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Original Article

Global Study of Social Odor Awareness

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Abstract

Olfaction plays an important role in human social communication, including multiple domains in which people often rely on their sense of smell in the social context. The importance of the sense of smell and its role can however vary inter-individually and culturally. Despite the growing body of literature on differences in olfactory performance or hedonic preferences across the globe, the aspects of a given culture as well as culturally universal individual differences affecting odor awareness in human social life remain unknown. Here, we conducted a large-scale analysis of data collected from 10 794 participants from 52 study sites from 44 countries all over the world. The aim of our research was to explore the potential individual and country-level correlates of odor awareness in the social context. The results show that the individual characteristics were more strongly related than country-level factors to self-reported odor awareness in different social contexts. A model including individual-level predictors (gender, age, material situation, education, and preferred social distance) provided a relatively good fit to the data, but adding country-level predictors

(Human Development Index, population density, and average temperature) did not improve model parameters. Although there were some cross-cultural differences in social odor awareness, the main differentiating role was played by the individual differences. This suggests that people living in different cultures and different climate conditions may still share some similar patterns of odor awareness if they share other individual-level characteristics.

Key words: odor awareness, olfaction, smell, culture

Introduction

Olfaction plays an important role in human social communication (Stevenson 2010), including multiple domains in which people often rely on their sense of smell in the social context. For example, odors influence assessments of one's attractiveness (Roberts et al. 2011) and personality (Sorokowska et al. 2012), they enhance the proneness to displaying prosocial behaviors (Baron 1997) and can influence social desirability (Regenbogen et al. 2017).

The importance of the sense of smell in the social context can however vary across individuals. Odor awareness reflects the extent to which people are affected by odors in everyday life and their metacognition of olfactory sensations (Smeets et al. 2008). In existing olfactory awareness scales (Cupchik and Phillips 2005; Smeets et al. 2008; Croy et al. 2010) much attention is paid to social odors (e.g., "Do you notice the smell of people's breath or sweat?", "Do you pay attention to the perfume, the aftershave or deodorant other people use?"). An odor-oriented person pays much attention to odors in everyday life and is likely to feel positive or negative affect as a result of exposure to certain odors. Higher awareness might intensify the emotions resulting from exposure to a partner's odor (Smeets et al. 2008). Further, it is suggested that odors play an important role in attachment and romantic relationships (Schaal 1997; Cupchik and Phillips 2005). For example, sense of smell aids selection of heterozygous mates (Winternitz et al. 2017). At the same time, romantic love reduces women's attention to body odors obtained from men other than their current partner, which is considered as evidence for love being an emotion helping intimate partners to maintain their relationship (Lundström and Jones-Gotman 2009).

In addition to certain individual variation, social odor responsiveness and awareness seems to vary between cultures (Schleidt et al. 1981; Ferdenzi et al. 2008; Ferdenzi et al. 2011; Seo et al. 2011; Saxton et al. 2014). The cultural differences in attitudes towards odors seem to appear early in development as they are observable also in children (Ferdenzi et al. 2011, 2008; Saxton et al. 2014). Nevertheless, to date, only a few cross-cultural studies on odor awareness exist; additionally, they usually cover a small number of countries which limits possible conclusions on factors potentially underpinning the observed differences. For example, Saxton and colleagues (2014) found that Namibian children reported higher social odor awareness than Czech children. In a different study, Mexicans described odors as more important than did Koreans, Czechs and Germans, and recalled more odors pertaining to "social" category than members of other cultures (Seo et al. 2011). Still, it is not clear why such results are observed and whether cross-cultural differences would be also present between members of other cultures. We aimed to address these gaps in the current study.

Country-level factors

As olfaction plays a role in proxemics and interpersonal distancing (Ferdenzi et al. 2008; Seo et al. 2011), the first factor that could potentially affect social olfactory awareness on the country level is whether the culture is described as contact or noncontact (Hall 1966; Mazur 1977; Sussman and Rosenfeld 1982). Yet, the contact-noncontact grouping seems to be more anecdotal than evidence-based (see Sorokowska et al. 2017), since no clear criteria for such division have been examined and described. A factor related to proxemics in this context is *population density*. Living in populous sites may increase the closeness and frequency of social contacts and enhance the exposure to odors in everyday life (Cleaveland et al. 2001; Jones et al. 2008). In addition, through mere exposure, it could also increase a person's familiarity with odors in different social contexts, influencing olfactory perception (Ferdenzi et al. 2013) and awareness of social odors.

