
Judgement of Odor Intensity is Influenced by Subjects' Knowledge of the Odor Source

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Abstract

Odor perception, including intensity, is affected by knowledge of odor source. For 76 subjects tested with 24 everyday odorants, ratings of intensity, pleasantness and familiarity were enhanced when subjects either could identify the odor source themselves or were provided with the name by the experimenter. Ratings were highest when subjects judged that the names provided matched their own perception, suggesting an interaction between individuals' cognitive representation of odors and their immediate perceptual experience.

Introduction

The underlying principle behind the present study was a belief in the importance of experience in shaping perception of odor and thus in directing olfactory-guided behavior. This belief derives from a consideration of the natural odor world and in particular, the near-infinite dimensionality and inherent unpredictability of potentially relevant stimuli (Hudson, 1999; Hudson and Distel, 2001). In an evolutionary sense this has made it difficult for nervous systems to reduce the chemical world to a few primary features and to map these on to receptor surfaces or brain structures. Learning—the acquisition or enhancement of patterns of neural activation of relevance to the individual—is one evolutionary and psychobiological answer to this problem. Accordingly, individuals will encounter, respond to and form neural representations of chemical stimuli in distinct ways as a consequence of their particular life histories and associated judgements of stimulus relevance. Such sensory tailoring to the chemical environment makes good functional sense, presumably enabling individuals to respond more selectively to those features of a particular environment relevant for survival.

Indeed, a large body of literature points to the idiosyncratic nature of olfactory perception and the fundamental role of everyday experience in shaping this (Ayabe-Kanamura *et al.*, 1998; Hudson and Distel, 2001). More specifically, we recently demonstrated a relationship between such experience and odor perception in a cross-cultural study examining subjects' responses to odors of everyday substances either typical or foreign to the particular cultural

environment. Both cultural and individual differences were found in the ability of subjects correctly to name or describe the odor sources (Ayabe-Kanamura *et al.*, 1998), and a positive correlation was found between this ability and judgements of familiarity, pleasantness and intensity (Distel *et al.*, 1999).

A positive relationship between familiarity and ratings of pleasantness is a well established phenomenon (Jellinek and Köster, 1983; Engen, 1988; Rabin and Cain, 1989). However, much less is known about a possible relationship between familiarity and intensity (Distel *et al.*, 1999). Yet, it would seem to make ecological sense that odors of behavioral relevance should be perceived—whatever the underlying mechanisms—more sharply (Hudson and Distel, 1998). In the laboratory, one means of investigating the influence of experience or knowledge of odors on the manner in which they are perceived is to ask subjects to name them, that is, to identify the odor source. A second means is to provide information on the odor source directly. A third means—given the mismatch that may occur between subjects' personal experience or memory of an odor and the particular example presented by the experimenter—is to ask subjects how well a particular stimulus fits their expectation following provision of the name. In tapping such responses, it is obviously important to work with odorants with which subjects are likely to be familiar from contexts relevant to everyday life.

The aim of the present study was, therefore, to examine the influence of knowledge about everyday odors as repres-

Table 1. Odorants used

Set A		Set B	
Odorant ^a	Amount	Odorant ^a	Amount
Chocolate , dark	0.69 g	Banana aroma ^c	0.003 ml
Apple cider	0.5 ml	Stale bread, dark	0.5 g
Cinnamon , ground	0.026 g	Parmesan cheese	0.25 g
Cumin seeds	0.26 g	Coconut cream	0.28 g
Hazelnuts , chopped	2.0 g	Marzipan	1.1 g
Honey	4.3 g	Mayonnaise	0.5 g
Olive oil	0.2 ml	Oregano , dried	0.053 g
Orange oil ^b	0.003 ml	Rosemary , fresh	0.023 g
Sawdust	1.5 g	Rum , brown	0.2 ml
Sherry	0.3 ml	Tobacco , pipe	0.3 g
Soil , humid	2.0 g	Vanilla pod	0.16 g
Tea (Darjeeling)	0.6 g	Scotch whisky	0.3 ml

^aBold type shows the name provided.

^bDrom.

^cGivaudan-Roure.

ented by (i) spontaneous identification of the odor source; (ii) provision of this information by the experimenter; and (iii) the goodness of fit between this information and subjects' actual perception of odors. In particular, we were interested in following up previous indications that perceived intensity might be affected by such knowledge since this would modify the assumption of classical psychophysics that intensity is a direct result of stimulus concentration. Here we confirm the previous observation that spontaneous identification of an odor source is associated with enhanced ratings of its intensity, pleasantness and familiarity. In addition, we report that rating of these parameters is strongly affected by goodness of fit between the name of the odorant provided by the experimenter and subjects' actual perception.

