

## Differences in Perception of Everyday Odors: a Japanese–German Cross-cultural Study

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### Abstract

There is a growing appreciation that experience with odors may strongly influence their perception. To further investigate this, the responses of 40 Japanese and 44 age-matched German women to everyday odorants were compared. Subjects were presented with 18 stimuli in squeeze bottles and asked to rate them according to intensity, familiarity, pleasantness and edibility, to describe associations elicited by them and, if possible, to name them. One-third of the odorants were presumed to be familiar to the Japanese only, one-third to the Germans and one-third to both populations. Significant differences were found between the two populations on all measures. Better performance by the Japanese in providing appropriate descriptors for 'Japanese' odorants and by the Germans for 'European' odorants supported the pre-selection of stimuli as culture-typical. Particularly clear differences between the two populations were found in pleasantness ratings. In general, a positive relationship was found between pleasantness and judgement of stimuli as edible, suggesting that culture-specific experiences—particularly of foods—may significantly influence odor perception. Somewhat unexpectedly, significant differences were also found between the two populations in intensity ratings for some odorants. These differences did not seem simply to be artefacts of the test situation and raise the possibility that experience may even influence such basic aspects of odor perception as stimulus intensity.

### Introduction

The olfactory system is faced with a particular problem—the high dimensionality and inherent unpredictability of the chemical world. Most natural odors encountered in everyday life are complex mixtures of many different volatiles (Laing *et al.*, 1989). This means that from the outset the olfactory system has to contend with a great and often unpredictable diversity of molecules, making it difficult for stable primary features of the chemical world to be mapped onto the sensory surface. One solution to such unpredictability is provided by learning. Learning confers flexibility, enabling the individuals of a given species to acquire and make use of the most appropriate information in a particular environment (Hudson *et al.*, 1997). An increasing number of studies suggest learning to play a significant part in odor perception. The power of odors to evoke memories and associations (Schab, 1990; Engen, 1991; Schab and Crowder, 1995; Ayabe-Kanamura *et al.*, 1997), the influence of experience on hedonic judgement of odors (Moncrieff, 1966; Cain and Johnson, 1978; Jellinek

and Köster, 1983; Engen, 1988; Rabin and Cain, 1989; Saito *et al.*, 1996), and the early acquisition of odor preferences in both animals and humans (Schaal, 1988; Hvastja and Zanuttini, 1989; Schmidt, 1992; Hudson, 1993; Porter and Schaal, 1995; Saito and Arakawa, 1995; Saito *et al.*, 1996) have been well documented. Furthermore, there is good evidence that experience may affect the ability to perceive and discriminate particular odors (Rabin, 1988; Rabin and Cain, 1989; Wysocki *et al.*, 1989; Jehl *et al.*, 1995). Despite the implications of such findings for both basic and applied research, there have been surprisingly few studies of the influence of everyday experience on odor perception (Cain, 1979, 1982). One way of investigating this methodologically difficult question is to make use of presumed geographical differences in olfactory experience and compare responses to everyday odors across cultures.

Apart from scattered reports by anthropologists at the turn of the century, cross-cultural research on odor perception has been initiated only quite recently (Doty,

1986). Thus, Schleidt and colleagues, in a study comparing responses of Japanese, Italian and German subjects to body odors, found differences in pleasantness ratings which were thought in part to relate to cultural differences in attitude to the suppression of personal odors (Schleidt *et al.*, 1981; Schleidt and Hold, 1982). Furthermore, in a comparison of spontaneous odor memories and associations of German and Japanese subjects, most differences appeared to reflect everyday experiences associated with housing, sleeping habits, diet and hygiene practices (Schleidt *et al.*, 1988). More recently, Ueno (1993) asked Japanese and Sherpa subjects to group 20 artificial Japanese food aromas according to perceptual similarity and to assign verbal labels to these groups. Despite broad agreement between the populations, clear differences were also found—for example, in categorizing the odor of fish—which could be attributed to differences in personal or cultural experience. And in a study comparing responses of Canadian, Indonesian and Syrian children to 14 synthetic odorants, Schaal *et al.* (1997) found similarities but also culturally specific differences in hedonic judgements.