Second of the country-level variables is *temperature*, because it has been shown to be related to preferred social proximity, perception of social exclusion, focus on relationships and interpersonal communication (Zhong and Leonardelli 2008; IJzerman and Semin 2010; Sorokowska et al. 2017). Thus, indirectly, temperature may influence exposure to social odors and their relative importance, since engagement in olfaction-related activities is associated with odor awareness (Martinec Nováková et al. 2014; Martinec Nováková and Vojtušová Mrzílková 2016; Martinec Nováková et al. 2018). For example, odor exposure in children predicts (Martinec Nováková and Vojtušová Mrzílková 2016) and even increases (Martinec Nováková et al. 2018) their olfactory awareness. Further, from the physiological point of view, temperature is related to sweating and thus to more intense body odor, to which people from countries with higher average temperature are more exposed. This could also change body odor-related behaviors and perception of social odors. Intensified body odor can be seen as a stronger stimulus in communication, but on the other hand it may be commonly masked by fragranced cosmetics, and the use of odorants can affect people's body odor and the way they are perceived by others (Sorokowska et al. 2016; but see Lenochová et al. 2012).

Socio-economic status is one of the factors that might differentiate odor awareness similarly to its hypothesized influence on preferred social distance (Sorokowska et al. 2017). On a country-level, this variable can be expressed in the Human Development Index (HDI), which reflects a country's gross national income per capita, average life expectancy, and expected education levels. However, because incomes within one country can vary greatly even in countries with high HDI, we need to consider socio-economic status from both individual and country-level perspectives. Potential mechanisms of influence of socio-economic status on olfactory awareness are discussed below, in the section describing individual-level variables.

Individual factors

Besides exploring country-level characteristics ascribed to the entire populations, the aim of this paper is to establish links between individual factors and social odor awareness; among these *gender* is one of the most salient ones. Women value odors more than men in mating (Herz and Cahill 1997; Herz and Inzlicht 2002; Havlicek

et al. 2008), and outside mating contexts (Havlicek et al. 2008), suggesting their relatively higher odor awareness in the social context. Further, odor awareness is linked to female-stereotyped activities in childhood and adulthood (Nováková et al. 2014). Nevertheless, although the gender difference in olfactory performance is quite well documented (yet, not pertaining to all odor-related tasks, for a review see Doty and Cameron 2009), still little is known about gender effects in the context of attention paid to social odor cues.

Another individual factor, potentially related to odor awareness, is *age*. Some studies find odor awareness to be correlated with olfactory abilities (Smeets et al. 2008), and olfactory acuity changes with age (Sorokowska et al. 2015). Specifically, people below 20 years of age and above 60 years of age score lower in identification tests than people aged 20–60. The relative decline in odor identification after age 60 is broadly described and refers to an immense percentage of society (Larsson et al. 2005; Doty and Kamath 2014). Prior to age 20, olfactory skills are known to increase as a function of experience and cognitive development (Ferdenzi et al. 2013). Due to the impairment of smell abilities with age and in line with some previously published data (e.g., Dematte et al. 2011), we hypothesize that older participants will display lower odor awareness also in the social context (but see Croy et al. 2010).

Both low levels of *education* and *material situation* can affect personal hygiene (Cleland and van Ginneken 1988; Kuusela et al. 1997; Ilika and Obionu 2002). Because odor awareness is related to behaviors such as avoidance of people with an unpleasant smell, paying attention to odorants or noticing other people's sweat or breath (Smeets et al. 2008), people who are exposed to strong, unpleasant social odorants in their everyday life are likely to become accustomed and pay less attention to them. Consequently, they may score lower on measures of social odor awareness. As odor identification has been shown to be influenced by education (Liu et al 1995; Larsson et al 2004), it is likely that education alters also odor awareness through an indirect connection with olfactory acuity (Smeets et al. 2008). On the other hand, people in a non-industrialized society of Tsimane' were found to have lower thresholds of odor detection (Sorokowska et al. 2013), while hunter-gatherers from Malaysia exhibited notably developed ability to identify odors (Majid and Kruspe 2018). These exceptional olfactory abilities could probably be due to environmental pressures that promoted olfaction as a useful sense for hunting, fishing, gathering and horticulture. Yet, because our sample comprises mostly industrialized societies where sense of smell is no longer used for hunting or foraging, we hypothesize that better education and higher socio-economic status will be positively correlated with social odor awareness.