Methods

A total of 76 medical students (36 women and 40 men; mean age: 24.2 ± 5.2 years) from the University of Munich were presented with 24 everyday odorants (Table 1). Except for the orange oil and banana aroma, stimuli were off-the-shelf products from a local Munich supermarket. As described previously (Ayabe-Kanamura *et al.*, 1998), the odorants were placed in teapot filter bags and suspended inside 250 ml polyethylene squeeze bottles; liquids were first pipetted on to absorbent paper strips.

Subjects were randomly divided into two equally sized groups (groups 1 and 2) of 38 subjects each, and odorants were randomly divided into two two sets of 12 odorants each (sets A and B; Table 1). Each subject was given two sets of tests. In the first test, odorants were presented without any name and in random order—set A to group 1 and set B

to group 2. Subjects were asked to rate the intensity of each odor on a 10 cm scale, and then, in a second round of presentations, to rate pleasantness and familiarity on similar 10 cm scales. They were given no further instructions, although 2 cm sections of the scales were labelled with German words corresponding to 'minimal' (0–2 cm), 'moderate' (2–4 cm), 'medium' (4–6 cm), 'strong' (6–8 cm) and 'maximal' (8–10 cm). Finally, subjects were asked to try to name the odor source or to provide an appropriate association. In the second test, odorants were again presented in random order but this time together with the name of the odor source (provided on the score sheets). Using a crossover design, odorant set B was now presented to group 1 and odorant set A to group 2. Subjects were asked to rate intensity, pleasantness and familiarity as in the first test; they were also asked to rate how well the name provided by the experimenter fitted the odor on a scale from 1 (fits exactly) to 5 (does not fit at all). Thus, all odorants were tested equally often with and without subjects being provided with the name of the odor source.

The tests were performed on the same afternoon. The interval between stimuli was ~1.5 min, so each presentation of 12 odorants (twice in the first test, once in the second test) lasted ~20 min.

This experimental design allowed three main comparisons: (i) between scores of intensity, pleasantness and familiarity when subjects were provided with the name of the odorant or not ('with name' versus 'without name'); (ii) in the 'without name' condition, between scores when subjects were able correctly to identify the odor source or not ('identified' versus 'not identified'); and (iii) in the 'with name' condition, between scores when the name provided by the experimenter was judged to fit the odor or not ('fitting' versus 'not fitting'). For comparison 2, data were divided according to whether or not subjects could correctly name the odor source, and for comparison 3, data were divided using the fits-name scores 1 or 2 versus scores 3–5. For each of these three comparisons, the data were analyzed in two ways: (i) for each odorant separately using the Mann–Whitney *U*-test and (ii) across all odorants using median scores and the Wilcoxon signed ranks test. Significance levels were set at $P \leq 0.05$. Given the non-parametric nature of the data, medians were used for the statistical tests. However, average scores are given in Figure 1 for descriptive purposes.

Results and discussion

'With name' versus 'without name'

Significant differences were found between these two conditions in the median rating scores across all 24 odorants combined, for intensity, pleasantness and familiarity (Table 2, top panel; Wilcoxon test). For intensity, higher median ratings were given for 18 of the 24 odorants when the name was provided, with significantly higher differences for four

Table 2 Overall median rating scores for the 24 odorants on intensity, pleasantness and familiarity

	'With name'	'Without name'	Wilcoxon ($P \leq$)
Intensity	5.5	4.8	0.001
Pleasantness	6.8	5.5	0.002
Familiarity	6.0	5.0	0.0025

	'Without name' 'Identified'	'Not identified'	$P \leq$
Responses	37%	63%	
Intensity	5.0	4.3	0.001
Pleasantness	7.5	5.0	0.0001
Familiarity	7.0	3.8	0.0001

	'With name'	'Fitting'	'Not fitting'	$P \leq$
Response	41%		59%	
Intensity	6.8		5.0	0.0001
Pleasantness	7.5		6.0	0.0001
Familiarity	8.8		5.0	0.0001

Comparisons were made between median ratings in the 'with name' and 'without name' conditions, between median ratings of subjects identifying the odorants or not in the 'without name' condition, and between median ratings of subjects judging the names provided fitting to the odors or not in the 'with name' condition (24 odorants; Wilcoxon signed ranks test).

of the odorants, but lower differences for one (Figure 1; Mann–Whitney U -test). Providing the name was also associated with higher median scores for pleasantness (16 of 24 odorants; six of these differences were significant) and familiarity (17 of 24 odorants; nine of these differences were significant).