The introduction of microencapsulated fragrances has been particularly helpful in enabling large populations to be tested with identical sets of stimuli. Using this method to compare pleasantness judgements among subjects from 20 nations, Davis and Pangborn (1985) found similarities but also significant differences between populations. Furthermore, application of one of the best known of these tests, the University of Pennsylvania Smell Identification Test (UPSIT), to compare odor identification abilities of three American ethnic groups and a Japanese population revealed significant differences between them. In particular, the Japanese had difficulty with some stimuli with which they were less familiar (Doty *et al.*, 1985; Doty, 1986). As a result of such findings, abbreviated, internationally applicable versions of the UPSIT (Doty *et al.*, 1996; Matsuda *et al.*, 1996), as well as tests designed specifically for Japanese (Saito *et al.*, 1995) and for Scandinavians (Nordin *et al.*, 1997), have now been developed.

In the largest international smell survey to date, that of the National Geographic Society, responses from 1.4 million people from ~80 countries were collected (Gibbons, 1986). Subjects were asked to rate each of six microencapsulated fragrances for pleasantness, intensity, edibility and vivid memories, and to choose the best descriptor from a list of 12 labels. Consistent relationships between odor-elicited memory and intensity and pleasantness were found, and grouping the data according to nine geographic regions revealed differences in pleasantness and intensity ratings across odorants and regions (Wysocki *et al.*, 1991).

In an extension of these reports, it was the aim of the present study to investigate the degree and possible nature of experience-dependent differences in odor perception by comparing the responses of Japanese and German subjects to complex odors taken from everyday life. Natural,

everyday substances were chosen as stimuli in the hope of achieving maximum ecological validity and thereby drawing maximally on subjects' real-life experiences.

## Materials and methods

### Subjects

To reduce variability arising from possible sex differences in responding to odorants (Cain, 1982; Doty *et al.*, 1985; Wysocki *et al.*, 1991), only women were tested. All were healthy volunteers with no history of olfactory impairment. A total of 40 Japanese and 44 Germans were recruited in equal numbers from two age groups: 20–30 and 39–50 years. Subjects were either students, housewives or university personnel. Ten of the Japanese had been to Europe but none of the Germans had been to Japan.

### Odorants and stimulus delivery

Eighteen odorants were chosen as stimuli—six which were thought to be typically Japanese, six thought to be typically European and six thought to be international (Table 1). Exactly the same substances and the same methods of stimulus presentation were used in the two laboratories. Except for incense, exact quantities of each substance were presented in 250 ml polyethylene squeeze bottles equipped with a flip-up spout (Laska and Hudson, 1991). To minimize visual, acoustic or proprioceptive cues, substances were secured in disposable teapot filter bags (Cilia<sup>®</sup>, Melitta, Germany) and these suspended inside the bottles. Liquids were presented on absorbent surgical strips (Sugi<sup>®</sup>, Kettenbach, Germany) inside the filter bags. In the case of incense, this was lit and a 200 ml glass jar held over it for several minutes to collect the smoke. The jar was kept closed except when briefly presented to the subject. Substances were renewed either before each session (beer), on each test day (perishable foods) or after 3–7 days (inedible substances as well as the more durable foods).

### Test procedure

Testing was carried out over a period of 2 weeks. Each subject was presented with the 18 stimuli in random order in a test session lasting ~30 min. Subjects were allowed to sample each substance freely and were asked to rate in the following sequence: (i) intensity on a six-point scale from not detectable to very strong; (ii) pleasantness on an 11-point scale with disgusting at -5, neutral at 0 and extremely pleasant at +5; (iii) familiarity on a six-point scale from completely unknown to extremely familiar; and (iv) edibility on a two-category scale of yes or no. In addition, subjects were asked to say what the odor reminded them of and, if possible, to name it.