Further, higher exposure to interpersonal odors is likely to vary with subjectively preferred interpersonal distance, as detecting other people's odor is related to closer contact (Schleidt et al. 1981; Ferdenzi et al. 2008). Consequently, people who feel more comfortable in personal or intimate contact use their sense of smell more frequently and actively in the social context, which, in turn, makes them more likely to be odor-aware than people who prefer greater interpersonal distance. Relatedly, they could often rely on odors during social judgements. Preferred social distance is, however, known to vary both as a function of cultural and individual differences, so it is important to control it for each participant individually (Sorokowska et al. 2017).

Generally, despite the growing body of literature on differences in olfactory performance or hedonic preferences across the globe, we still do not know which aspects of the culture affect olfactory awareness. Further, while affective responses to specific odors are known to vary and reflect familiarity with the stimuli (Ferdenzi et al. 2013), little is known about the subjective importance of social odors in everyday life across different countries. In order to cover the broad spectrum of variables potentially correlated with odor awareness, it is crucial to conduct a study on a large sample, including participants from various geographic regions. Therefore, we conducted a large-scale analysis of data collected from 10 794 participants from 52 study sites all over the world. Our research aimed at exploring a number of potential individual and country-level correlates of odor awareness in the social context. This is the first to date global research focused on social odors, providing data from a large number of cultures about potential individual- and cultural-level factors related to the importance of the sense of smell and role of odors in the social context.

Materials and methods

Ethics Statement

This study was approved by the ethical board of the Institute of Psychology, University of Wroclaw (and other ethical committees in countries where additional approvals were necessary). The work was performed in accordance with the Declaration of Helsinki for Medical Research involving Human Subjects. All participants provided written, informed consent prior to their inclusion in the study.

Participants

The sample in this investigation comprised 10 794 individuals: 4896 men and 5855 women (43 participants decided not to disclose their gender, they were excluded from further analyses involving this variable). Participants' age ranged from 17 to 88 years, with $M = 39.62$ and $SD = 11.71$. Participants lived in 44 countries and 52 sites—as there were multiple sites in Brazil (3), India (3), Nigeria (3), and Turkey (3). The study sites included: Argentina, Austria, Brazil (Natal), Brazil (Porto Alegre), Brazil (Rio de Janeiro), Bulgaria, Canada, China, Colombia, Croatia, Czech Republic, Estonia, Germany, Ghana, Greece, Hong Kong, Hungary, India (Chennai), India (Bangalore), India (Guwahati), Indonesia, Iran, Italy, Kazakhstan, Kenya, Malaysia, Mexico, Nigeria (Benin), Nigeria (Enugu), Nigeria (Ondo), Norway, Pakistan, Peru, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia, Slovakia, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey (Ankara), Turkey (Antalya), Turkey (Sivas), Uganda, Ukraine, United Kingdom, and USA.

The participants were recruited by investigators in their respective countries. In most study locations, the participating groups comprised both a community sample and a student sample. Community samples were recruited in neighborhoods of large markets and shopping malls, neighborhoods of university facilities, local administration offices, public parks and other city facilities, and among members of vocational courses conducted at different universities (for example in Hungary, Peru, Norway, Poland, Saudi Arabia, Ghana, Brazil, Nigeria, the Netherlands, Ukraine, Korea, Canada, Kenya, Austria, United Kingdom, South Korea, Italy). In some countries, in addition to locations specified above, the research was conducted during individual visits in participants' homes—this was done, for example, in Kazakhstan, China, Croatia, Hungary. Further, we used chain-referral method (snowball sampling)—in all participating countries the researchers invited friends and family members of the participants, their acquaintances, and their students to take part in the study. Finally, some samples included also parents of children taking part in a different project (USA), and participants recruited through online and journal announcements (Italy and USA).

All participants were naïve to the hypotheses of the study, they completed the questionnaires independently and individually. The data collection was a part of a larger project—the participants took part also in a study on interpersonal distance preferences (Sorokowska et al. 2017), and in some countries, married participants completed additional questionnaires on their marital satisfaction (Hilpert et al. 2016; Sorokowski et al. 2017).

Measures and procedure

The data were collected by co-authors and their respective research teams. All respondents took part in the study voluntarily and provided written consent prior to participation. They were not compensated for their participation. Participants completed paper-and-pencil questionnaires—the original version of the questionnaire was in English, but in all non-English speaking countries, the questions were translated to the native language by researchers fluent in English and a given language using back-translation procedures (Brislin 1970).

