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Approach to characterize a sub-group susceptible to odour annoyance

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Exposure to environmental odours can induce annoyance reactions and complaints about headache, nausea, or eye and throat irritation, for example. Field studies conducted in the vicinity of industrial or agricultural odour sources show that environmental odour exposure modifies behaviour and impairs quality of life. In addition, person-related factors like age and gender, smoking behaviour, and the health status considerably influence the annoyance response. Physiological hypersensitivity like "chronic" sinusitis, allergy or asthma has been found to be a risk factor for reporting odour annoyance and health symptoms. In order to improve the characterization of people who respond more sensitive than others to the perception of odours different tests were applied: Self-reported multiple chemical sensitivity, the odour identification sub-test of the Sniffin' Sticks test, the odour awareness scale (OAS), and polarity profiles for hydrogen sulphide (H_2S) and phenylethylalcohol (PEA). In total, 322 visitors of the international trade fair A+A 2009 "Personal Protective Equipment, Occupational Safety and Health" in Düsseldorf were tested. Among them 59 subjects with self-reported multiple chemical sensitivity (sMCS) and 225 not-sMCS subjects could be identified. The results show that sMCS subjects give lower ratings of PEA intensity and higher unpleasant ratings of PEA hedonic tone compared to not-sMCS subjects. Differences were not found concerning olfactory functioning, i.e. the ability to correctly identify everyday odours, or awareness about odours in the environment.
In sum, these results suggest that easy to apply measures, like self-reported multiple chemical sensitivity and the rating of hedonic tone and intensity of PEA, can be used to characterize a sub-group of people susceptible to experience annoyance and health complaints from environmental odours.

1. Scope

Exposure to environmental odours can induce annoyance reactions and complaints about headache, nausea, or eye and throat irritation, for example (Steinheider et al., 1998; Sucker et al., 2009). Field studies conducted in the vicinity of industrial or agricultural odour sources show that environmental odour exposure modifies behaviour and impairs quality of life (Radon et al., 2004; Sucker et al., 2008).

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The relationship between odour perception and odour annoyance is a complex process. What is a smell to one person can be a stench to another. It has been shown, that the mere perception of an odour particularly if evaluated as unpleasant can trigger an annoyance reaction (Sucker et al., 2008). In some persons the perception of unpleasant odours can cause a sense of alarm and activate hypotheses about possible adverse health effects (Smeets and Dalton, 2005).

In addition to olfactory factors like frequency of odour events, intensity and unpleasantness several person-related factors have been identified to influence odour perception and modulate the annoyance response (Sucker et al., 2001).

Physiological hypersensitivity like "chronic" sinusitis, allergy (e.g. hay fever) or asthma (Shusterman, 2002; Herr et al., 2003) has been found to be a risk factor for reporting odour annoyance or health symptoms. Besides age (younger subjects more sensitive), gender (females more sensitive) and smoking behaviour (non-smokers more sensitive) (Steinheider and Winneke, 1993), personality traits like the "tendency to exhibit annoyance, which generalizes across environmental stressors" (Steinheider and Winneke, 1993) contributes to the great variability of responses to homogeneous exposure conditions. Furthermore, self-reported sensitivity to pollutants (Shusterman, 2002) or chemicals (van Thriel et al., 2008), is usually associated with odour hypersensitivity and proposed to be a potent modulator of odour perception and olfactory-mediated symptoms.

2. Aims

In order to improve the characterization of people who respond more sensitive than others to the perception of odours and thus belong to a sub-group susceptible to odour annoyance, person-related factors as described above, namely, age, gender, health status concerning allergy/asthma, and self-reported chemical sensitivity, were assessed. Thus, we analysed the influence of these factors on the ability to identify everyday odours, on the amount of awareness of odors in the environment and on the responses to hydrogen sulphide (H_2S) as an unpleasant and phenylethylalcohol (PEA) as a pleasant pure odour.

The sample was recruited among participants of the international trade fair A&A 2009 "Personal Protective Equipment, Occupational Safety and Health" in Düsseldorf between the 3rd and the 6th November 2009.

