Emotion

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Do affective responses to odors vary as a function of culture? To address this question, we developed two self-report scales in the United Kingdom (Liverpool: LEOS) and in Singapore (city of Singapore: SEOS), following the same procedure as used in the past to develop the Geneva Emotion and Odor Scale (GEOS: Chrea, Grandjean, Delplanque et al., 2009). The final scales were obtained by a three-step reduction of an initial pool of 480 affective terms, retaining only the most relevant terms to describe odor-related subjective affective states and comprised of six (GEOS) or seven affective dimensions (LEOS and SEOS). These included dimensions that were common to the three cultures (Disgust, Happiness Well-being, Sensuality Desire, and Energy), common to the two European samples (Soothing Peacefulness), and dimensions that were culture specific (Sensory Pleasure in Geneva; Nostalgia and Hunger Thirst in Liverpool; Intellectual Stimulation, Spirituality, and Negative Feelings in Singapore). A comparative approach showed that the dimensional organization of odor-related affective terms in a given culture better explained data variability for that culture than data variability for the other cultures, thus highlighting the importance of culture-specific tools in the investigation of odor-related affect.

Keywords: olfaction, affective experience, self-report, cross-cultural differences, dimensional models of emotion

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Many studies in fields as varied as psychology, neuroscience, and sociology agree that affect is a major feature of olfactory perception. In a general sense, affect can be defined as "a mental state that is characterized by emotional feeling" and refers to various categories of mental processes and states, such as emotions, attitudes, or moods (Frijda & Scherer, 2009, p. 10). Research on affective dimensions of olfactory perception has mainly focused on narrower defining characteristics of an affect, using dimensional approaches (valence/arousal dimensions) or a limited number of basic emotions. Many studies focused on the bipolar hedonic valence dimension, that is, the propensity of an odor to be pleasant, liked, agreeable, and pleasurable (or, on the contrary,

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unpleasant, disliked, disgusting, and repulsive). Most of these studies (and, particularly, in the unpleasant pole, see Ehrlichman & Bastone, 1992, for a review) report that unpleasant odors have negative impacts and pleasant odors have positive impacts on moods, performance in cognitive tasks, object evaluation, or consumer behaviors (e.g., Degel & Köster, 1999; Herz, 2002; Knasko, 1992, 1995; Rotton, 1983; Schiffman, Miller, Suggs, & Graham, 1995; Schiffman, Sattely-Miller, Suggs, & Graham, 1995; Spangenberg, Crowley, & Henderson, 1996). Other works focused on arousal, namely, the excitatory (or activating) versus calming (or inhibiting) effects of odors, whether estimated in terms of self-report or physiological measures. They revealed calming properties of some floral odors, such as lavender (Goel, Kim, & Lao, 2005; Heuberger, Redhammer, & Buchbauer, 2004), and stimulating effects of some others, such as jasmine (Torii et al., 1988; but see Goel & Lao, 2006). These effects seem to be mostly mediated by psychological factors, for example, expectations about and/or explicit identification of odors (Lorig & Roberts, 1990; see Herz, 2009, for a review). Studies have predominantly focused on the valence and arousal aspects of affective responses to odors, probably because (a) valence is a dominant dimension of odor perception (Engen, 1982; Yeshurun & Sobel, 2010) and (b) one of the main classical theories of emotion summarizes facets of emotion in these two dimensions (valence and arousal; Russell, 1980). However, the limitation of such a dimensional approach is that it is very reductive and does not allow a comprehensive view of odor-related affects. Finally, some other researchers have investigated affective odor perception, using the theory of basic emotions, generally defining six states (fear, anger, sadness, surprise, joy or happiness, and disgust). However, some of these affective states, especially fear, anger, and sadness, are very seldom evoked by odor stimuli (Bensafi et al., 2002; Chrea, Grandjean, Delplanque et al., 2009; Desmet, 2006; see also Porcherot et al., 2010).

Memory association between odors, and both the context in which they are encountered (e.g., Forestell & Mennella, 2005; Robin, Alaoui-Ismaili, Dittmar, & Vernet-Maury, 1999) and autobiographical events (Chu & Downes, 2000; Proust, 1922), is particularly strong. Odors are thus very likely to elicit a much wider range of affective feelings than those related to dimensional models, including valence and arousal, or basic emotions. In view of this, Chrea, Grandjean, Delplanque et al. (2009) developed the Geneva Emotion and Odor Scale (GEOS) to allow a detailed investigation of odor-elicited affective feelings in their most relevant dimensions. It must be noted that although the term "emotion" designates more restricted phenomena when used *sensu stricto* (see Scherer, 2005), our use in the title of the scales must be understood in the broadest sense of the word, to designate "subjective affective experience," that is, feelings. Inspired by a study on music and emotions (Zentner, Grandjean, & Scherer, 2008), the development of GEOS, with a French-speaking sample in Geneva, Switzerland, followed three steps. First, 220 subjects rated the relevance of 480 affective terms to describe affective feelings triggered by odors, allowing to reduce the set to the 73 most relevant terms. Second, 37 subjects smelled 24 odorants and rated their affective feelings with this subset of terms, leading to a reduction to 36 terms. Third, the relevance and structure of the scale were confirmed with 210 subjects, using 56 odorants. The quality of GEOS was ensured by the wide range of initial terms, participants, and odorants used. Its superiority (in terms of inter-rater agreement and interodor discriminative power), compared to the classical dimensional and basic emotion models, has been assessed and confirmed (Chrea, Delplanque, Grandjean et al., 2009). However, the range of affective states triggered by odors is likely to vary according to cultures because they provide contrasted contexts to which odors are associated (e.g., with regard to food and hygienic habits or other domestic use of odors). If so, this would prevent the use of GEOS in any other culture in the absence of any prior investigation of potential cultural differences and would suggest that adapted scales should be used in different cultures.

To our knowledge, cross-cultural studies in psychology have not, to date, investigated odor-elicited affective states in such a comprehensive manner as that of the GEOS approach. Rather, they have mainly focused on hedonic aspects of odorants (valence) presented experimentally (e.g., Schaal et al., 1997) or with freely recalled associations with odors imagined by the participants (e.g., Schleidt, Neumann, & Morishita, 1988). The underlying question of these studies was whether hedonic responses to odors are universal or dependent on an individual's experiential and cultural background. Support for the latter possibility comes from two major cross-cultural studies. The first study, led by Pangborn, Guinard, and Davis (1988), examined the responses of participants from 16 regions to 22 odorants and showed a positive correlation between hedonic appreciation and the frequency with which the raters had encountered the odorants in their daily lives. The second study (National Geographic Smell Survey) was conducted by Wysocki, Pierce, and Gilbert (1991) on 1.4 million participants over the five continents. Consistently with the first study, they showed geographic variation in hedonic ratings of six odorants. For instance, the odor of wintergreen was more appreciated in the United States, where it is positively associated with candies, than in Europe, where it is negatively associated with medication. Nevertheless, there is also evidence for cultural convergence in odor processing. For example, Schleidt et al. (1988) and Schaal et al. (1998) found consensus between cultures for the unpleasant pole of odor hedonics, namely, a convergent negative evaluation of the odors of decaying organic matter, feces, and body odors (Japanese vs. German participants in Schleidt et al., 1988; Indonesian vs. Canadian participants in Schaal et al., 1998). These results nevertheless need to be qualified, because tolerance to some unpleasant smells might be greater in some cultures, compared to others (mercaptan and derivates: Pangborn et al., 1988; Schaal et al., 1998; Wysocki et al., 1991). In contrast, there is higher cultural variability in hedonic ratings of relatively pleasant odors (i.e., odors from nature, hygiene, or food: Schaal et al., 1998; Schleidt et al., 1988). The link between experience and liking (which probably underpins this variation) is revealed by the positive link between pleasantness on one hand and, on the other hand, familiarity (Delplanque et al., 2008), frequency of use, and presence in the culture (Ayabe-Kanamura et al., 1998; Distel et al., 1999; Pangborn et al., 1988).