The social odor awareness questionnaire applied in this study comprised items from the Odor Awareness Scale (Smeets et al. 2008). The participants did not complete the full scale, instead, we selected 6 items related to perception of odors in interpersonal situations, i.e., "Do you pay attention to the perfume, the aftershave or deodorant other people use?"; "How important is it to you that your partner has a pleasant smell?"; "Do you notice the smell of people's breath or sweat?"; "When someone has an unpleasant body odor, does that make you find him or her unattractive?"; "When someone has a pleasant body odor, do you find him or her attractive?"; "You are in a public space sitting close to someone who has an unpleasant smell. Do you look for another seat if possible?". In all questions, we used original response scales and verbal descriptors. The range of possible results was between 6 and 30 points. The reliability of this scale in the whole sample was good (Cronbach's $\alpha = 0.80$), similarly as reliability within-countries (min $\alpha = .53$ [Bulgaria], max $\alpha = 0.87$ [South Korea], median $\alpha = 0.76$), with only 2 countries' reliability estimated as below 0.60 (Bulgaria, $\alpha = 0.53$, Saudi Arabia, $\alpha = 0.59$).

In addition to participants' report on gender and age, we measured their education level quantified as "1—no formal education, 2—primary school, 3—secondary school, 4—high school or technical college, 5—bachelor or masters degree". The material situation was rated on a five-point scale, from "1—much better than average in my country" to "5—much worse than average in my country". Further, the participants declared their preferred interpersonal distance to (a) a stranger, (b) an acquaintance, and (c) a close person. Answers were given on a distance (0–220 cm) scale anchored by 2 human-like figures, labeled A for the left one and B for the right one. Participants were asked to imagine that he or she is Person A. The participant was asked to rate how close a Person B could approach, so that he or she would feel comfortable in a conversation with Person B. The participants marked the distance at which Person B should stop on the scale below the figures (see Sorokowska et al. 2017 for details of the method). Based on the participants' reply, we calculated mean preferred interpersonal distance for each person. In addition, we analyzed country-level variables: population density (United Nations population density report; United Nations 2013), and average, yearly temperature in a given study site (provided by respective coauthors), and the Human Development Index (HDI; UNDP 2013).

Statistical analyses

As individuals were nested within countries, we analyzed data using multilevel regression models (aka hierarchical linear models). We started with a baseline (empty) model to estimate the variability of the social olfactory awareness in the social context across countries. In the next model, we included individual-level variables: gender, age, the level of education, self-reported material situation and preferred interpersonal distance. In the third and final model, we added country-level predictors: HDI, population density (log-transformed) and average temperature. We compared the models using −2 log likelihood (−2LL) statistics and Akaike Information Criterion (AIC), with lower values in both cases indicating better models. In all models, we controlled for nesting participants within countries and estimated fixed effects of Level-1 (Individuals) and Level-2 (Countries) variables using a maximum likelihood estimator.

Results

Table 1 summarizes the main characteristics of each site and Table 2 shows the questionnaire results for men and women. Our main analyses were conducted by means of a series of multilevel regression models. As illustrated in Table 3, the baseline model showed that there was substantial variability in self-reported sense of smell in the social context at both individual and country levels. Intra-class correlation coefficient (ICC) demonstrated that 29% of the sense of smell's variability was associated with country level, while 71% of the variance was located at the level of individuals.

In Model 2, we included individual-level predictors. As illustrated by -2LL and AIC parameters, this model was characterized by better fit than the initial model (Δ-2LL = 3589.05, ΔAIC = 3579.05, both ps < .001) and explained 3% of Level-1 variance. Consistent with our predictions, women had higher social olfactory awareness than men ($B = 0.90$, $SE = 0.09$, $P < 0.001$), and olfactory awareness decreased with age ($B = -0.02$, $SE = 0.004$, $P < 0.001$) and increased with educational level obtained ($B = 0.23$, $SE = 0.05$, $P < 0.001$). It was not related, however, to reported material conditions of participants ($B = -0.08$, $SE = 0.05$, $P = 0.15$) and their preferred interpersonal distance ($B = -0.0003$, $SE = 0.001$, $P = 0.82$).

In Model 3 we included country-level predictors: HDI, average temperature and log-transformed population density. None of these variables, however, were statistically significant predictors of self-reported social olfactory awareness. Similarly, adding these predictors into the model did not improve it as compared to Model 2 and illustrated by higher value of AIC.

Discussion

The current study examined social olfactory awareness in 44 countries, taking into account both country- and individual-level predictors of this variable. Our results revealed that participants from different countries indeed differ in terms of odor awareness; however, a much smaller variability of the odor awareness was due to country-level than to individual-level factors (29 and 71%, respectively). A statistical model including individual-level predictors (gender, age, material situation, education, and preferred social distance) provided a relatively good fit to the data, but adding country-level predictors (Human Development Index, population density, and average temperature) did not improve model parameters. None of the examined country-level predictors proved statistically significant.

