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# Olfactory Sensitivity of Subjects Working in Odorous Environments

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## Abstract

The aim of the present study was to investigate whether people with a professional interest in odors also exhibit higher olfactory sensitivity. To this end, we investigated 58 subjects (age  $33.6 \pm 11.0$  years, mean  $\pm$  SD; 55 women) employed in perfume retail outlets and compared their olfactory sensitivity to 58 controls (age  $34.6 \pm 9.9$  years; 53 women) matched for age, gender and professional activities who did not work in such odorous environments. Olfactory function was assessed using the 'Sniffin' Sticks' test kit which includes tests for *n*-butanol odor threshold, odor discrimination and odor identification. Subjects working in perfume retail outlets scored higher in odor discrimination tests compared to controls. Working in an odorous environment for a full day had no major effect on general olfactory abilities, as indicated by measures performed at the beginning and end of a working day. Taken together, results from the present study do not support the idea that odorous environments are deleterious to general olfactory function.

**Key words:** environment, learning, training, smell

## Introduction

Odors are an important part of our environment. However, in a modern society some places are more odorous than others, e.g. perfumeries or drug stores. In this context, it is unclear whether and if so, how such odorous environments impact on the olfactory sensitivity of individuals who choose to work in these environments. To our knowledge, there is only one publication by Snyder *et al.* (2003) in farm workers indicating that the long-lasting exposure to manure odor had no significant impact on general olfactory function. Thus, the aim of the present study was to investigate whether people exposed to relatively high concentrations of environmental odors would exhibit a different olfactory sensitivity compared to subjects without such exposure to odors. To this end, we compared the olfactory function of people employed in perfume retail outlets (PERF subjects) with that of controls matched for age and gender who worked in a less odorous environment. In order to get an idea about the potential impact of the duration of this exposure, measures of olfactory function in PERF subjects were taken in the morning and in the evening of a full working day.

## Materials and methods

The study was performed according to the Declaration of Helsinki (Summerset West amendment) on guidelines for

biomedical research involving human subjects. All subjects provided written consent after they were thoroughly acquainted with all details of the investigation. All testing was performed in well ventilated rooms.

## Participants

We investigated 58 subjects (age  $33.6 \pm 11.0$  years, mean  $\pm$  SD; 55 women) employed in perfume retail outlets (PERF subjects; duration of employment 1–43 years, mean  $11.0 \pm 1.3$  years) and compared their olfactory sensitivity to 58 controls matched for age and gender (age  $34.6 \pm 9.9$  years; 53 women). These groups were not significantly different in terms of age [ $t(114) = 0.64$ ,  $P = 0.52$ ]. All PERF subjects actually handled fragrance materials during their working hours.

## Study design

PERF subjects were tested in the morning and in the evening after a full day of work (generally an 8 h working day). Measures performed in the morning or evening were randomized across subjects. Controls were investigated only once. Subjects were instructed to refrain from smoking, drinking anything but water and eating at least 30 min before the experiment. Although workers in general did not

leave the building before commencement of the measurements in the evening in order to get some fresh air, this was not specifically monitored. Exclusion criteria were employment for <1 year, severe diseases, e.g. endocrinological diseases and epilepsy, drug and nicotine abuse (>10 cigarettes per day), current cold, active nasal allergy and known olfactory or gustatory dysfunction. Prior to examination of olfactory sensitivity subjects were asked to fill in a questionnaire with questions related to general olfactory abilities.