Anthropological and sociological studies have pioneered the study of cultural differences in odor perception (e.g., Classen, Howes, & Synnott, 1994; Drobnick, 2006). They have the advantage of examining cultural aspects of affective responses in a wider field than just the hedonic valence mentioned above, but these studies are only few in number. To our knowledge, there has been

no systematic investigation, to date, of the cultural variation of subjective affective experiences in the broadest sense. Thus, the aims of the research presented in this article were (a) to develop culture-specific scales to verbally measure affective feelings triggered by odors in two distinct cultures, Singapore and the United Kingdom (Liverpool), (b) to test different scale architectures in order to obtain the best model for each culture, and (c) to compare the resulting models with regard to cultural differences. The selection of Singapore and Liverpool, in addition to Geneva, was motivated both by the two possible levels of cross-cultural comparison (i.e., two different European cultures, and European vs. Asian cultures) and by practical reasons (i.e., collaborations with local universities). The method used was similar to the one used to develop the Geneva Emotion and Odor Scale in a French-speaking population (Chrea, Grandjean, Delplanque et al., 2009). In this article, we present the Singapore Emotion and Odor Scale (SEOS) and the Liverpool Emotion and Odor Scale (LEOS) models, and we compare them with the Geneva Emotion and Odor Scale (GEOS) in order to identify both cultural invariants and specificities in self-reported affective responses to odors.

Method

Materials

List of affective terms. A total of 480 terms were taken from the literature with or without reference to the olfactory modality, forming an initial list, which was as exhaustive as possible (same list as in Chrea, Grandjean, Delplanque et al., 2009). The terms were chosen because they represent affective feelings experienced in everyday life. This list was progressively reduced from Study 1 to Study 3.

Odorants. Odorant stimuli were used in Studies 2 and 3 only. We used 24 odorants in Study 2 and 56 odorants in Study 3 that were identical to those used in Chrea, Grandjean, Delplanque et al. (2009; Appendix 1). In Study 3, three culture-specific odorants were added in Singapore, raising the number of odorants to 59: pandan (a tropical plant widely used in Southeast Asian cooking), soya, and coconut. This augmentation was performed because the 24 odorants of Study 2 were less familiar in Singapore than in Geneva or Liverpool (cf. Supplemental Material, part 1). In a pilot study run between Studies 2 and 3, Singaporean participants were asked to suggest up to three odors that they thought to be very typical of their culture and that did not appear in the list of odors we planned to use. The three retained odors (cited above) were those that were both the most frequently suggested and most easily available as raw material (cf. Supplemental Material, part 2). The odor sets used in Studies 2 and 3 were composed of a large range of everyday odors, selected according to the following criteria: (a) as many pleasant as unpleasant odors, (b) high proportion of familiar odors to elicit affective reactions linked to autobiographical memories, and (c) various odor-related contexts (food: sweet, savory, fruits, spices, drinks, and vegetables; nonfood: cosmetic, household, woody, plants, animal, floral, and medicine). The odorants, provided by Firmenich (Geneva, Switzerland), were diluted in odorless dipropylene glycol. Pen-like devices (Sniffin' Sticks; Burghart Gmbh, Germany) were filled with 7 mL of each diluted solution and coded with a three-digit number. To limit olfactory fatigue in Study 2, the 24-odor set was split into two subsets of 14 odorants, differing on 10 odorants and possessing four odorants in common. As the interparticipant consistency was good for these four odorants (cf. Supplemental Material, part 3), the 56 (Liverpool) and 59 (Singapore) odor sets of Study 3 were split into eight distinct subsets of seven to eight odorants (no odors in common). During data collection, the odorants were presented in random order.

Participants

In Studies 1 and 2, participants were recruited among the undergraduate students of the University of Liverpool (mostly in Psychology, Biological Sciences, and Veterinary Sciences) and of the University of Singapore (mostly in Psychology). In Study 3, people from the general public were recruited, in the World Museum of Liverpool and in the Science Center of Singapore. Participants were remunerated for their participation. Characteristics of age, gender, sample size, and percent smokers of the samples are presented in Table 1. In Singapore, well-known for its high diversity, participants' ethnicity was mostly Chinese (79%), but also Indian (8%) and Malay (6%). Note that the experiment was performed in English, because it is one of the country's four official languages. In Liverpool, participants were all English native speakers and were originating from England (90%), but also from Ireland (4%), Wales (4%), and Scotland (2%).

Table 1
*Size (*N*), Gender (% Males), Age (M ± SD, in Years) and % Smokers of the Groups of Participants in Study 1, 2, and 3 in Singapore, Liverpool, and Geneva*

	Study 1	Study 2	Study 3
Singapore	$N = 105$ (27% males) Age 20.7 ± 1.4 4% smokers	$N = 38$ (29% males) Age 21.1 ± 1.9 3% smokers	$N = 211$ (41% males) Age 30.0 ± 9.0 8% smokers
Liverpool	$N = 148$ (35% males) Age 21.7 ± 3.4 11% smokers	$N = 41$ (46% males) Age 23.6 ± 5.1 12% smokers	$N = 351$ (41% males) Age 32.3 ± 13.8 18% smokers
Geneva (Chrea, Grandjean, Delplanque et al. 2009)	$N = 220$ (29% males) Age 31.7 ± 11.5 21% smokers	$N = 37$ (32% males) Age 24.6 ± 5.1 19% smokers	$N = 210$ (28% males) Age 37.8 ± 12.1 21% smokers

Procedure and Data Analysis

Study 1. The aim of Study 1 was term reduction. Participants took part in two 30-min sessions taking place in computer rooms, 1–7 days apart. During these sessions, they were presented with the 480 initial affective terms, presented in random order and split into two subsets (one per session; the order of subsets was counterbalanced across participants). Participants answered the question: "In your opinion, is this term relevant for describing an emotional state you have already experienced when smelling odors in the past?" by rating the terms on a continuous scale ranging from 0 (*not at all relevant*) to 200 (*completely relevant*). They also had the opportunity to tick a box labeled "not understood." Data were collected via a computer-based program.

Following the same procedure as in Geneva, term reduction successively consisted of (a) eliminating the terms that were not understood by more than 5% of the participants (i.e., 76 terms not understood by 8 Liverpudlians or more and 145 terms not understood by 6 Singaporeans or more), (b) keeping only the terms that had a relevance score above 100 in more than 66% of the respondents, and (c) eliminating terms that were considered redundant by three experts of the Geneva coordinating laboratory.

Study 2. The two aims of Study 2 were further term reduction and exploratory analysis of the structure of odor-elicited affective states. Participants were assigned to one of two groups and took part in a single 90-min session, during which they had to smell 14 odorants (10 group-specific odors and four odorants common to the two groups). The odorants were presented in random order and were evaluated by 18–21 participants, according to group and country. Participants picked up the odor pen with the code corresponding to the number indicated by the computer, removed the cap, and smelled the tip of the pen as many times as needed. For each odor, participants rated the intensity of the affective states they had experienced when smelling the odor, on a scale going from 0 (*not at all*) to 200 (*extremely*). The affective states were the terms retained after Study 1, that is, 79 in Liverpool and 81 in Singapore. Affective ratings were followed by familiarity, pleasantness, and intensity rating on 0–200 scales, and odor identification (results not presented here).

Term reduction again consisted in first eliminating terms that were not understood by more than 5% of the participants (i.e., two terms not understood by 2 Liverpudlians or more, and seven terms not understood by 3 Singaporeans or more). Then, an exploratory factor analysis (EFA) with normalized Varimax rotation was performed (with Statistica 8.0; StatSoft Inc., Tulsa, OK), allowing us to retain factors with Eigenvalues > 1.00 and Cronbach's alpha $>$ .80 (i.e., having a satisfactory internal consistency; the Cronbach's alpha was computed on the terms of having a loading of $> .50$ on the dimension). Term selection was then performed based on the following criteria: (a) selected terms had to have high interrater agreement, as measured by the intraclass correlation index (ICC), (b) selected terms had to have a high loading on only one of the retained factors (good discriminating power), and (c) an equivalent number of terms had to be selected for each factor, as far as possible. This procedure retained 37 terms in Liverpool and 36 terms in Singapore, constituting the final scales in each culture.