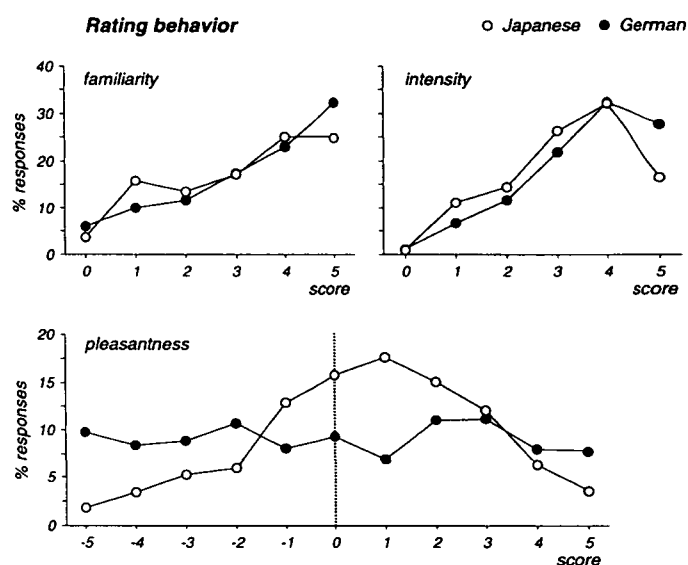
### Data analysis

All measures were analysed by odor and nationality. Mean rating scores were calculated for intensity, familiarity and

**Table 1** Odorants and descriptors which were accepted as correct

Odorants	Amount	Descriptors
<b>'Japanese' odorants</b>		
Dried bonito flakes (Katsuobushi)	0.5 g	dried fish
Soy sauce	1 g	soy sauce, soy
Roasted tea (Houjicya)	5 g	Japanese tea
Dried fermented soybeans (Hoshi-natto)	2 g	fermented soybeans
India ink (Sumi)	1 g	India ink
Japanese cypress wood (Hinoki) flakes with artificial hinoki aroma	2.5 g	wood, furniture
<b>'International' odorants</b>		
Ground coffee	1 g	coffee
Grated dark chocolate	4 g	chocolate, cacao
Chopped, roasted peanuts	4 g	peanuts
Lowenbrau®	5 ml	beer
Vick's vaporub®	0.5 g	ointment with menthol perfume
Angel® (1.5% aqueous solution)	0.5 ml	
<b>'European' odorants</b>		
Marzipan	4 g	almond, marzipan
Blue cheese	4 g	cheese
Pernod®	1.5 ml	anisetto, anise product
Italian salami	4 g	salami
Sawdust of pinewood	2.5 g	wood, furniture
Catholic church incense	see Materials and methods	incense

pleasantness, and used for the figures, and percentages were calculated for edibility and for the most commonly mentioned associations. The 1.2% of cases in which subjects claimed not to be able to perceive a particular stimulus were excluded from the analysis. These mainly involved the odors of India ink, pinewood and almond, and were distributed similarly across the two populations. To decide which descriptors to accept as appropriate for each odorant, a combination of two criteria was used: first, responses were examined for the most frequently given associations or names, and second, among these the terms coming closest to describing the actual odor source were taken (Table 1). An example is provided by dried fish. Although both groups frequently identified it as fish, a high percentage of Japanese but no Germans associated it specifically as dried fish and so this higher level of precision was taken as the criterion. A second example is Pernod. Although a number of subjects in both groups described it as alcohol, a high percentage of



**Figure 1** Comparison of the rating behavior of Japanese and German subjects for the three parameters of familiarity, intensity and pleasantness. Each point represents the percentage of total responses made to 18 odorants by 40 Japanese and 44 German women.

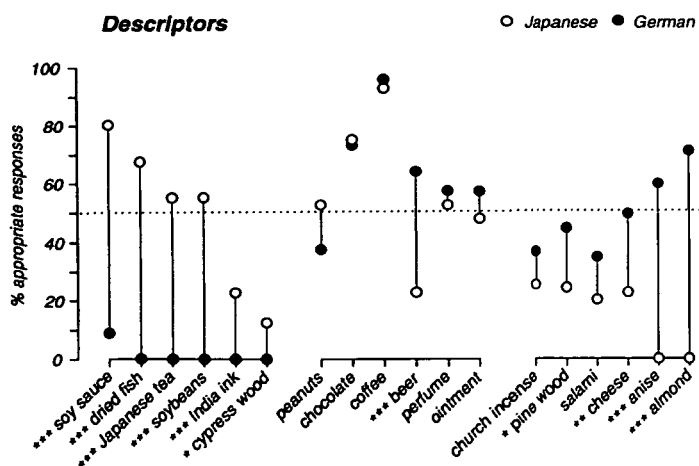
Germans but no Japanese also mentioned anise, and so recognition of this distinctive quality of the odor source was taken as the criterion. However, in such cases as the perfume 'Angel', for which neither group gave a more precise and differentiated label than 'perfume', this was taken as the criterion.