The results suggest that individual differences play an important role in social odor awareness, i.e. in aspects of odor awareness that are related to non-verbal communication between humans. We found 3 statistically significant predictors of odor awareness—gender, age, and education in the largest international sample to date.

Table 1. Summary of descriptive statistics

Country/study site	City/study sites	Sample size	% Females	Age		Education		Material situation		Mean preferred distance		HDI	Population density	Average temperature
				M	SD	M	SD	M	SD	M	SD	M	M	M
Argentina	Parana	201	65%	32.31	11.16	3.91	0.96	2.74	0.49	58.64	22.80	0.81	14.52	19.00
Austria	Vienna	200	43%	26.59	9.73	4.12	0.61	2.73	0.66	68.93	23.77	0.90	100.19	11.50
Brazil	Natal	240	42%	35.58	9.59	4.44	0.82	2.51	0.69	81.42	36.74	0.73	22.93	26.00
Brazil	Porto Alegre	140	26%	33.34	8.39	4.86	0.37	2.26	0.60	73.00	32.34	0.73	22.93	20.00
Brazil	Rio de Janeiro	100	42%	43.16	11.74	4.62	0.72	2.27	0.63	75.60	23.84	0.73	22.93	24.00
Bulgaria	Blagoevgrad	102	38%	38.35	8.95	4.65	0.77	3.04	0.20	62.81	8.72	0.78	66.62	10.00
Canada	Halifax	68	63%	38.43	10.15	4.66	0.48	2.79	1.04	87.75	40.40	0.91	3.42	7.60
China	Shanghai, Beijing	365	53%	37.00	6.06	4.19	1.03	2.47	0.74	63.36	43.92	0.70	141.69	15.09
Colombia	Santa Maria	100	59%	41.10	11.81	3.83	1.07	2.77	0.74	87.93	28.66	0.72	40.78	26.00
Croatia	Zagreb	614	51%	44.75	11.65	3.97	0.98	2.67	0.75	91.54	22.15	0.81	76.73	11.00
Czech Republic	Prague	167	52%	36.48	15.93	4.19	0.71	2.86	0.79	82.95	23.05	0.87	133.82	8.00
Estonia	Tartu	146	66%	42.93	12.30	4.48	0.78	2.89	0.74	94.41	26.16	0.85	28.80	5.00
Germany	Dresden	154	60%	31.59	13.39	4.26	0.71	3.41	0.99	69.18	31.21	0.92	232.53	9.40
Ghana	Legon, Accra	103	50%	40.42	9.53	4.24	1.06	2.03	0.75	81.36	28.26	0.56	101.72	26.00
Greece	Thessaloniki	91	54%	38.77	9.07	4.22	0.76	2.96	0.61	68.09	22.18	0.86	84.19	15.10
Hong Kong	Hong Kong	94	43%	47.09	9.98	3.88	0.96	2.60	0.80	91.00	31.17	0.91	6414.48	23.00
Hungary	Pecs	237	68%	37.80	9.56	4.09	0.93	3.08	0.64	107.62	29.53	0.83	107.60	10.00
India	Chennai	206	50%	42.21	5.17	4.03	0.70	2.19	0.84	53.53	60.93	0.55	366.76	27.67
India	Bangalore	96	64%	40.48	9.28	4.96	0.29	1.76	0.76	76.39	30.36	0.55	366.76	24.00
India	Guwahati	203	51%	31.03	5.02	4.93	0.25	1.89	0.82	89.46	32.46	0.55	366.76	24.00
Indonesia	Bandung	92	73%	41.74	9.90	4.51	0.93	2.69	0.65	87.03	24.95	0.63	126.37	24.40
Iran	Tehran	606	57%	38.81	10.88	3.69	1.14	2.93	0.74	85.25	38.49	0.74	45.18	17.00
Italy	Milan	322	61%	48.39	11.06	4.00	0.85	2.65	0.64	67.66	26.12	0.88	200.81	12.00
Kazakhstan	Kokshetau	120	50%	37.03	8.18	4.30	0.96	2.69	0.63	69.56	33.96	0.75	5.80	4.00
Kenya	Nairobi	294	50%	37.38	8.22	3.77	1.20	2.85	0.91	74.22	36.18	0.52	70.49	21.63
Malaysia	Sintok	99	51%	40.03	8.92	4.45	0.72	2.91	0.52	77.78	21.57	0.77	85.72	27.00
Mexico	Mexico City	157	51%	38.81	11.24	4.18	1.08	2.62	0.63	82.78	39.77	0.78	60.20	16.00
Nigeria	Benin	97	54%	39.04	7.44	4.48	0.75	2.18	0.97	82.89	35.25	0.47	172.90	26.00
Nigeria	Enugu	214	39%	42.33	9.00	4.33	0.93	2.31	0.97	78.66	21.36	0.47	172.90	27.00
Nigeria	Ondo	285	56%	36.45	8.82	4.27	1.01	1.84	0.96	84.38	36.73	0.47	172.90	27.00
Norway	Trondheim	100	28%	41.29	13.51	4.75	0.58	2.57	0.73	70.47	24.84	0.96	12.70	5.00
Pakistan	Karachi	121	55%	36.17	10.33	4.78	0.61	1.79	0.81	88.91	31.78	0.52	217.50	26.00
Peru	Lima	102	52%	31.66	10.49	4.22	0.85	2.42	0.74	61.96	25.41	0.74	22.80	19.40
Poland	Wroclaw, Brzeg	425	62%	40.65	11.68	4.37	0.71	2.80	0.72	70.56	24.25	0.82	118.17	8.00
Portugal	Coimbra	280	65%	46.04	11.17	3.80	1.02	3.11	0.63	77.91	30.94	0.82	115.10	15.00
Romania	Cluj-Napoca	181	85%	35.68	6.65	4.93	0.52	3.48	0.76	94.00	35.54	0.79	91.70	8.00
Russia	Moscow	224	46%	38.61	13.86	4.52	0.91	2.79	0.75	69.55	23.01	0.79	8.41	5.00
Saudi Arabia	Riyadh	198	56%	36.16	8.31	4.60	0.79	2.44	0.83	109.83	42.04	0.78	12.68	26.00
Serbia	Belgrade	105	82%	24.96	7.01	4.15	0.52	2.99	0.58	66.98	29.28	0.77	109.18	11.80
Slovakia	Nitra, Bratislava	233	67%	42.76	11.74	4.49	0.57	2.89	0.71	66.09	27.33	0.84	110.81	10.00
South Korea	Seoul	100	50%	41.76	7.74	4.36	0.56	3.15	0.63	85.40	37.11	0.91	486.80	12.00
Spain	Valencia, Grenada	199	53%	47.14	9.39	3.81	1.11	2.90	0.54	73.63	30.64	0.89	91.27	15.98