Study 3. Study 3 aimed at confirming the dimensional structure of odor-elicited affective states, using larger samples of participants (recruited in public areas: museums) and a larger set of odorants. The task was identical to the one in Study 2, except that participants were assigned to one of eight groups, each group being presented with seven to eight odorants (i.e., 56 in Liverpool and 59 odorants in Singapore, divided into eight subsets). Participants rated their affective feelings during 15-min sessions, with the terms retained from Study 2 and several "additional terms." Indeed, to have a sufficient number of terms in common in the three cultures to allow cross-cultural comparison, we added seven terms of the final Geneva model (*salivating*, *soothed*, and *nostalgic* in Singapore; *amusement*, *pleasant*, and *well-being* in Liverpool; *serene* in both countries). Note that these seven terms were, of course, not included in the analyses to obtain the final models for Singapore and Liverpool, as participants from these cultures rated them as irrelevant. Participants thus used 40 terms in Singapore (36 + 4) and 41 terms in Liverpool (37 + 4). As in Study 2, affective ratings of each odorant were followed by familiarity, pleasantness, and intensity rating on 0–200 scales, and odor identification (results not presented here).

An EFA with normalized Varimax rotation was again performed (with Statistica 8.0), followed by confirmatory factor analyses (CFAs) (with MPlus 6.0; Muthén & Muthén, 2010). The CFA tested how well our model fitted the data, the model being the organization of affective terms into a small number of latent variables (here, the affective dimensions, i.e., Energy, Disgust, etc.). Therefore, we tested several models to determine best fit: the model from EFA in Study 2, the model from EFA in Study 3, and two models corresponding to classical theories of emotions, namely, valence and valence/arousal (among the basic emotion terms present in the initial list, some were rated as not relevant to describe odor-related feelings, e.g., "fear," and the basic emotion model could thus not be tested). According to the criteria proposed by Hu and Bentler (1999), a model can be considered as good when the root mean square error of approximation (RMSEA) is $< .06$. A second criterion, the comparative fit index (CFI), indicates acceptable fit when CFI $> .90$. In a comparative approach, the model with the highest CFI and the lowest RMSEA is considered the best. The significance of the differences of fit between the different models was analyzed through the Satorra-Bentler scaled chi-square difference test (Satorra & Bentler, 2001).

Cross-Cultural Comparison

To further test the hypothesis of cultural specificity, we determined whether the structure of one culture would fit better to the data of that culture than to the data of the other cultures. To achieve this, we first used 21 terms that were present in the three cultures, and we organized them either according to the Geneva, the Liverpool, or the Singapore structure. Note that among these 21 terms, six were "additional terms" as described above (Study 3; the seventh "additional term" *nostalgic* was not included in this first comparison because it could not be conceptually placed in any of the dimensions investigated).

As this first comparison failed to consider culture-specific terms, we conducted a second comparison that used all terms present in Singapore, Liverpool, and Geneva, respectively (Singapore: 36 + 4 "additional terms"; Liverpool: 37 + 4 "additional terms"; Geneva: 36 terms). For example, to test the Geneva structure on the Liverpool data, all terms of the Liver-

pool model were organized according to the Geneva structure, and terms that did not appear in the Geneva structure were placed together in what we called an additional "mixed" dimension. When a single term was identified as belonging to one of the Geneva dimensions, it was placed in the mixed dimension, because it is not possible to have a dimension constituted by only one term. This procedure was identical for all samples, allowing us to test the structures of the three cultures on the data from these same three cultures.

Results

Study 1

According to the participants' ratings of the relevance of each 480 affective terms to describe affective feelings elicited by odors, we were able to select 81 and 79 terms in Singapore and Liverpool, respectively (73 were retained in Geneva). At this stage, 47 terms were common to all three cultures, and each culture had between 17 and 20 specific terms (i.e., retained only in that given culture).

Study 2

In Study 2, the EFA on the data from Singapore and Liverpool yielded six dimensions, with eigenvalues > 1.00 in either culture (see Table 2). In Singapore, interitem consistency was high, with Cronbach's alphas ranging from .77 to .99. Although our criterion to retain dimensions was an internal consistency above .80, we kept one dimension with an internal consistency of .77, because this dimension was considered conceptually important (Spirituality) and because alphas greater than .70 are acceptable (Kline,

Table 2
Factors (Dimensions) of the Exploratory Factor Analyses (EFA) in Study 2 and 3, in The Singapore and the Liverpool Samples

Dimensions	Terms	% explained variance[a]	Cronbach's alpha[b]
	Singapore		
STUDY 2			
1. Disgust	Horrible, disgusted, unpleasant, uncomfortable, unpleasantly surprised, dirty, sick, irritated, etc.	13.6	.96
2. Sensuality-desire	Sexy, sexually aroused, adoring, sensual, admiration, in love, romantic, charmed desire, etc.	3.6	.94
3. Energy-well-being	Pleasant, happiness, relaxed, well-being, refreshed, comforted, revitalized, pleasantly surprised, energetic, etc.	44.2	.99
4. Negative feelings	Sad, boredom, depressed, stressed, angry, etc.	2.3	.86
5. Intellectual stimulation	Amusement, interesting, fascinated, etc.	2.2	.81
6. Spirituality	Religious feeling, spiritual feeling, etc.	1.9	.77
STUDY 3			
1. Disgust	Horrible, disgusted, unpleasant, uncomfortable, sick, irritated, unpleasantly surprised, dirty, stressed, angry	17.3	.95
2. Sensuality-desire	Sexy, sexually aroused, romantic, in love, sensual, adoring, charmed, desire, admiration	37.0	.94
3. Energy-well-being	Refreshed, relaxed, revitalized, comforted, pleasant, well-being, happiness, energetic, pleasantly surprised	4.6	.94
4. Negative feelings	Sad, boredom, depressed	3.4	.65
5. Intellectual Stimulation	Amusement, interesting, fascinated	2.9	.77
6. Spirituality	Religious feeling, spiritual feeling	4.1	.69
	Liverpool		
STUDY 2			
1. Disgust	Repelled, unpleasant, uncomfortable, disgusted, nauseous, unpleasantly surprised, sick, dirty, etc.	12.7	.97
2. Sensuality-desire	Sexy, lustful, romantic, to feel intimacy, desire, attracted, in love, sensual, etc.	3.3	.94
3. Energy-well-being	Energetic, rejuvenated, revitalized, refreshed, stimulated, in a good mood, clean, pleasantly surprised, etc.	38.3	.98
4. Soothing-peacefulness	Relaxed, peaceful, soothed, meditative, comforted, protected, drowsy, dreamy, etc.	3.8	.95
5. Hunger-thirst	Thirsty, salivating, famished, etc.	2.7	.80
6. Nostalgia	Sentimental, nostalgic, etc.	1.6	.83
STUDY 3			
1. Disgust	Disgusted, sick, unpleasant, nauseous, repelled, uncomfortable, unpleasantly surprised, dirty	14.2	.95
2. Sensuality-desire	Sexy, lustful, romantic, in love, to feel intimacy, desire, sensual, attracted, dreamy, peaceful	39.0	.94
3. Energy-well-being	Refreshed, revitalized, rejuvenated, energetic, clean, stimulated, in a good mood, soothed, pleasantly surprised, relaxed	5.1	.93
4. Hunger-thirst	Salivating, famished, thirsty	4.3	.67
5. Nostalgia-soothing	Nostalgic, sentimental, protected, drowsy, comforted, meditative	3.6	.79

Note. Terms are presented in descending order based on their loading on the dimension. For Study 2, only terms that have been retained after the EFA are presented (i.e., about half of the terms initially included in the EFA), and for Study 3, all terms included in the analyses are presented. The percentage of explained variance and the consistency (Cronbach's alpha) of each dimension is also presented.
[a] Computed on all the terms included in the EFAs. [b] Computed on all terms with a loading $> .50$ in Study 2, and on all terms in Study 3.

