not show any positive values on the acceptability scale and are not accepted even for low odor intensities.

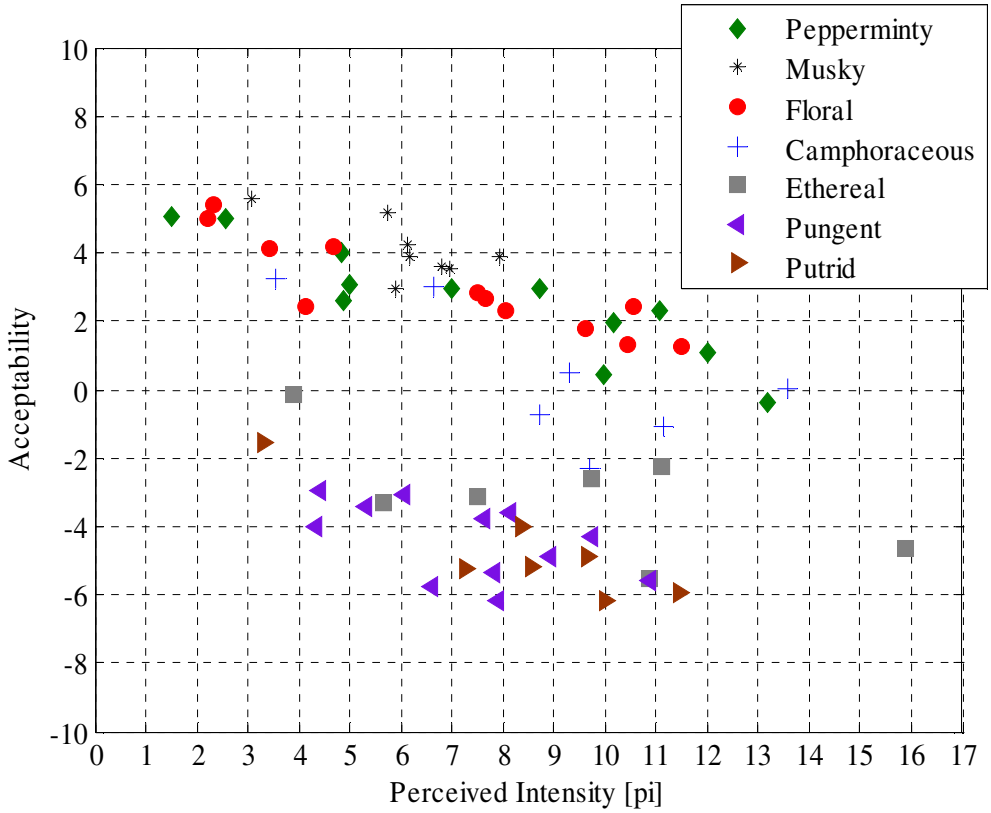

Figure 2. Relationship between the perceived intensity and the acceptability of basis odors

The hedonic impression

The hedonic tone is assessed by both the panel using the comparative scale and the panel judging the acceptability. Thus the relationship of the hedonic tone to the intensity as well to the acceptability can be derived from the measured experimental data. The experiments indicate that the hedonic tone is not or only weakly depending on the perceived intensity (see Figure 3). Using a comparative scale leads to perceived intensity assessments.

The acceptability on the other hand depends mainly on the hedonic impression. With decreasing acceptability the hedonic impression decreases linearly (see Figure 4). This correlation seems to be independent from the kind of odor. The measurement points are grouped in the more acceptable positive odors in the upper right quadrant and the not acceptable negative odors in the bottom left quadrant of the diagram.

The assessments of the acceptability and the intensity are done by two different sensory groups. The comparison of the results of the intensity and the acceptability assessments require that both panels represent a similar sample of society and have a similar perception of odors. The hedonic impression is therefore assessed by both groups. This enables to evaluate the differences in the odor perception. Figure 5 shows the assessments of the hedonic impression of the seven basis odors for the panel using a comparative scale in relation to the hedonic impression assessed by the panel for acceptability judgments. The voting of the hedonic impressions shows only a small deviation from the one-to-one linear correlation. The assessments of the panel using the comparative scale tend to be less positive for the pleasant odors. The sizes of the panels are not identical and hence the uncertainties and the standard deviation of the hedonic assessments are equal for both groups the data for the larger group should be considered more accurate.