### Olfactory testing

For assessment of general olfactory function pen-like odor dispensing devices ('Sniffin' Sticks') were employed (Hummel *et al.*, 1997; Kobal *et al.*, 2000). This kit is comprised of three tests of olfactory function, namely tests for *n*-butanol odor threshold, odor discrimination and odor identification. For odor identification, 16 odorants were presented to each of the subjects who were free to sample the odors as often as necessary in order to identify the odors from a list of four descriptors. The experimenter presented odor pens separated by an interval of at least 30 s to prevent olfactory desensitization (Köster and de Wijk, 1991; Hummel *et al.*, 1996). Odor discrimination was performed using 16 triplets of odorants. Subjects were presented with three odorants; their task was to identify the sample that smelled differently. Subjects were blindfolded to prevent visual detection of the target odor pens. They were allowed to sample each odor only once. Presentation of odor triplets was separated by at least 30 s. The interval between presentation of individual odor pens was ~3 s. Odor threshold was determined using *n*-butanol as the odorant (Cain, 1989); dilutions were presented in a geometric series (Hummel *et al.*, 1997). Presentation of the odorants was similar to that described above for the discrimination task. Again, subjects were blindfolded to prevent visual identification of the odor-containing pens. Three pens were presented to each subject in a randomized order, one contained the odorant at a certain dilution, the other two solvent only. The subject's task was to find out which of the three pens smelled differently. Presentation of triplets occurred every 20 s, until subjects had correctly discerned the odorant in two successive trials which triggered a reversal of the staircase. From a total of seven reversals the mean of the last four staircase reversal points was used as threshold estimate (Ehrenstein and Ehrenstein, 1999). While these tools have been developed mainly for clinical purposes (e.g. Welge-Luessen *et al.*, 2000; Hummel *et al.*, 2002), they also seem to be useful for the assessment of subtle differences in the olfactory sensitivity of healthy subjects (e.g. Hummel *et al.*, 2003).

### Statistical analyses

Data were investigated using SPSS 11.5 for Windows®. Differences between PERF subjects and controls were analyzed using ANOVAs [analyses of variance; general linear model, repeated measures design; 'test' (threshold,

discrimination, identification) as within-subject factor, 'group' (PERF, controls) as between-subject factor]. In case main effects of the factor 'group' or its interaction with the factor 'test' were significant, *post hoc* comparisons between groups were performed using *t*-tests. In addition, *t*-tests were employed for investigations of differences in olfactory function in relation to the time of day. Finally, correlational analyses were performed using Pearson statistics. Degrees of freedom are indicated in parentheses following the *F*- or *t*-values. The alpha level was 0.05.

### Results

Descriptive statistics of the tests of olfactory function are presented in Table 1 separately for the two groups investigated.

Comparisons between general olfactory function of PERF subjects and controls revealed a significant interaction between factors 'test' and 'group' [ $F(1,228) = 3.89$ ,  $P = 0.022$ ]. Further, there was a tendency for groups to differ significantly [ $F(1,114) = 3.75$ ,  $P = 0.055$ ]. *Post hoc* tests revealed that the difference between groups was present for odor discrimination [ $t(114) = 3.54$ ,  $P = 0.001$ ], but not for odor identification or odor thresholds [ $t(114) < 0.24$ ,  $P > 0.81$ ].

With regard to measures in PERF subjects obtained in the morning or evening no significant differences were observed [ $t(57) < 0.89$ ,  $P > 0.37$ ], indicating that the odorous environment had no major influence on general olfactory abilities. In addition, as indicated by partial correlations controlling for age, in PERF subjects there was no significant correlation between the number of years of work at perfume retail outlets and general olfactory function [ $r(55) < 0.21$ ,  $P > 0.13$ ].

**Table 1** Descriptive statistics of measures of olfactory function in subjects working in perfume retail outlets ( $n = 58$ ) and controls ( $n = 58$ )

	Subjects working in perfume retail outlets ( $n = 58$ )		Controls ( $n = 58$ )	
	Mean	SEM	Mean	SEM
Odor identification <sup>a</sup>	13.6	0.2	13.6	0.2
Odor discrimination <sup>a</sup>	13.3	0.2	12.4	0.2
Odor threshold <sup>a</sup>	10.2	0.2	10.1	0.2
Odor discrimination, morning <sup>b</sup>	13.4	0.2	–	–
Odor threshold, morning <sup>b</sup>	10.0	0.2	–	–
Odor discrimination, evening <sup>c</sup>	13.3	0.2	–	–
Odor threshold, evening <sup>c</sup>	10.3	0.2	–	–

<sup>a</sup>Measures which were performed in all subjects; <sup>b,c</sup>measures which were only performed in subjects working in perfume retail outlets, either in the morning or in the evening, respectively, of a day of, usually, 8 h of work.