1993). Cronbach's alphas were also high in Liverpool, ranging from .80 to .98. The titles of the dimensions are interpretations based on the contributing terms. Consequently, similar dimensions were attributed the same label in both cultures: Energy-Well-being, Disgust, and Sensuality-Desire. Culture-specific dimensions were: Negative Feelings, Intellectual Stimulation, and Spirituality in Singapore, and Soothing-Peacefulness, Hunger-Thirst, and Nostalgia in Liverpool.

Study 3

In Study 3, the EFA on the data from Singapore yielded six dimensions, with eigenvalues > 1.00 that were identical to the ones obtained in Study 2, except that the terms *stressed* and *angry* loaded more on the Disgust dimension than on the Negative Feelings dimension (see Table 2). Cronbach's alphas were slightly lower than in Study 2, but were still acceptable (see Figure 1). For the Liverpool data, the structure emerging from the EFA was somewhat less consistent for Studies 2 and 3. There were six dimensions that had eigenvalues > 1.00 in Study 2, whereas there were five in Study 3. As for the Singapore sample, Cronbach's alphas were slightly higher in Study 2 than in Study 3 (see Figure 2).

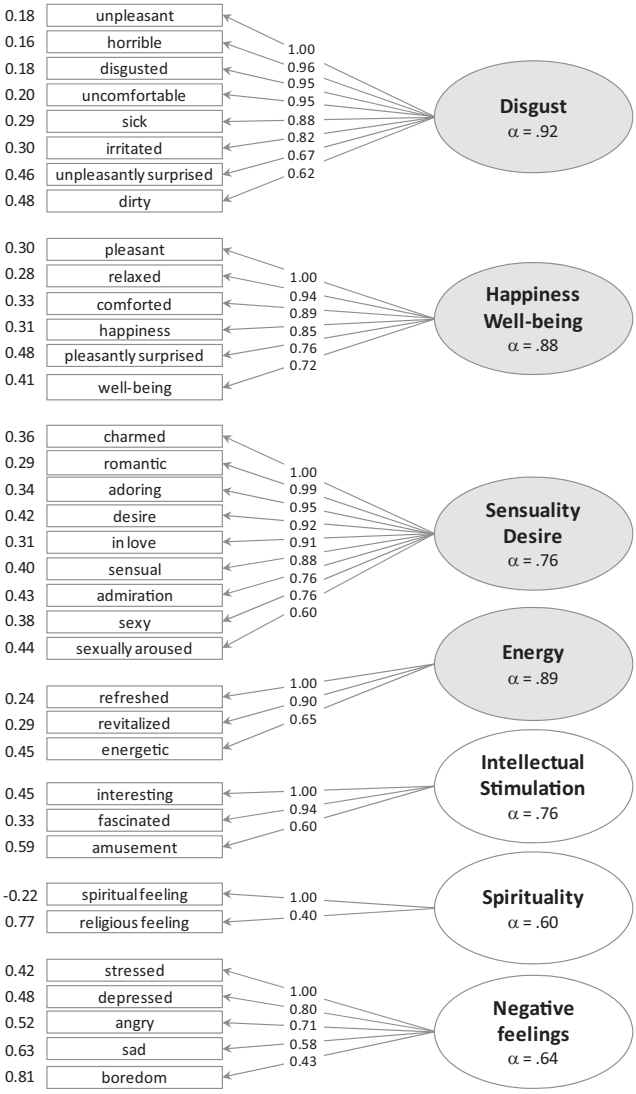

Figure 1. Singapore Emotion and Odor Scale (SEOS). Structure of the final model describing odor-related affective feelings in Singapore (latent factors on the right and items on the left), with the CFA results (error terms on the left, parameter estimates on the arrows). Interrater agreement for each dimension is indicated by the Cronbach's alpha value (α), which is equal to the average of the alphas of the eight groups of participants. Dimensions shared between cultures are shaded.

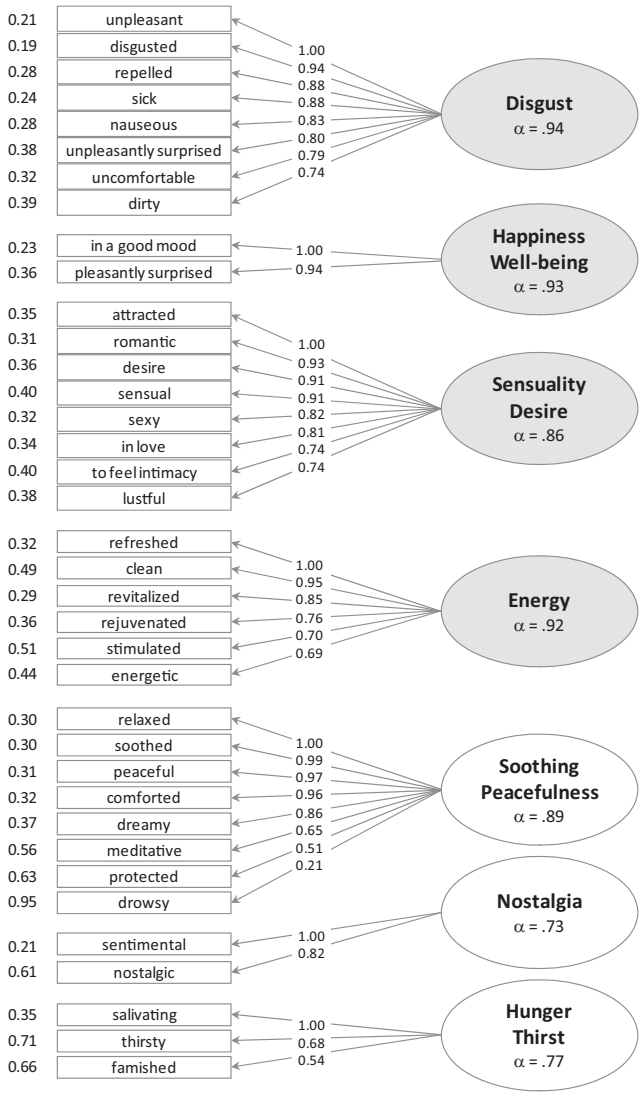

Figure 2. Liverpool Emotion and Odor Scale (LEOS). Structure of the final model describing odor-related affective feelings in Liverpool (latent factors on the right and items on the left), with the CFA results (error terms on the left, parameter estimates on the arrows). Interrater agreement for each dimension is indicated by the Cronbach's alpha value (α), which is equal to the average of the alphas of the eight groups of participants. Dimensions shared between cultures are shaded.

Best-Fit Model and Final Scale

We performed CFAs to identify the model that best explained the data obtained in Study 3. The models tested were the models

emerging from EFA in Studies 2 and 3, the models emerging from EFA in Studies 2 and 3 with the Energy-Well-being dimension split into two dimensions (energy terms on one side and happiness/well-being terms on the other, as it was in Geneva), a valence model, and a valence-arousal model. For the valence model, we defined two latent variables: positive and negative feelings. Negative feelings were described by the terms belonging to the dimensions Disgust and Negative Feelings in Singapore, and only Disgust in Liverpool (see Table 2). Positive feelings were described by the remaining terms from each culture. For the valence-arousal model, we defined four latent variables: positive and negative feelings, and high and low arousal. A similar categorization as for the valence model was applied to positive and negative feelings, with the exception that some terms from the positive-feelings category were moved to the high- and low-arousal categories, according to the expert recommendations (Geneva laboratory). For the Liverpool data, the low-arousal category corresponded to the Soothing-Peacefulness dimension and the high-arousal category contained the terms of the dimensions Hunger-Thirst and Energy-Well-being (except *in a good mood*) (see Table 2, Study 2). For the Singapore data, we moved the terms *relaxed* and *comforted* into the low-arousal category, and the terms of the Intellectual Stimulation dimension and some terms of the Energy-Well-being dimension (*refreshed*, *revitalized*, *pleasantly surprised*, and *energetic*) into the high-arousal dimension.