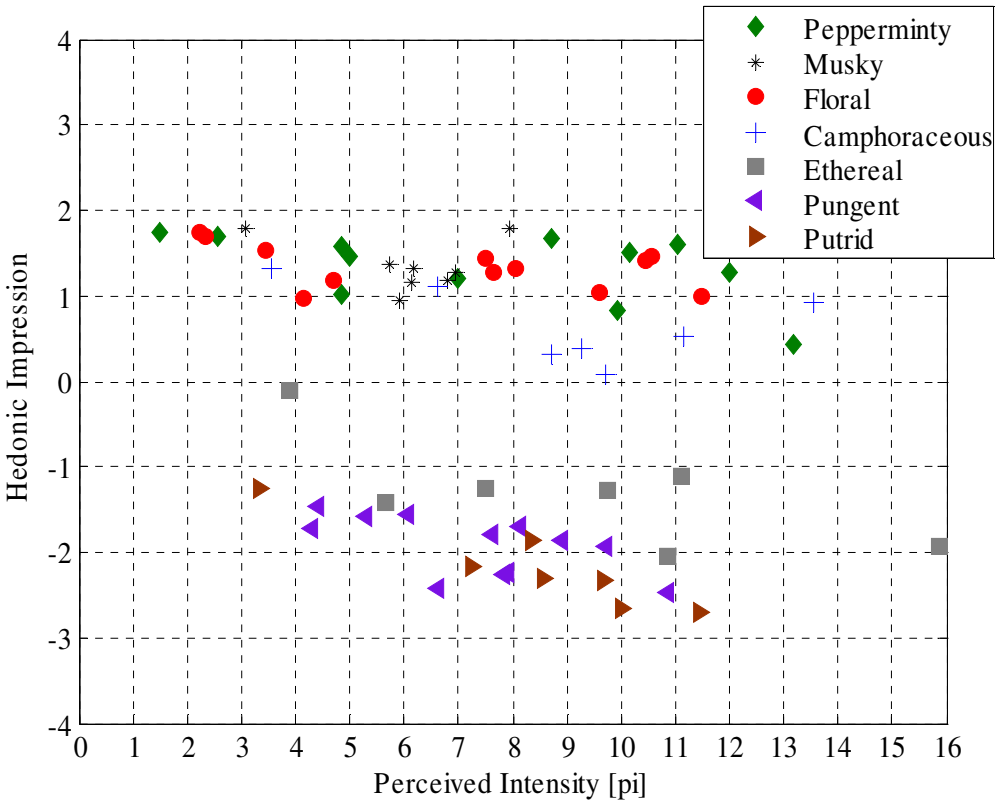

Figure 3. Comparison of the hedonic impression and perceived intensity

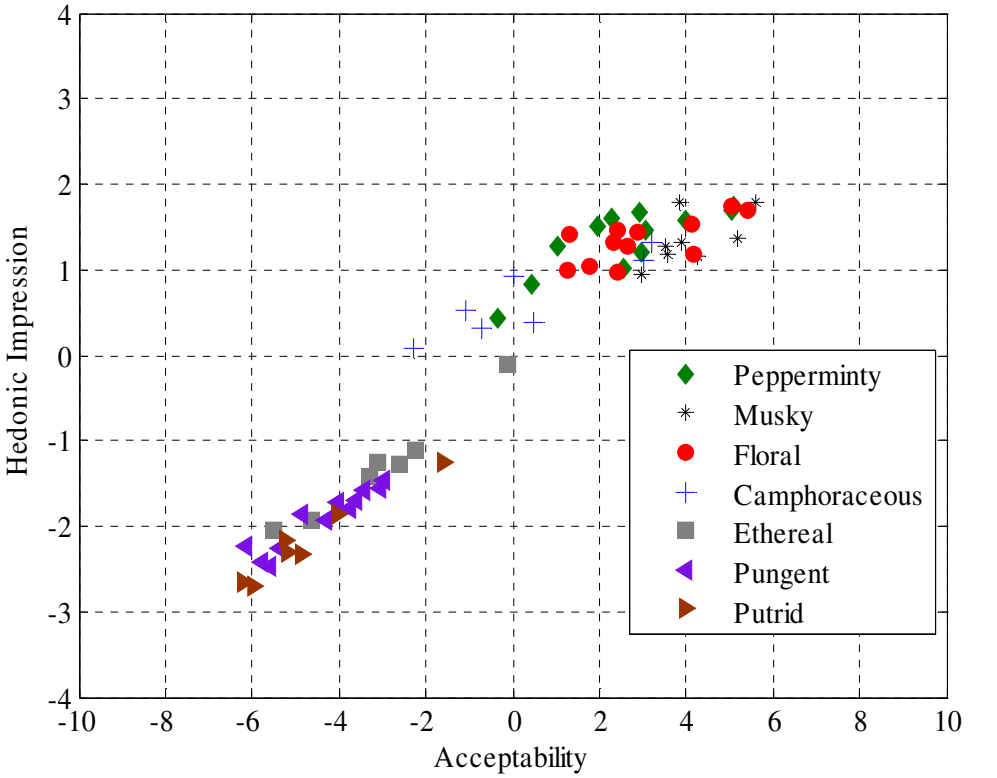

Figure 4. Comparison of the hedonic impression and acceptability

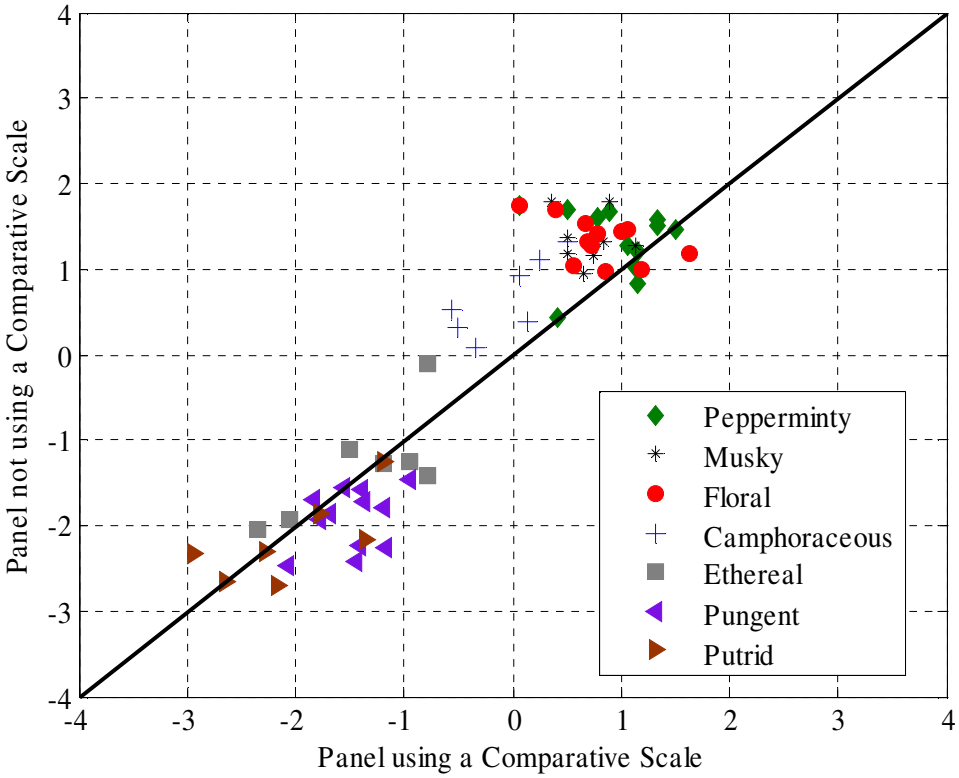

Figure 5. Comparison of the hedonic impression of the two different panels

DISCUSSION

The experiments clearly show that the acceptability votes of a panel which uses no comparative scale is a combined impression of the perceived intensity and the hedonic tone. The intensity assessed by a panel using the comparative scale assesses the perceived intensity almost not influenced by the hedonic tone and thus without a mental valuing process of the perceived odors. The acceptability votes mainly decrease when the ratings of the intensity are increasing. The assessments can be grouped in the pleasant, acceptable odors and the unpleasant, not acceptable odors. This, however, indicates that there exists no universal transfer function between the acceptability and intensity votes. It always depends on the pleasantness of the odors. A combination of assessments of the intensity and the hedonic tone to estimate the acceptability is a promising approach.

So far, the investigation has been done at constant relative humidity and temperature. As mentioned before, the relative humidity has an influence on the perception of the intensity whereas the specific enthalpy is influencing the acceptability of the odors. In the course of this project the influence of the relative humidity on the acceptability-intensity relationship will be investigated. Combination of basis odors, which will also be measured later on, will give insight in the perception of mixtures especially when combining a pleasant with an unpleasant odor.

ACKNOWLEDGEMENT

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