## Discussion

The present investigation provided the following two major results. (i) Subjects working in perfume retail outlets were significantly better in odor discrimination compared with subjects not working in such odorous environments. (ii) Working in an odorous environment for 1 day had no major effect on general olfactory abilities.

Previous research indicated that environmental exposure to odors may specifically decrease sensitivity to the odors to which the subjects was exposed (Berglund *et al.*, 1992; Mergler and Beauvais, 1992; Hummel *et al.*, 1999) which may lead to the hypothesis that environmental exposure to odors may produce a decrease of olfactory sensitivity (cf. Barber, 1997). In contrast to such beliefs, the present data indicated that working in an odorous environment had no major effects on general olfactory function. The present results suggested that subjects working in perfume retail outlets were even better than controls in terms of supra-threshold odor discrimination. One explanation for this finding might be that PERF subjects already had a higher olfactory sensitivity than controls before they started to work in perfume retail outlets. It appears comprehensible that individuals with higher olfactory sensitivity would also develop a stronger interest in professions involving certain olfactory abilities (cf. auditory abilities of musicians; Johnson *et al.*, 1986; Magne *et al.*, 2003; Munte *et al.*, 2003). Accordingly, people working in other olfactory challenging environments (e.g. wineries) might also be expected to show a higher olfactory sensitivity (Wysocki and Beauchamp, 1988). What may, however, argue against this explanation is the fact that PERF subjects and controls did not differ in odor thresholds. This assumption is based on the idea that odor thresholds relate more strongly to peripheral olfactory function (Jones-Gotman and Zatorre, 1988; Hornung *et al.*, 1998) and that odor discrimination and odor identification rather reflect higher order olfactory functions (e.g. Zatorre and Jones-Gotman, 1991; Hummel *et al.*, 1998; Frasnelli *et al.*, 2002). Accordingly, if peripheral olfactory function was better in PERF subjects, it could have been expected that PERF subjects had lower olfactory thresholds than controls.

An alternative explanation of the increased odor discrimination abilities of PERF subjects may relate to effects of repeated exposure to odors on general olfactory function. Numerous studies indicated that training with odors results in increased olfactory function. This has been shown for thresholds towards a number of different odorants (Engen and Bosack, 1969; Wysocki *et al.*, 1989; Cain and Gent, 1991; Möller *et al.*, 1999; Dalton *et al.*, 2002; Wang *et al.*, 2004). On a suprathreshold level effects of training with odors have been demonstrated for odor discrimination (Rabin, 1988). The basis for such training effects may relate to changes at the level of the olfactory epithelium (Hudson and Distel, 1998; Wang *et al.*, 2004) or the olfactory bulb (Durand *et al.*, 1998; Doty *et al.*, 1999), or at even higher levels of processing (Livermore and Laing, 1996; Faber *et*

*al.*, 1999). However, recent data also indicate that repeated exposure to odors does not necessarily result in increased olfactory function (Buonviso and Chaput, 2000; Livermore and Hummel, 2004).

Comparisons between olfactory measures taken in PERF subjects in the morning and in the evening of a full working day did not yield significant differences. This indicates that working in the odorous environment of a perfume retail outlet had no major acute effect on general olfactory abilities. The findings are consistent with results from studies in young, healthy subjects indicating that olfactory abilities do not change in a systematic fashion during a day (Lotsch *et al.*, 1997) and that circadian rhythms play a minor role in nasal chemosensitivity (cf. Doty and Frye, 1991; Koelega, 1994). An alternative explanation of this negative finding might relate to the fact that only subjects were investigated who had already worked in these environments for a year. It might be, that changes had taken place that were relatively stable after this year and longer than one or two nights away from the working environment would be needed to recover. Future studies should focus on possible effects of time-dependent sensitization over a period of months or years of working in these odorous environments; they should also include a measure of nasal congestion, e.g. acoustic rhinometry.

Taken together, results from the present study do not support the idea that odorous environments are deleterious to general olfactory function. In fact, the data may be interpreted such that exposure to odors produces an increase in abilities to discriminate odors. However, other interpretations may relate to the idea that subjects with relatively high olfactory sensitivity would be drawn more to professions involving certain olfactory abilities.

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