Table 1. Continued

Country/study site	City/study sites	Sample size	% Females	Age		Education		Material situation		Mean preferred distance		HDI	Population density	Average temperature
				M	SD	M	SD	M	SD	M	SD	M	M	M
Sweden	Trollhättan	212	50%	43.52	4.55	4.16	0.69	2.44	0.63	36.38	38.36	0.92	20.85	6.64
Switzerland	Zurich	179	39%	48.77	12.87	4.38	0.58	2.35	0.82	92.55	24.47	0.91	189.68	9.00
Thailand	Chiang Mai	240	50%	44.53	7.22	3.82	1.38	2.48	0.85	61.22	46.95	0.69	129.41	26.92
Turkey	Ankara	104	27%	48.09	14.25	4.13	1.04	2.40	0.99	67.95	29.77	0.72	92.06	12.00
Turkey	Antalya	187	57%	44.12	12.75	4.31	0.91	2.63	0.73	94.47	33.23	0.72	92.06	18.00
Turkey	Sivas	100	18%	34.61	10.59	3.52	1.22	2.02	0.88	109.87	29.70	0.72	92.06	9.00
Uganda	Kampala	91	38%	34.89	10.55	4.13	0.97	2.62	0.86	96.49	42.81	0.46	141.00	21.50
Ukraine	Lviv	311	79%	29.22	8.75	4.80	0.49	2.88	0.79	63.37	23.90	0.74	76.28	8.08
United Kingdom	Cardiff	100	58%	45.04	11.57	4.31	0.72	2.42	0.73	78.73	26.10	0.88	255.52	9.00
USA	Philadelphia, Washington, Durham	424	64%	41.74	15.62	4.75	0.50	2.43	0.81	70.61	29.33	0.94	32.43	12.00
Total		10 751	54%	39.62	11.71	4.25	0.95	2.63	0.84	77.52	35.13	0.77	163.63	15.55