In a first step, the "Sniffin’ Sticks Identification Test" (Hummel et al., 1997; Kobal et al., 2000) was used to classify individual factors related to the olfactory functioning of the subjects, i.e. the ability to identify everyday odours. The test was conducted by pen-like odour-dispensing devices. Reliability and validity of the Sniffin’ Sticks are well established (Hummel et al., 2007; Kobal et al., 2000).

Then participants were asked about age, gender, smoking status and the presence or absence of asthma or an allergy (e.g. hay fever) using a short questionnaire. At the end of the questionnaire, items of the German questionnaire on chemical and general environmental sensitivity (Kiesswetter et al., 1999) were used to identify subjects who describe themselves as more sensitive to chemicals. Only those 8 items were used that were related to "self-reported multiple chemical sensitivity" (sMCS). These items describe the individual reaction to the odour of a chemical, for example: "If I smell paint in a room with wet paint, I feel breathless." Subjects rated the appropriateness of these items on a 5-point scale. They were allocated to the group of sMCS, if at least one out of the eight statements was rated as "5-very appropriate".

In a second step, if the participants were ready to invest some more time, the odour awareness scale (Smeets et al., 2008) was applied and responses to H_2S and PEA were assessed with the polarity profile method (Guideline VDI 3940/Part 4, 2010).

The odour awareness scale (OAS) is a 32-item questionnaire designed to assess individual differences in awareness of odors in the environment. Five-point scales are used as response categories in most cases and an overall sum-score as well as a positive awareness sub-score (11 items) and a negative awareness sub-score (21 items) is calculated. A recent study (Smeets et al., 2008) suggests a causal relation between awareness of potentially negative odours, olfactory performance and experiencing health effects from environmental odour exposure.

The polarity profile consists of 29 pairs of polar adjectives used to describe different sensory experiences (e.g. pungent versus dull, rough versus smooth, heavy versus light). Each adjective pair was rated on a 7-point scale. Subjects had to judge concrete odorants as well as their "mental concepts" of stench and fragrance without having any real odour on hand. In order to analyse the profile ratings, each of the 29 ratings of every subject was weighted (i.e. multiplied) with a given factor score and averaged above all subjects (see Guideline VDI 3940/Part 4). In addition, the first adjective pair (strong versus weak; intensity) and the 29^{th} (pleasant versus unpleasant; hedonic tone) were evaluated separately.

3. Results

In total, 322 persons were examined. Due to missing data for gender, age, smoking status, Sniffin' Sticks identification test and self-reported multiple chemical sensitivity the final sample consisted of 272 subjects. Overall, males were predominant, current smokers were rare. Characteristics of subjects with self-reported multiple chemical sensitivity (sMCS) and those without (not-sMCS) (see below) did not differ, with the exception of higher proportion of females and asthmatics among those rating themselves as chemical sensitive (Table 1).

The ability to correctly identify everyday odours as well as the odour awareness sum-score as well as the positive and the negative sub-scores were not associated with self-reported chemical sensitivity (Table 2). However, sMCS subjects rated the pleasant odorant PEA as significantly less intensive but more unpleasant than subjects in the not-sMCS group. Differences regarding the ratings of H_2S intensity and unpleasantness were not found.

Females differed significantly from males, achieving a higher odour awareness sum-score (135.9 ± 13.7 vs. 126.7 ± 13.0; $p = 0.018$) as well as higher positive (45.7 ± 5.0 vs. 42.7 ± 4.3; $p = 0.024$) and negative sub-score (81.4 ± 10.2 vs. 74.4 ± 7.3; $p = 0.021$). Gender differences as to odour identification ability or the rating of H_2S and PEA were not found. No group differences were found on any of the measures as to non-smokers and ex-/smokers or asthmatic/allergic and healthy subjects.