The Mann-Whitney *U*-test was used to compare rating scores for intensity, familiarity and pleasantness, and the Fisher exact probability test was used to compare the provision of appropriate descriptors and edibility judgements (Siegel and Castellan, 1988). As a considerable difference was found between Japanese and German subjects in the use of the rating scale for pleasantness (Figure 1), rating behavior for this parameter was normalized by ranking each individual's responses to the 18 odorants. These ranks were then taken and odor judgements of the two populations again compared using the Mann-Whitney *U*-test. An alpha value of 0.05 was taken as the level of significance throughout.

## Results

### Descriptors

Differences between the two populations in providing appropriate descriptors for the odorants largely confirmed the a priori selection of the stimuli as well known either to Japanese, to Germans or to both nationalities. Thus, the Japanese more often gave appropriate associations or names in response to the 'Japanese' odors than the Germans, whereas the Germans identified the 'European' odors correctly more often than the Japanese (Figure 2). As



**Figure 2** Comparison of the ability of the Japanese and German subjects to provide appropriate descriptors for six 'Japanese' (left), six 'international' (center) and six 'European' odorants (right). Each point represents the percentage of subjects responding appropriately to the odorant (cf. Table 1). (\* $P \leq 0.05$ ; \*\* $P \leq 0.01$ ; \*\*\* $P \leq 0.001$ ).

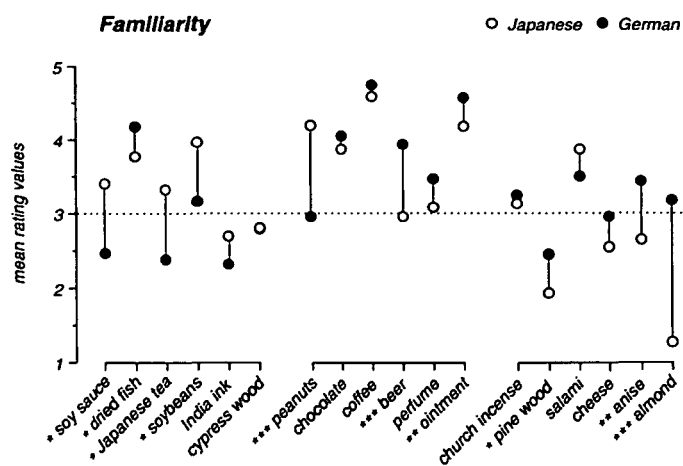
expected, fewer significant differences were found between the two groups in associations given for the 'international' odors, although the Germans identified beer correctly significantly more often than the Japanese. However, cultural differences in the pattern of responding were less distinct for the other parameters.

### Familiarity

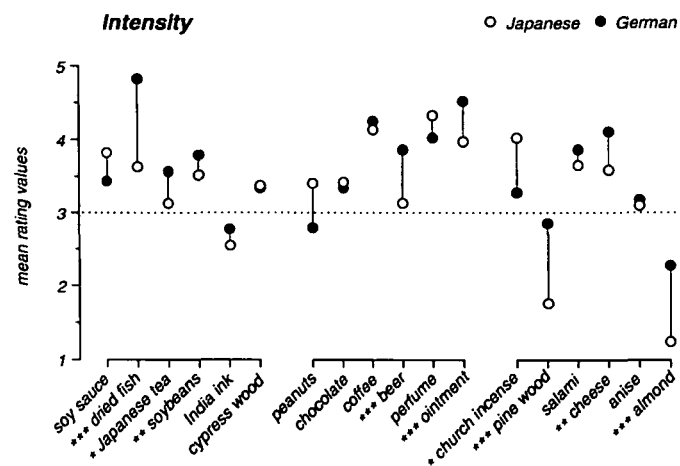
Familiarity judgements were generally in agreement with the ability of the two nationalities to provide appropriate descriptors for the odorants (Figure 3). That is, Japanese odors were overall more familiar to the Japanese, and European odors more familiar to the Germans, while the international odors were generally the most familiar stimuli for both groups. However, differences between the two populations were less marked and less consistent than in the case of the descriptors. Most notably, the German subjects rated the odor of dried fish as significantly more familiar than the Japanese, while the Japanese subjects rated salami more familiar, although not significantly so, than the Germans. Cross-cultural differences in identifying the international odors were also reflected in the familiarity judgements. Thus, the odor of peanuts was significantly more familiar to the Japanese, and the odor of beer to the Germans.