Our findings on gender concur with previous research on attitudes towards the sense of smell. Women consider olfaction more important than men in self-report questionnaires related both to sexual (Herz and Cahill 1997; Herz and Inzlicht 2002; Havlicek et al. 2008) and to non-sexual contexts (Havlicek et al. 2008). Further, Croy et al. (2010) showed that female respondents judged the sense of smell as being more important in their lives than male respondents. As mentioned in the Introduction, also in a previous cross-cultural study conducted in 4 countries, women indicated a higher interest in the sense of smell than men (Seo et al. 2011). Our study extends all these findings by showing that female olfactory awareness in the social context was higher than male across 44 countries. The predictive value of education is less obvious, yet also consistent with our hypothesis. Education could be associated with higher expenses on personal hygiene and, therefore, more attention paid to pleasantness of body odors. Further, more educated people might be more aware of their sense of smell and its importance and be more aware of different olfactory cues. The case of age is, however, more complicated. Croy et al. (2010) found that the importance of the sense of smell remains relatively unchanged throughout the life-span, and we observed a slight, albeit statistically significant decrease in social olfactory awareness associated with aging. It is possible that either the previous results were specific to one culture, or that olfactory awareness in the social context is somewhat different from general odor awareness, as measured by Croy et al. (2010).

It should be highlighted that our findings on social olfactory awareness in 44 countries are consistent with well characterized age- and gender-related differences in olfactory abilities. Studies on various aspects of olfactory perception show that women outperform men in tasks like odor memory and identification, and in the social context, they rely on body odor to a greater extent while evaluating a potential partner (Brand and Millot 2001; Doty and Cameron 2009; Ferdenzi et al. 2013). Our results revealed the same pattern. Further, we observed that social olfactory awareness decreases with age, and it is known that so does olfactory performance (Doty 2009; Sorokowska et al. 2015). Lower olfactory abilities in older people might result from, among others, cumulative damage to the olfactory epithelium from repeated infections, or a variety of neurodegenerative diseases (Doty 2009). The findings on age- and gender-dependent olfactory abilities and our data seem to suggest that people with a better sense of smell use it in more ways and are more aware of odors than those with lesser smell ability (Smeets et al. 2008), especially in the social context. Still, it needs to be highlighted that studies regarding odor awareness in relation to olfactory performance produce mixed results (see Smeets et al. 2008; Dematte et al. 2011). Odor awareness, a metacognitive measure, and various aspects of odor perception (assessed by various psychophysical tests) are not equivalent. Nevertheless, our data suggest that, at least in the social context, odor awareness could be subject to influence of biological factors, like it is in the case of olfactory sensitivity (Gross-Isseroff et al. 1992). Further, preference for certain odors, especially those of other people, can be genetically determined (Milinski and Wedekind 2001; Havlicek and Roberts 2009; Janeš et al. 2010). Therefore, it is possible that subjective importance of social odors is also dependent on some innate, genetic factors (like HLA—human leukocyte antigen).

Understanding the interplay between genetic and environmental factors is, however, really complicated in all studies involving human subjects. In addition to genetics, olfactory sensitivity is impacted in complex ways by environment (Hudson et al. 2006; Knaapila et al. 2008; Guarneros et al. 2009; Calderón-Garcidueñas et al. 2010;

Table 2. Means and standard deviations of the results obtained by men and women across participating sites