Table 1 Characteristics of 272 participants with (sMCS) and without (not-sMCS) self-reported multiple chemical sensitivity

	sMCS (n = 57)	not-sMCS (n = 215)	p-value	Total (n = 272)
Female gender: n (%)	25 (43.9)	62 (28.8)	0.031	87 (32.0)
Age: yrs [mean ± SD]	46.4 ± 13.2	44.6 ± 12.4	0.233	45.0 ± 12.6
Smoking status:			0.312	
Smoker: n (%)	7 (12.3)	38 (17.7)		45 (16.5)
Ex-smoker: n (%)	14 (24.6)	36 (16.7)		50 (18.4)
Non-smoker: n (%)	36 (63.2)	141 (65.6)		177 (65.1)
Asthma: n (%)	14 (6.6)	9 (15.8)	0.027	23 (8.5)
Allergy: n (%)	23 (40.4)	74 (34.4)	0.406	97 (35.7)

Table 2 Test results of 272 participants with (sMCS) and without (not-sMCS) self-reported multiple chemical sensitivity

	sMCS (n = 57)	not-sMCS (n = 215)	p-value	Total (n = 272)
Sniffin' Sticks Identification Test: [mean ± SD]	13.5 ± 1.7	13.6 ± 1.6	0.890	13.6 ± 1.7
Odour Awareness Scale:				
Total (n = 51)	130.3 ± 23.4	130.8 ± 11.9	0.953	130.7 ± 14.0
Positive (n = 50)	43.6 ± 7.4	44.1 ± 4.4	0.792	44.0 ± 4.8
Negative (n = 43) [mean ± SD]	83.8 ± 11.4	76.1 ± 8.4	0.053	77.2 ± 9.1
Polarity Profiles for H_2S (n = 48):				
intensity ratings	5.1 ± 2.0	5.8 ± 1.4	0.358	5.7 ± 1.5
hedonic tone ratings [mean ± SD]	6.9 ± 0.4	6.8 ± 0.5	0.753	6.8 ± 0.5
Polarity Profiles for PEA (n = 48):				
intensity ratings	2.6 ± 0.8	4.5 ± 1.8	0.013	4.2 ± 1.8
hedonic tone ratings [mean ± SD]	2.9 ± 1.5	1.7 ± 1.0	0.019	1.9 ± 1.2

4. Conclusions

The results for self-reported chemical sensitivity were as expected from earlier studies: Subjects with higher sensitivity rated the pleasant rose odour (PEA) as more unpleasant, but less intensive, whereas no differences were found concerning H_2S ratings, odour identification ability or odour awareness. Our results are in accordance with previous findings for patients with multiple chemical sensitivities (MCS) or idiopathic environmental intolerance (IEI).

Even though many MCS/IEI patients feel that their sense of smell is more sensitive to environmental odours than that of the general population, several psychophysical and electrophysiological studies showed no increased sensitivity of MCS/IEI patients to olfactory or trigeminal stimulation (Dalton and Hummel, 2000).

Odour detection thresholds for PEA and pyridine, as a measure of odour sensitivity, and odour identification ability (based on University of Pennsylvania Smell Identification Test results) were equivalent for MCS subjects as well as for healthy controls. However, MCS subjects reported significantly more symptoms and lower esthetic ratings, when exposed to PEA compared to pyridine (Caccappolo et al., 2000). The authors summarised that MCS subjects did not show lower olfactory threshold sensitivity or enhanced ability to identify odours, but they differ in their symptomatic and esthetic ratings of PEA, but not pyridine. In a more recent study, patients with IEI had significantly lower pleasantness ratings for PEA, H_2S and menthol compared to healthy controls, but no significant differences of the perceived odour intensity was found (Papo et al., 2006).

These findings suggest that in order to predict the individual response to environmental odours more precisely, odour perception needs to be differentiated into detection and evaluation processes. Cognitive, non-sensory factors appear to play a major role in both the initiation and maintenance of odour annoyance and complaints about health impairment. Hence, especially for susceptible subjects, interventions focused only on environmental control of odours may not be a particularly effective way to remediate their distress. Just as negative information about the consequences of exposure can elevate symptom reporting, positive information about the benefits of exposure can reduce symptom reports below the baseline response when no information is provided (Dalton and Hummel, 2000). This suggests that efforts to provide education and communication addressing the relationship between odours, perceived toxicity, and actual health risk may be of significant value for individuals who appear to be more sensitive than others to experience environmental intolerance.

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