### Intensity

As can be seen from the judgements of intensity, most of the odors were clearly perceptible (Figure 4). Only India ink, pinewood and almond were judged below medium intensity by the two populations. The Germans judged three of the Japanese odors—dried fish, Japanese tea and soybeans—as significantly more intense than did the Japanese themselves,



**Figure 3** Comparison of the mean rating values for familiarity by the Japanese and German subjects for the 18 odorants (same conventions as for Figure 2).

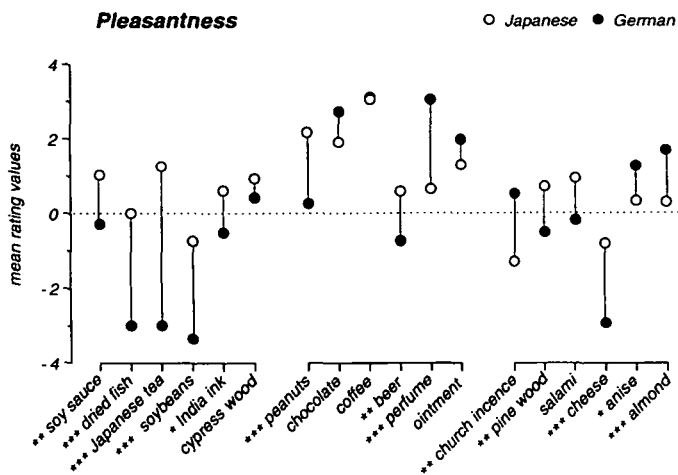


**Figure 4** Comparison of the mean rating values for intensity by the Japanese and German subjects for the 18 odorants (same conventions as for Figure 2).

whereas the Japanese judged one of the European odors—church incense—as significantly more intense than did the Germans, but three other odors—pinewood, cheese and almond—as significantly less intense. Of the international odors, beer and ointment were judged more intense by the Germans.

### Pleasantness

Considerable differences were found in individual pleasantness judgements for most of the odors, and often averaged out to produce mean values in the more neutral range (Figure 5). Nevertheless, the international odors were generally rated as pleasant by both populations, whereas the Japanese odors were generally rated as



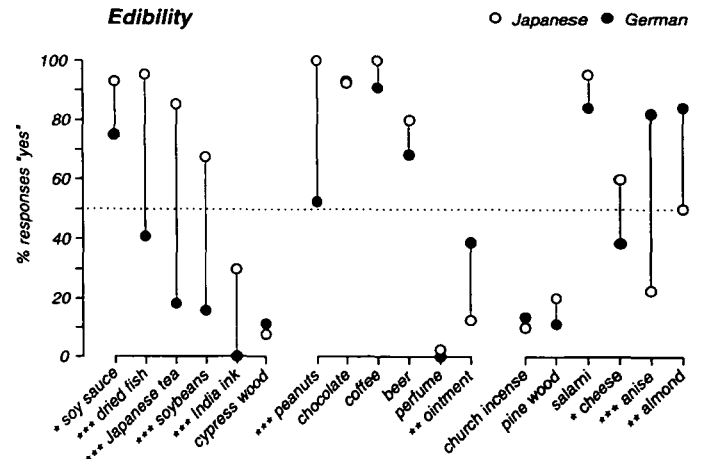
**Figure 5** Comparison of the mean rating values for pleasantness by the Japanese and German subjects for the 18 odorants (same conventions as for Figure 2).

unpleasant by the Germans, and the European odors received mixed judgements. Significant differences between the two populations in pleasantness ratings were found for all the Japanese odors except cypress wood. Of the European odors, the Japanese rated church incense, anise and almond as significantly less pleasant than the Germans but pinewood and cheese as significantly more pleasant. Of the international odors, the Germans rated perfume as significantly more pleasant, and peanuts and beer as less pleasant than the Japanese.