The fit results for all six models are shown in Table 3 for Singapore and Liverpool separately. When computation was possible, the results of the chi-square difference test performed between the best model (with the highest CFI and lowest RMSEA) and the other models are shown in Table 3 (i.e., when the two compared models had different degrees of freedom). In both cultures, the seven-factor model obtained from the EFA in Study 2 with Energy and Happiness-Well-being separated had the best-fit indices and was statistically better than all the other models, including the valence and valence-arousal models. Moreover, the goodness of fit indices of the best model was within the range required to consider it as a good model (CFI $>$ .900 and RMSEA $<$ .060).

The structures of the final seven-factor models are presented in Figure 1 for Singapore, Figure 2 for Liverpool, and Figure 3 for Geneva. After interpreting the nature of each dimension, four dimensions emerged consistently in the three cultures. One was Disgust, comprising terms that describe the negative feelings triggered by unpleasant odors, from mere inconvenience to sickness. In this dimension, five terms were common to the three cultures: *dirty*, *disgusted*, *sick*, *unpleasant*, and *unpleasantly surprised*. This

Table 3
Goodness of Fit Indices for the Different Models Tested on the Data From Singapore and Liverpool

Tested model	χ^2	df[a]	RMSEA	CFI	Corrected $\Delta\chi^2$	Δdf	p^b
			Singapore				
6-Factor model Study 2 *DISG, SENSU, ENERHAPP, NEGF, INTE, SPIR*	1747.09	579	0.036	0.941	44.95	6	<.001
7-Factor model Study 2 *DISG, SENSU, ENER, HAPP, NEGF, INTE, SPIR*	**1625.03**	**573**	**0.034**	**0.947**			
6-Factor model Study 3 *DISG, SENSU, ENERHAPP, NEGF, INTE, SPIR*	1918.56	579	0.039	0.932	84.17	6	<.001
7-Factor model Study 3 *DISG, SENSU, ENER, HAPP, NEGF, INTE, SPIR*	1797.62	573	0.037	0.938	—[c]	—	—
Valence model *V+, V−*	3645.10	593	0.058	0.846	485.63	20	<.001
Valence-arousal model *V+, V−, A+, A−*	3132.21	588	0.053	0.871	400.02	15	<.001
			Liverpool				
6-Factor model Study 2 *DISG, SENSU, ENERHAPP, SOOT, HUNG, NOST*	2794.09	614	0.038	0.929	171.30	6	<.001
7-Factor model Study 2 *DISG, SENSU, ENER, HAPP, SOOT, HUNG, NOST*	**2358.47**	**608**	**0.034**	**0.943**			
5-Factor model Study 3 *DISG, SENSU, ENERHAPP, HUNG, SOOTNOST*	3997.55	619	0.047	0.891	536.62	11	<.001
6-Factor model Study 3 *DISG, SENSU, ENER, HAPP, HUNG, SOOTNOST*	3269.22	614	0.042	0.914	279.43	6	<.001
Valence model *V+, V−*	6073.27	628	0.060	0.824	893.32	20	<.001
Valence-arousal model *V+, V−, A+, A−*	3927.40	623	0.047	0.893	521.44	15	<.001

Note. The number of observations was 1554 in Singapore and 2448 in Liverpool, and the number of observed variables was 36 in Singapore and 37 in Liverpool. The models with the best fit are in bold. A+ = Positive arousal; A− = Negative arousal, DISG = Disgust, ENER = Energy; HAPP = Happiness well-Being; HUNG = Hunger-thirst; INTE = Intellectual stimulation; NEGF = Negative feelings; NOST = Nostalgia; SENSU = Sensuality Desire; SOOT = Soothing peacefulness; SPIR = Spirituality; V+ = Positive valence; V− = Negative valence.

[a] df = degrees of freedom. [b] Corrected $\Delta\chi^2$, Δdf, and p refer to the comparison of the given model with the best model in bold (i.e., the model with the lowest RMSEA and the highest CFI indices) for the data of a given culture. [c] Statistical comparison between two models were possible only when their degrees of freedom were different.

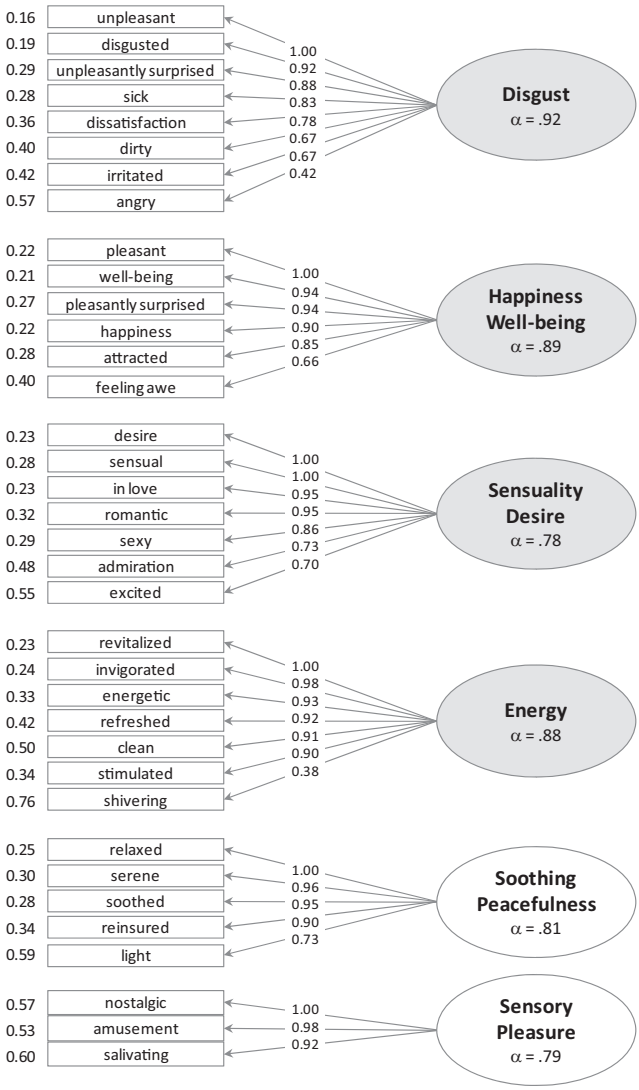

Figure 3. Geneva Emotion and Odor Scale (GEOS; from Chrea, Grandjean, Delplanque et al., 2009). Structure of the final model describing odor-related affective feelings in Geneva (latent factors on the right and items on the left), with the CFA results (error terms on the left, parameter estimates on the arrows). Interrater agreement for each dimension is indicated by the Cronbach's alpha value (α), which is equal to the average of the alphas of the eight groups of participants. Dimensions shared between cultures are shaded.

dimension was mainly driven by the odors of civet and dirty socks. The smell of durian, a popular tropical fruit in Southeast Asia, evoked, because of its smell of decay, high disgust ratings in the European samples, but not in Singapore, consistent with the cultural variations of familiarity and pleasantness.

The second dimension that showed across cultures was Sensuality-Desire, referring to sociosexual contexts involving interpersonal attraction and intimate relationships. Again, five terms were common to the three cultures: *desire*, *in love*, *romantic*, *sensual*, and *sexy*. Odorants having the highest ratings on this dimension were strawberries, flowers, and, in Liverpool and Singapore only, cosmetics (e.g., shampoo, laundry soap).