In explaining these differences it seems obvious that providing the name would have made subjects feel more confident of their knowledge about the odor and thus would have increased their judgements of familiarity. This is even more likely given that the odorants were taken from everyday life and so had probably been experienced previously, at least in some form, by all participants. The increase in pleasantness ratings when names were provided is consistent with previous reports of a generally positive relationship between familiarity and ratings of pleasantness as mentioned above (Jellinek and Köster, 1983; Engen, 1988; Rabin and Cain, 1989). The increase in intensity judgements is also consistent with our previous finding of a positive correlation between familiarity, strength of hedonic judgement and intensity, although the causal relationship between these parameters remains unclear (Distel *et al.*, 1999).

'Identified' versus 'not identified'

The ability of subjects to identify odorants in the 'without name' condition was associated with a similar enhancement of judgements to when the name was provided in the 'with

name' condition described above. Each odor was correctly identified on average by 37% (SD 18%) of the 38 subjects per stimulus in the 'without name' condition, with the most frequently identified substances, cinnamon and orange, being named by 27 subjects (71%) and the least frequently identified substances, honey and rosemary, by three and four subjects (8% and 11%), respectively. Across all 24 odorants combined, significantly higher median scores were recorded for intensity, pleasantness and familiarity when subjects could identify the odor source (Table 2, center panel; Wilcoxon test). Median ratings of intensity were higher for 17 of the odorants when correctly named (seven were significantly higher; Mann–Whitney U -test; Figure 1); median ratings of pleasantness and familiarity were higher for 22 odorants (12 significant) and 23 odorants (18 significant), respectively, when odorants were correctly named.

These findings are consistent with what was discussed above regarding the effect of being able to identify the odor source, and with the previous cross-cultural study in which the ability of subjects to generate accurate descriptors was associated with higher ratings of intensity, pleasantness and familiarity (Ayabe-Kanamura *et al.*, 1998). However, in the present study, significant differences in intensity ratings associated with identification were only found for substances of lower intensity (Figure 1), suggesting an interaction between stimulus concentration and enhancement of perceived intensity by knowledge of the odor source.

In the present study it is not clear whether identification of an odor source influenced actual perception, or generated more confident use of the rating scales, resulting in stronger judgements, or whether more strongly perceived odors were identified more readily (van der Klaauw and Frank, 1996). However, the finding that an increase in intensity ratings with identification was associated primarily with substances of lower intensity suggests that neither a general change in subjects' use of the rating scales nor a tendency to identify stronger smelling substances better can account for the findings. Although, the possible relationship between stimulus concentration and enhancement of perceived intensity associated with knowledge of odor source needs further investigation, it may be noted that since identification reflects experience and presumably stimulus relevance, perceptual enhancement of weak stimuli should be of functional advantage.

'Fitting' versus 'not fitting'

In the 'with name' condition, a surprisingly small percentage of subjects considered the names provided by the experimenter to fit the odor stimuli, even though—with the exception of banana aroma and orange oil—everyday substances were used. On average, only 41% (SD 13%) of the 38 subjects per odorant in this condition rated the names as fitting the odors 'exactly' or 'rather well'. The lowest percentages were recorded for whisky and rum (21%) and the highest for coconut (66%) and chocolate (61%).