As indicated in Materials and methods, the rating behavior for pleasantness (Figure 1) differed considerably between the two populations, raising the question of whether the scores reflect true differences in the hedonic evaluation of the odors or simply differences in the use of the rating scale. Possible differences in use of the scale were controlled for by converting scores to ranks, and again comparing the two populations. Although this resulted in a general reduction in differences between the two populations, these were still significant for the Japanese odors of dried fish, Japanese tea and soybeans, for the international odors of peanuts and perfume, and for the European odors of church incense, anise and almond.

### Edibility

Not surprisingly, the Japanese rated Japanese food odors as edible significantly more often than the Germans, the Germans rated the European odors of anise and almond as edible significantly more often than the Japanese, whereas no significant difference in rating the international food odors of chocolate, coffee and beer was found (Figure 6). However, one of the European food odors—cheese—and one of the international food odors—peanuts—were judged significantly more edible by the Japanese than by the



**Figure 6** Comparison of the edibility judgements by the Japanese and German subjects for the 18 odorants (same conventions as for Figure 2).

Germans. Inedible substances generally received low or zero edibility ratings, although 25% of the Japanese thought the odor of India ink and nearly 40% of the Germans thought the odor of the ointment represented an edible substance.

### Additional associations and descriptions

In addition to the ability of subjects to assign appropriate descriptors to the odorants, further associations provided by them may help account for differences in the patterns of judgement described above, particularly in relation to edibility and pleasantness. Considering the edible Japanese substances first, the most common description given for the odor of fermented soybeans by German subjects was 'cheesy' in the sense of sweaty feet (29.5%), while only 5% of Japanese used this type of description. The smell of dried fish was clearly associated with edible food by the Japanese while the majority of Germans associated it with rotten and never with dried fish (38.6%), or with something decayed or with excrement (21.4%). A similar pattern of description was found for the odor of Japanese tea. The most frequent German description of this was 'fishy' in the unpleasant, inedible sense (36.4%), while Japanese subjects not recognizing the odor as tea also associated it with fish but dried and thus edible (20%). The smell of soy sauce was considered to represent an edible substance by the majority of both cultural groups, although German subjects associated it with fresh bread (38.6%) rather than with a soy product.

Considering the edible European substances, the majority of German subjects were able to identify the odor of marzipan (73.8%) as either marzipan or almond, whereas no consistent description or association was given for this by the Japanese who mentioned substances as diverse as flour, oil, beeswax and sawdust. Similarly, the majority of German subjects associated the odor of Pernod (59%) with an anisette or an anise product such as liquorice, while the most

common associations given by the Japanese related to disinfectant (37.5%) and only 5% thought it to represent liquor. Although the cheese odor was correctly identified by 47.7% of the Germans, only 29.5% considered it edible while the rest associated it with decayed, old cheese. The most common associations for Japanese subjects were edible cheese (17.5%), or butter (10%) which was never mentioned by the Germans. Although most German and Japanese subjects associated the odor of salami with some form of processed meat (70 and 77.5% respectively) and thus judged it to be edible, a higher but not quite significant percentage of Germans specifically identified it as salami (cf. Figure 2;  $P < 0.07$ ).

For the edible international substances rather different associations were given by the two populations for the odors of peanuts and beer. Whereas the Germans often associated the peanut odor with inedible, decayed nuts or other inedible plant material (24.3%), such negative associations were never given by the Japanese. Similarly, the Germans associated the odor of beer with perished beer or soured wine (29.5%) more frequently than the Japanese (7.5%), who instead associated it with other alcoholic beverages.

For the inedible substances, the most common associations to India ink were mould (23.3%) or cleanser (16.3%) by the Germans, and some kind of ointment or medicine (25%) by the Japanese. This latter association seemed to derive from a menthol-like component which was only rarely mentioned by the German subjects. The international ointment odor Vick's vaporub was associated with menthol or camphor by 80% of the Japanese, and with menthol and eucalyptus oil by about the same percentage of Germans, who in addition frequently associated it with something edible like cough candies.

## Discussion

This study was based on the assumption that by using everyday odorants as stimuli it would be possible to demonstrate experience-dependent differences in odor perception between Japanese and German subjects. Although the a priori classification of odorants as 'Japanese', 'European' or 'international' was not completely supported by the results, the existence of cross-cultural differences in knowledge of everyday odors was largely confirmed. Thus, the differential ability of Japanese and German subjects to provide appropriate descriptors for the various odor sources was in good agreement with the a priori selection. In total, significant differences between the two nationalities on this measure were found for 11 of the 18 odorants.