The two other dimensions common to all three cultures were Energy and Happiness-Well-being. Energy had more common terms across the three cultures (*energetic*, *refreshed*, and *revitalized*) than Happiness-Well-being (*pleasantly surprised*), suggesting that the latter affective dimension is culturally less stable (references to soothing aspects appeared in that dimension in Singapore only, for instance). Citrus fruits (grapefruit, tangerine) and minty odors (peppermint, eucalyptus) scored highly on Energy, whereas sweet odors (especially strawberry) scored highly on Happiness-Well-being.

The last common dimension, Soothing-Peacefulness, was shared by the two European samples. However, in either case, this dimension comprised different terms (except *relaxed* and *soothed*). It was more linked to lethargy in Liverpool, with the terms *dreamy* and *drowsy* that did not appear in Geneva. In both samples, this dimension was associated with sweet, cosmetic, and flowery odors.

Besides these common dimensions, cultural specificities emerged. In Liverpool, the culture-specific dimensions were Nostalgia, associated with flowery odors and candy odors (aniseed and strawberry, probably recalling childhood memories), and Hunger-Thirst, referring to the desire for foods and drinks and mainly associated with fruity and sweet odors. In Singapore, three specific dimensions can be described. First, Intellectual Stimulation referred to positive interest and arousal, and was characterized by fruity and sweet odors. Second, Spirituality referred to terms that were irrelevant in the two European samples (eliminated in Study 1), namely, *religious feeling* and *spiritual feeling*. Odors scoring the highest on this dimension were incense and woody odors (note that, in Singapore, the odor of wood-firsantol was directly or indirectly identified as incense in 75% of the identification responses in Study 3, which was not the case in Liverpool). This result is certainly due to the association between incense and praying or meditation, as shown by the content of identification responses, including items such as "altar," "temple," "church," "praying," "meditation," "religious lamps," "incense," "joss sticks," and "talisman water." Finally, a dimension grouping Negative Feelings emerged. This dimension concerned the negative impact of odors that went beyond simple disgust or sickness. The fact that, despite our efforts in the odor selection for Study 3, odors were less liked in Singapore (liking scale: $M = 54.8 \pm 37.6$ vs. $M = 71.5 \pm 41.9$ in Liverpool and $M = 75.2 \pm 40.4$ in Geneva; $F_{2,165} = 4.13$, $p < .05$, post-hoc Tukey's HSD test at $\alpha = .05$) could be an explanation why the negative pole was more represented in the affective scale in Singapore (two dimensions: Disgust and Negative Feelings) than in the two other samples (one dimension: Disgust).

Although a qualitative approach of interrater agreement (represented by Cronbach's alpha by dimension, see Figures 1, 2, and 3) would suggest that participants were the most consistent using terms related to Disgust and were less consistent using terms related to culture-specific dimensions, there was no significant statistical difference between the different dimensions within each culture (cf. Supplemental Material, part 4).

Cross-Cultural Comparison (Study 3)

First, goodness of fit statistics of the Geneva, Liverpool, and Singapore models on the data from Geneva, Liverpool, and Sin-

Table 4
Goodness of Fit Indices for the Models From Singapore, Liverpool, and Geneva on the Data From the Three Cultures, Based on 21 Common Terms

	Singapore data ($N = 1554$)	Liverpool data ($N = 2448$)	Geneva data ($N = 1446$)
Singapore 5-factor model = DISG + SENSU + ENER + SEPL[a] + HAPP (relaxed, pleasant, pleasantly surprised, well-being + serene[b], soothed[b])	$\chi^2 = 568.99$ df = 179 RMSEA = 0.037 CFI = 0.950	$\chi^2 = 982.49$ df = 179 RMSEA = 0.043 CFI = 0.947	$\chi^2 = 1050.81$ df = 179 RMSEA = 0.058 CFI = 0.941
Liverpool 6-factor model = DISG + SENSU + ENER + SEPL[a] + SOOT (relaxed, soothed) HAPP (pleasantly surprised + serene[b], pleasant[b], well-being[b])	$\chi^2 = 538.25$ df = 174 RMSEA = 0.037 CFI = 0.954	$\chi^2 = 878.34$ df = 174 RMSEA = 0.041 CFI = 0.953	$\chi^2 = 890.88$ df = 174 RMSEA = 0.053 CFI = 0.952
Geneva 6-factor model = DISG + SENSU + ENER + SEPL[a] + SOOT (relaxed, serene, soothed) HAPP (pleasant, pleasantly surprised, well-being)	$\chi^2 = 512.52$ df = 174 RMSEA = 0.035 CFI = 0.957	$\chi^2 = 810.64$ df = 174 RMSEA = 0.039 CFI = 0.958	$\chi^2 = 742.82$ df = 174 RMSEA = 0.048 CFI = 0.962
Chi-square difference tests[c]			
Geneva vs. Singapore	$\Delta\chi^2(5) = 21.46^{***}$	$\Delta\chi^2(5) = 67.09^{***}$	$\Delta\chi^2(5) = 111.12^{***}$
Geneva vs. Liverpool	—[d]	—	—
Singapore vs. Liverpool	$\Delta\chi^2(5) = 12.00^{*}$	$\Delta\chi^2(5) = 51.96^{***}$	$\Delta\chi^2(5) = 67.93^{***}$

Note. Constant dimensions across models are DISG = Disgust (dirty, disgusted, sick, unpleasant, unpleasantly surprised); SENSU = Sensuality desire (desire, in love, romantic, sensual, sexy); ENER = Energy (energetic, refreshing, revitalized) and SEPL = Sensory pleasure (amusement, salivating). Dimensions with variable contents are SOOT = Soothing peacefulness, and HAPP = Happiness well-being.
[a] Dimension containing the additional terms *amusement* and *salivating* (additional terms: terms exclusively present in the Geneva model and added in Study 3 data collection in Liverpool and Singapore, for the purpose of model comparison). [b] Additional terms. [c] Corrected $\Delta\chi^2$, Δdf within brackets and p (***: $p < .001$; * $p < .05$) refer to the comparison of the given model with the best model (i.e. the model with the lowest RMSEA and the highest CFI indices) for the data of a given culture. [d] Statistical comparison between two models were possible only when their degrees of freedom were different.

gapore for the 21 terms common to the three cultures (Study 3) are given in Table 4. Although we expected the model from a given culture to explain the data of that culture better than the models of the other cultures, it appeared that the Geneva model outperformed the models of the other cultures in explaining the data in the three cultures (higher CFI and lower RMSEA indices, and statistically significant chi-square difference tests). This might be due to the fact that the 21 terms involved six terms relevant in Geneva that we artificially introduced in Liverpool and Singapore (although they were not relevant in those samples) for purpose of comparison. Nevertheless, and consistent with our initial hypothesis, the Liverpool model predicted the Liverpool data better than the Singapore model, and the Singapore model predicted the Singapore data better than the Liverpool model. This first cross-cultural analysis suggests that it is possible to use one unique reduced model (i.e., the 21-term Geneva model) in the three studied cultures to satisfactorily structure the participants' answers.

Second, when all terms used in each culture were retained for analysis, organized according to the Geneva, Liverpool, and Singapore structures plus a mixed dimension gathering all remaining items (see method section), we obtained the goodness of fit statistics shown in Table 5. For all three cultures, and consistent with our hypothesis, the model of a given culture explained the data of that culture better than the models of the other cultures. This second cross-cultural analysis suggests that, although a unique model can be used satisfactorily, as seen above, there is a significant advantage to use culture-specific models to explain and structure the scores of participants from that culture.

Finally, the common dimensions (Disgust, Happiness-Well-being, Desire, and Energy in the three cultures, and Soothing-Peacefulness in the two European cultures) elicited a comparable interrater agreement level (represented by Cronbach's alpha by dimension) in all cultures (no significant statistical difference; cf. Supplemental Material, part 4).