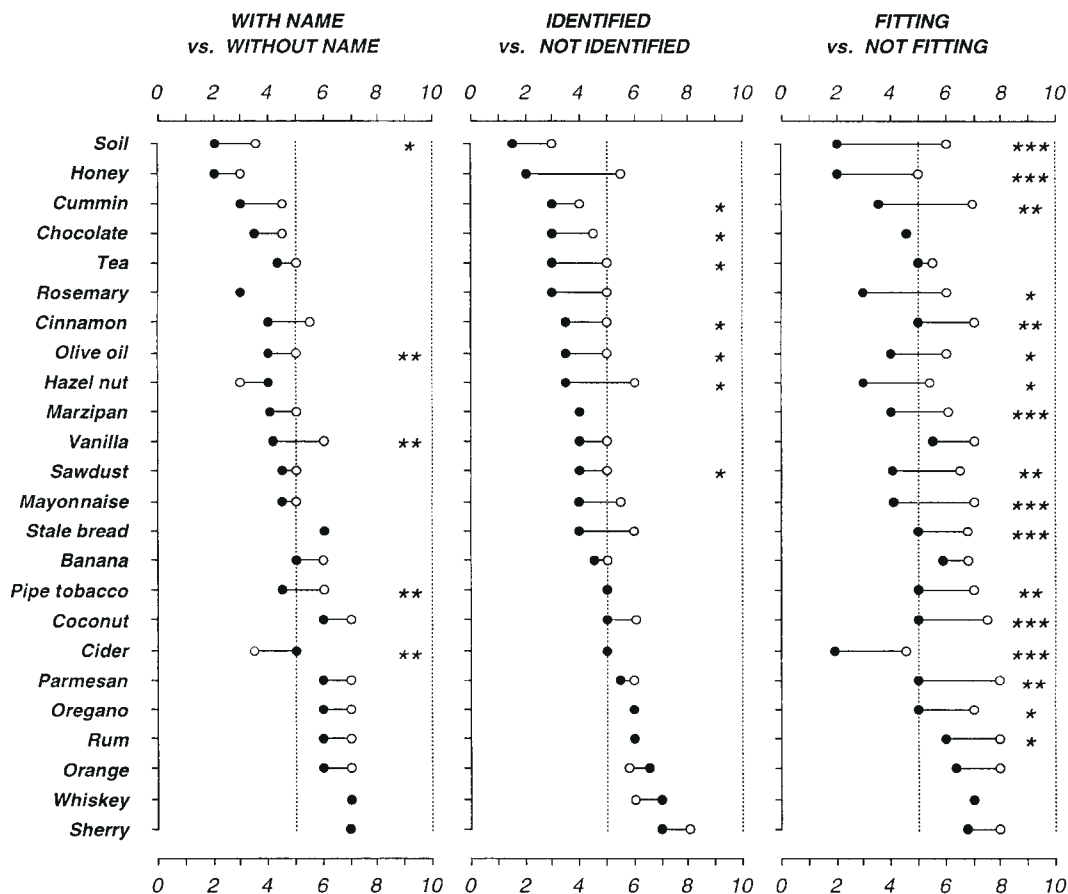


Figure 1 Average ratings of intensity judgements for odorants when presented with (○) and without (●) their names (left), when identified (○) or not identified (●) by the subjects in the 'without name' condition (center), and when judged as fitting (○) or not fitting (●) the name provided (right); * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ (Wilcoxon Mann–Whitney test using the median ratings).

However, even subjects who considered the names to fit the odors poorly, rated intensity, pleasantness and familiarity higher than subjects who failed to identify the odorants in the 'without name' condition (Table 2, middle and bottom panels), confirming previous reports that cognitive processes activated by information about odor source affect perception (Tuorila *et al.*, 1994; Dalton, 1996; Dalton *et al.*, 1997; Schifferstein *et al.*, 1999). The influence of such information was even more marked when subjects reported a good match between name the provided and their perception of the odor. Thus, highly significant differences in median rating scores across odorants were found when the names provided were judged to fit the stimuli compared with when they were not (Table 2, bottom panel; Wilcoxon test). Median ratings of intensity were higher for 22 of the odorants when the names were judged to fit (17 significant; Mann–Whitney U -test; Figure 1); median ratings of pleasantness and familiarity were for higher for 22 odorants (10 significant) and 24 odorants (all significant), respectively, when the names were judged to fit.

These findings suggest that knowledge of an odor source may not only enhance the feeling of familiarity of a par-

ticular odor, as considered as an explanation for the rating differences obtained in the 'with name' versus 'without name' conditions, but that subjects also match knowledge about an odorant against their immediate olfactory perception. Such matching would require that subjects possess perceptual schemas or stimulus expectations that are recruited during perceptual events (Zellner *et al.*, 1991; Cardello and Sawyer, 1992; Tuorila *et al.*, 1994; Schifferstein *et al.*, 1999). Thus, it may be speculated—at least in the case of intensity—that higher ratings in the 'fitting' condition resulted from a good match between the neural activation of such cognitive schemas and actual sensory input, and that lower ratings in the 'not fitting' condition resulted from an incomplete match, leading to enhanced or reduced neural activation, respectively.

The extent to which the phenomena described here translate into differences in actual everyday perception is an important topic for future research. One approach to this would be to examine the effect of knowledge of everyday odors on functional measures of perception such as odor discrimination (Rabin, 1988) and recognition thresholds.

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