Although significant differences in familiarity ratings were found for 10 of the odorants, the overall pattern was less distinct than for the descriptors. Values also seemed higher than one might have expected from the ability to correctly identify the odor sources. This may not be surprising considering the well known 'tip-of-the-nose'

effect; that is, the inability of subjects to name an otherwise familiar odor (Lawless and Engen, 1977; Engen, 1987). However, high familiarity scores almost certainly also resulted from subjects forming associations which did not correspond to the exact odor source. For example, German subjects strongly associated the odor of dried fish with rotten fish or excrement and thus rated it as very familiar.

Differences between the two populations were most marked for pleasantness judgements which differed significantly for 13 of the odorants. Although this may have been partly due to differences in the use of the rating scale, with the Germans tending to give more extreme ratings (Figure 1), significant differences still remained for eight of the odorants after individual rating scores had been normalized by converting them to ranks.

When the scores for the eight odorants which were judged significantly differently by the two populations both on pleasantness and intensity are compared, it is notable that in seven cases higher intensity ratings were associated with lower pleasantness ratings. In the case of almond the reverse relationship was observed, as was the case for soy sauce and peanut, although the differences in intensity ratings were not quite significant. Thus whether an odor is judged as pleasant or unpleasant cannot simply be accounted for by its perceived intensity, and vice versa (Moncrieff, 1966; Doty, 1975; Cain, 1979).

Comparing the scores for pleasantness and familiarity, it can be seen that six of the odorants which were judged significantly more pleasant by one population were also rated as significantly more familiar. This is in agreement with previous reports of a generally positive correlation between familiarity and pleasantness (Jellinek and Köster, 1983; Rabin and Cain, 1989). However, for three odors, dried fish, beer and pinewood, the opposite relationship was found, as it was for the odor of cheese, although the differences in familiarity ratings were not significant.

Perhaps most interestingly, if the scores for pleasantness and edibility are compared, it can be seen that when a population judged a particular odor as significantly more pleasant it was also judged significantly more often as edible. This was true in nine cases, and for three others—beer, ointment, and pinewood—the differences were significant only on one of the two measures. Perfume was the only odorant for which a significant difference in pleasantness ratings was not related to edibility. Taken together, these results suggest that clear cross-cultural differences in the hedonic evaluation of everyday odors exist and that these may be strongly influenced by culture-specific eating habits. Similar conclusions have been drawn in relation to flavor preference and early experience of particular foods (Teerling *et al.*, 1995), and are supported by the finding that odor pleasantness ratings predict food preference patterns (Raudenbush *et al.*, 1994).

Furthermore, the odor associations and descriptions provide an indication that experience may tune the

perception of everyday odors even more finely. For example, the German subjects gave relatively negative hedonic and edibility ratings for the odors of cheese and beer and more frequently mentioned off-notes, including for the odor of peanuts, than Japanese subjects. This may reflect a cross-cultural difference in tolerance to or acceptability of particular odor components such as has been reported for tastes (Prescott *et al.*, 1992). Alternatively, this could also reflect a cultural difference in the ability to perceive or read out particular notes (cf. Rabin and Cain, 1989). In either case, given that the negative responses were associated with high familiarity ratings, these judgements might reflect a more differentiated concept of edibility for these particular substances.

Finally, the differences in intensity ratings need to be considered. Since this measure was originally intended as a means of controlling for the comparability of the odor stimuli presented in the two laboratories, significant differences in intensity ratings seem at first sight to present a problem. Certainly, some variability between the laboratories in the preparation of perishable substances, e.g. beer, cannot be excluded. However, for the non-perishable substances, which could be presented in precise amounts and thus at the same concentration in both countries, significant differences in intensity ratings (e.g. for the odors of ointment and dried fish) suggest that true differences in intensity perception between populations may indeed exist. Moreover, when scores for intensity, familiarity and pleasantness were compared, the two populations showed very similar patterns of responding, with intensity being significantly correlated with familiarity and pleasantness (Distel *et al.*, 1997). To the extent that perceived intensity can indeed be shown to depend on experience, the mechanisms by which the environment can influence such a basic aspect of odor perception became of major interest (cf. Hyman, 1977; Pager, 1977).

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