Discussion

The aims of the present study were (a) to construct self-report scales of odor-related feelings in three cities belonging to different cultures that would allow a reliable, detailed description of affective states elicited by a wide variety of odors, (b) to test several alternative models in order to obtain the best culture-specific models in each culture, and (c) to compare the models obtained in each culture. Extending the procedure initially used by Chrea, Grandjean, Delplanque et al. (2009) in Geneva to Singapore and Liverpool, we obtained two scales satisfying the following quality criteria: exhaustiveness (due to the large number of initial terms and the wide variety of odors used), reasonable size (between 30 and 40 items, the most relevant to the olfactory domain), high interrater agreement, and high cultural specificity (by a strict selection of the sample). After testing several model architectures, coming both from EFAs on the data at several stages of the experiment and from theoretical hypotheses (e.g., valence-arousal dimensional model), we finally found that the models with the best fit were two 7-dimension models. These models, presented in Figures 1 and 2 and called the Singapore Emotion and Odor Scale (SEOS) and the Liverpool Emotion and Odor Scale (LEOS), can be used in the future to investigate verbal reports of odor-elicited feelings in those cultures. These two scales thus complement the previously developed GEOS that is currently used (Porcherot et al., 2010).

Table 5
Goodness of Fit Indices for the Models From the Three Cultures Tested on the Data From the Three Cultures, Based on 41 Terms in Liverpool (Including Four Added Geneva Terms), 40 Terms in Singapore (Including Three Added Geneva Terms), and 36 Terms in Geneva (G)

	Singapore data (N = 1554, 40 terms)	Liverpool data (N = 2448, 41 terms)	Geneva data (N = 1446, 36 terms)
Singapore model	8 factors χ^2 = 2058.87 df = 712 RMSEA = 0.035 CFI = 0.939	5 factors χ^2 = 8029.28 df = 769 RMSEA = 0.062 CFI = 0.791	5 factors χ^2 = 4680.26 df = 584 RMSEA = 0.070 CFI = 0.844
Liverpool model	5 factors χ^2 = 6394.56 df = 730 RMSEA = 0.071 CFI = 0.742	8 factors χ^2 = 3104.72 df = 751 RMSEA = 0.036 CFI = 0.932	5 factors χ^2 = 5132.70 df = 584 RMSEA = 0.073 CFI = 0.826
Geneva model	7 factors χ^2 = 6114.19 df = 719 RMSEA = 0.069 CFI = 0.754	7 factors χ^2 = 8646.16 df = 758 RMSEA = 0.065 CFI = 0.773	6 factors χ^2 = 2540.70 df = 579 RMSEA = 0.048 CFI = 0.925
Chi-square difference tests[a]			
Geneva vs. Liverpool	—[b]	$\Delta\chi^2(7) = 709.67^{***}$	$\Delta\chi^2(5) = 466.17^{***}$
Geneva vs. Singapore	$\Delta\chi^2(7) = 920.86^{***}$	—	$\Delta\chi^2(5) = 487.13^{***}$
Singapore vs. Liverpool	$\Delta\chi^2(18) = 1087.88^{***}$	$\Delta\chi^2(18) = 1088.46^{***}$	—

[a] Corrected $\Delta\chi^2$, Δdf within brackets and p (*** $p < .001$) refer to the comparison of the given model with the best model (i.e. the model with the lowest RMSEA and the highest CFI indices) for the data of a given culture. [b] Statistical comparison between two models were possible only when their degrees of freedom were different.

Comparison of the models obtained in Singapore, Liverpool (the present study), and Geneva (Chrea, Grandjean, Delplanque et al., 2009) revealed that odor-elicited affects share common characteristics, even in cultures differing from each other as much as European and Asian cultures. Although not built by exactly the same terms, four dimensions that we interpreted as being related to Disgust, Happiness-Well-being, Sensuality-Desire, and Energy were found in the three cultures (and Soothing-Peacefulness was found in the two European cultures). We hypothesized that these affective dimensions were recurrent because they are related to the major functions of olfaction. These are, according to a recent review (Stevenson, 2010), Ingestion, Avoidance of Environmental Hazards, and Social Communication (including reproduction). As first introduced by Darwin (1872), emotional processes prepare the individual to display adaptive behaviors, that is, to provide a suited response to the physical and social environment. Therefore, Disgust responses to odors help the detection and avoidance of hazards, such as gas leaks, fire, or spoiled food (Santos, Reiter, DiNardo, & Costanzo, 2004; Susskind et al., 2008), whereas body odors are involved in Sensuality and Desire (as are perfumes) and could play a significant role in the choice of a good partner in evolutionary terms (Havlicek & Roberts, 2009; Herz & Inzlicht, 2002; Saxton, Lyndon, Little, & Roberts, 2008).

Surprisingly, although eating and drinking have universal and essential functions for the survival of human beings, the dimension Hunger-Thirst was present only in Liverpool. Further investigations would be useful to better understand the origin of such unexpected cultural differences. Finally, Happiness-Well-being, Energy, and Soothing-Peacefulness are rather related to health and well-being that are also major human motivations. They manifest themselves through the practice of aromatherapy, for instance, which claims to enhance well-being, energy, and relaxation (cf. Herz, 2009). Experiencing these feelings might be associated to the fulfillment of expectancies, especially in contexts of food ingestion or social interaction, as suggested by the association of these feelings with fruity and cosmetic/floral odors.

A major part of odor-related affective feelings was thus shared between cultures. This is reinforced by the results of the CFA that applied, on the data of each culture, a reduced model made of 21 terms common to all three cultures. Whatever the organization of these terms (according to the structure of Singapore, Liverpool, or Geneva; see Table 4), the reduced models (and, especially, the Geneva one) all had an excellent ability to explain the data of all three cultures (goodness of fit indices: CFI $>$ .90 and RMSEA $<$ .06). This result suggests that it is possible to explain the odor-related affective states of people from different cultures with a unique short model (although it is not the best method; see below). Some studies have specified that the negative pole of olfactory affects elicits higher consensus among people from different cultures (Schaal et al., 1998; Schleidt et al., 1988). We observed that participants agreed as strongly on positive as on negative dimensions of odor-related emotions within each culture, and that interrater agreement levels were comparable in the three cultures (cf. Supplemental Material, part 4). Across these three samples, some odors elicited disgust reactions (civet, dirty socks), whereas others scored consensually high on positive dimensions (i.e., Happiness-Well-being: grapefruit and strawberry; Sensuality-Desire: strawberry; and Energy: grapefruit, peppermint, and strawberry). Some cross-cultural consensus can thus be found not only in the negative, but also in other dimensions of olfactory feelings.

Apart from identifying universal aspects of odor processing, our study also revealed cultural specificities. When all the affective terms present in a culture were organized according to the final structure obtained by CFA in each culture, the data of a given culture were explained significantly better by the structure of that culture than by the structures of the other cultures (see Table 5). The goodness of fit statistics obtained in a given culture with the models of the other cultures were not satisfactory (CFI $<$ .90 and RMSEA generally $>$ .60 or close to .60), showing that a culture-specific model explains the data best. We also showed that the principle of parsimony, that is, that one should not multiply entities unnecessarily, cannot be applied here. Indeed, the six- and seven-factor models proposed here to explain odor-related affects had better goodness of fit than simpler models classically used (i.e., valence and valence-arousal models). Overall, for researchers who want to measure self-reported affects related to odors in the future, we recommend using the complete culture-specific models.

We identified several dimensions that were relevant and specific to each studied culture. The two European cultures were largely comparable: They had five dimensions in common, and the dimensions Sensory Pleasure (with the terms *nostalgic, amusement,* and *salivating*) in Geneva and Nostalgia in Liverpool (with the terms *nostalgic* and *sentimental*) share a nostalgic connotation, even if they have been labeled differently. Only the Hunger-Thirst dimension was strictly specific to Liverpool. The model obtained in Singapore presented more differences, as compared with the two European samples. First, Singapore presented two dimensions labeled Intellectual Stimulation and Spirituality. The latter was associated with very specific odors that were unrelated to any other dimension: incense, woody and flowery odors that might contribute to the composition of incense (in the form of essential oils or plant extracts). Compared to Europe, the use of incense in Singapore is more widespread and can be found in temples, cemeteries, homes, or even on the roadside. Across these contexts, incense serves a religious function, especially in the Chinese community, which constituted 79% of our sample. As an example, a cohort study on Chinese people in Singapore showed that 77% of the participants use incense, and that among them, 93% use it on a daily basis (Friborg et al., 2008). Many Singaporean Chinese families who are Buddhist or Taoist have altars in their homes and burn incense as part of their offerings to their religious idols or deceased family members. The perception of incense-related odors is thus very likely to reactivate associated religious and spiritual feelings occurring during the religious practices. The psychological and physiological effects related to such a culture-specific dimension should be investigated systematically in future studies. Sociological and anthropological work has highlighted that the interaction between human and divine spheres is ritually governed by the sense of smell in traditional cultures of Southeast Asia. In hunter-gatherers from the Malay peninsula (Chewong, Temiar, and Batek Negrito people) and the Andaman Islands (Ongee people; India), for instance, odors are used to repel, attract, thank the spirits (souls of dead persons), and communicate with them. Fragrances also sometimes incarnate the deities or souls of people (Classen et al., 1994; Roseman, 1990; Shulman, 2006). Although not necessarily representing the Singaporean population, which has hardly ever been studied in terms of olfactory culture (see Low, 2005, though, for a sociocultural approach), these field studies stress the particular ancestral link between spiritual life and odor in Southeast Asian cultures. The association between olfaction and spirituality was also present in European Christianity before the 18th century, but vanished during the modern era (Classen, 2006). It suggests that this (and the other) culture-specific affective dimensions might be particularly sensitive to cultural variations across history, whereas the shared affective dimensions might be more stable over time. Finally, whereas in Geneva and Liverpool only one dimension refers to negative affective states (Disgust), in Singapore, a second dimension appeared (Negative Feelings) with terms that did not appear in the other cultures and that refer to negative moods (e.g., *depressed, angry,* and *sad*). First, this could be due to the fact that, overall, the pleasantness of the presented odorants was reduced in Singapore relative to Liverpool and Geneva. Second, it could also reflect a deeper intellectualization of the negative effects of odors in Singapore, compared to the European cultures. As odors are believed to have spiritual powers, their negative effects might exceed the first direct and momentary effect (e.g., making a person feel sick or disgusted) and might have a deeper and, perhaps, more long-lasting impact (e.g., altering the person's mood). In other words, the hostile reaction to unpleasant smells is expressed not only through the bodily symptoms of core disgust. In Singapore, it is possible that unpleasant smells constitute a more moral offense, which triggers not only disgust, but also high levels of other negative emotions, especially anger (about the link between moral disgust and anger, see Rozin, Haidt, & McCauley, 2008).

The present study had some limitations. First, a recurrent problem in cross-cultural studies that should be kept in mind by researchers willing to use the Odor and Emotion Scales is that these scales were developed in a single city of a country. A city is neither perfectly representative of a country nor of a culture (and country and culture, in turn, do not necessarily match). Nonetheless, variations of affective responses to odors within a geographic area are likely to be smaller than variations between geographic areas (Pangborn et al., 1988), which makes the use of the scales in other parts of the studied countries acceptable. The second limitation refers to linguistic considerations. There is a possibility that a given affective term does not designate exactly the same feeling in two different countries. Therefore, although the translation of the terms from French to English was performed with great caution and with the usual back-translation process in the present study, it cannot be excluded that subtle cross-cultural differences exist in the quality of the affect that is designated by one term—even if they belong to the same dimension. A database is available on cross-cultural differences in the meaning of emotional words, in terms of features such as appraisal (evaluation), bodily symptoms, expression, action tendencies, subjective feeling, and regulation (GRID instrument, unpublished data; see also Fontaine, Scherer, Roesch, & Ellsworth, 2007). As our study involved a larger set of words, it is not yet possible to reconsider our results in the light of this database, and a fully fledged study would be necessary to investigate potential semantic differences. However, a preliminary comparison of four terms (love, disgust, happiness, and anger) present in our study in at least two samples reveals that cultures do, indeed, differ significantly on some aspects, for example, on the expressive pattern of disgust or on the level of activation associated with Anger, in a context not specific to odors (cf. Supplemental Material, part 5, for more details). Finally, it must be noted that the participant samples were composed of more women than

men, because they are usually more prone to take part in psychology experiments involving odor. As women are known to have some advantages in processing olfactory information, such as odor identification and odor memory (e.g., Larsson, Lovden, & Nilsson, 2003), there might be gender-related variations in affective responses to odors in our experimental design. More particularly, identification might influence the affective ratings of some odors because of the associated representations related to some odor category, for example (results not presented here). These gender differences, together with other interindividual differences, such as identification ability, should be systematically investigated in future studies to characterize their potential influence on cultural differences.

To conclude, this is the first study using a comprehensive approach to odor-related affective feelings that compares the structure of the semantic spaces used by members of different cultures to describe their olfactory feelings. This comparison showed that odor-elicited affective feelings comprise some characteristics that are shared between cultures and some that are culture specific (in Europe: United Kingdom and Switzerland; in Asia: Singapore). Association between odors and feelings related to Sensuality-Desire, Disgust, Energy, and Happiness-Well-being are found in all cultures. These likely reflect adaptive behaviors common to all humans (i.e., danger avoidance, reproduction, and search for good mental and physical conditions). Adding other cultures to this approach in the future would reinforce the hypothesis that these dimensions could be universal. The more striking cultural specificities concerned the link between odors and the mental and spiritual life in Singapore, an aspect that did not emerge in the European cultures and that is indisputably due to the extensive use of fragrances (e.g., incense) in religious rituals in this culture. We are now using the Singapore and Liverpool scales SEOS and LEOS developed in this study to investigate further aspects of odor-elicited affective feelings, such as factors underlying interindividual variability within a given culture (e.g., age and gender of the perceivers).

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(*Appendix follows*)

Appendix

Odorants

List of Odorants Used in Study 2 and 3, and Their Concentration (in Volume-Volume Percentage)

	% V/V		% V/V
Study 2		Durian	10
Basil	5	Dynascone	10
Cake	20	Eucalyptus	20
Curry	10	Fig	10
Lime	20	Fire smoke (cade oil)	10
Manure (para-cresol)	1	Grapefruit	20
Orange blossom (neroli oil)	5	Grass	20
Pineapple	10	Honey	pure
Soap fragrance	10	Incense	50
Tutti fruiti	10	Incense (Chinese incense)	20
Study 2 & 3		Lilac	10
Beer	20	Lily of the valley	10
Butternut popcorn	10	Magnolia	20
Cheese	1	Olive oil	20
Civet	10	Pandan[a]	10
Dirty socks (isovaleric acid)	1	Paradisone	pure
Fried shallot, onion	20	Patchouli	10
Laundry soap fragrance	1	Pepper	pure
Lavender	10	Rotten egg (sulfox)	5
Leather	5	Rum	10
Mushroom (carbinol)	5	Soy bean[a]	20
Peppermint	20	Strawberry	10
Pine	pure	Strawberry (Cream strawberry)	5
Shampoo fragrance	10	Strawberry (Floral strawberry)	5
Synthetic body odor	pure	Sulfury and onion (sclarymol)	1
Wood (Landes wood)	5	Tangerine	20
Study 3		Thyme	20
Aniseed (anethol)	20	Tiare	pure
Beef	1	Vetyver	20
Caramel	20	Violet	10
Cigarette smoke	50	Wintergreen (methyl-salicylate)	10
Cinnamon	20	Wood (Agarwood smoke)	20
Clove (eugenol)	20	Wood (Firsantol)	20
Coconut[a]	10	Wood (Wolfwood)	pure
Coffee	20	Yogurt	10
Cucumber	20		

[a] In Singapore only

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