Country	Men			Women			Overall		
	M	*N*	*SD*	*M*	*N*	*SD*	*M*	*N*	*SD*
Argentina	21.39	71	4.39	23.72	130	4.15	22.90	201	4.37
Austria	22.69	115	3.82	21.76	85	3.46	22.30	200	3.69
Brazil (Natal)	21.71	137	3.36	22.41	100	4.33	22.00	237	3.80
Brazil (Porto Alegre)	24.46	103	3.04	21.62	37	3.44	23.71	140	3.38
Brazil (Rio de Janeiro)	24.26	58	3.58	21.55	42	4.23	23.12	100	4.08
Bulgaria	24.52	63	2.01	26.00	39	2.58	25.09	102	2.34
Canada	14.64	25	3.11	14.25	43	3.30	14.40	68	3.22
China	18.63	131	4.38	18.37	153	4.11	18.49	284	4.23
Colombia	24.05	41	3.60	25.12	59	3.29	24.68	100	3.44
Croatia	20.09	299	4.10	22.71	313	3.74	21.43	612	4.13
Czech Republic	22.13	80	3.57	24.57	87	3.11	23.40	167	3.54
Estonia	21.46	50	4.30	23.46	96	3.72	22.77	146	4.03
Germany	21.37	49	4.35	23.55	76	3.42	22.70	125	3.94
Ghana	24.71	52	3.11	22.47	51	4.29	23.60	103	3.89
Greece	22.10	42	4.11	24.08	49	4.56	23.16	91	4.45
Hong Kong	18.74	54	4.30	17.78	40	3.69	18.33	94	4.06
Hungary	23.29	76	4.03	24.70	161	3.67	24.25	237	3.84
India	17.03	75	5.23	17.14	29	4.45	17.06	104	5.01
India (Bangalore)	21.54	35	4.88	20.02	61	4.36	20.57	96	4.59
India (Guwahati)	18.24	100	4.72	18.40	103	5.13	18.32	203	4.92
Indonesia	21.76	25	4.27	22.64	67	3.45	22.40	92	3.69
Iran	21.26	261	5.17	22.41	344	4.92	21.91	605	5.06
Italy	21.70	127	3.98	23.59	195	3.83	22.84	322	3.99
Kazakhstan	24.35	60	3.55	24.98	60	3.33	24.67	120	3.44
Kenya	23.36	136	4.44	21.78	126	5.10	22.60	262	4.83
Maleysia	24.86	49	3.95	22.40	50	3.51	23.62	99	3.91
Mexico	22.25	77	4.73	23.80	79	4.78	23.03	156	4.80
Nigeria (Benin)	23.14	44	4.58	24.94	52	3.37	24.11	96	4.05
Nigeria (Enugu)	22.78	130	4.85	21.61	84	5.64	22.32	214	5.19
Nigeria (Ondo)	22.10	124	4.29	21.81	161	4.87	21.94	285	4.62
Norway	22.17	72	3.18	22.04	28	2.65	22.13	100	3.02
Pakistan	23.11	55	4.04	23.42	66	4.50	23.28	121	4.28
Peru	14.82	49	4.32	11.19	53	3.30	12.93	102	4.22
Poland	22.36	160	3.88	24.30	263	3.74	23.57	423	3.90
Portugal	21.11	99	3.85	23.42	178	3.39	22.60	277	3.72
Romania	22.07	28	2.16	24.09	153	4.46	23.77	181	4.25
Russia	21.23	120	4.27	24.49	104	3.98	22.75	224	4.43
Saudi Arabia	23.06	87	4.29	24.58	111	3.34	23.91	198	3.85
Serbia	22.84	19	4.19	23.97	86	3.38	23.76	105	3.55
Slovakia	21.99	76	4.30	24.24	157	3.83	23.51	233	4.12
South Korea	18.20	50	4.92	19.58	50	4.51	18.89	100	4.75
Spain	21.88	93	4.32	24.07	106	3.26	23.05	199	3.94
Sweden	22.16	69	3.64	19.08	53	3.95	20.82	122	4.06
Switzerland	11.85	109	4.04	13.87	67	3.83	12.62	176	4.07
Thailand	18.77	91	4.02	18.04	76	4.29	18.44	167	4.15
Turkey (Ankara)	21.36	76	4.82	23.29	28	3.92	21.88	104	4.66
Turkey (Antalya)	22.76	80	4.05	24.25	107	3.76	23.62	187	3.95
Turkey (Sivas)	22.13	82	4.59	19.17	18	4.49	21.60	100	4.69
Uganda	21.86	56	4.73	19.23	35	6.08	20.85	91	5.41
Ukraine	20.91	66	4.75	24.13	245	3.40	23.45	311	3.95
United Kingdom	21.79	42	4.03	23.10	58	3.55	22.55	100	3.80
USA (Durham, North Carolina)	20.61	174	4.76	19.62	138	4.54	20.17	312	4.68
USA (Philadelphia)	21.19	153	4.27	23.34	271	3.64	22.57	424	4.01
Total	21.30	4595	4.81	22.49	5423	4.73	21.94	10 018	4.80

Doty et al. 2011), and odor awareness, however defined, must take this into account. Additionally, there are experience- and learning-mediated effects on different aspects of odor perception (e.g., Schaal et al. 1997; Distel et al. 1999; Schaal 2012). This potential influence of personal history is particularly interesting, as studies show that learning and experience can shape also olfactory awareness. Parental reports of the children's odor exposure predicted their offspring's odor awareness, in preschool children (Martinec Nováková and Vojtušová Mrzílková 2016) and in young adults (Nováková et al. 2014). Despite difficulties in determining whether the sources

Table 3. A summary of multilevel models regressing social olfactory awareness on individual- and country-level predictors.

Predictors	Model 1 (baseline) *B* (*SE*)	Model 2 (Level-1 predictors) *B* (*SE*)	Model 3 (Level-1 and Level-2 predictors *B* (*SE*)
Fixed effects			
Individual-level predictors			
Intercept	21.78 (0.36)***	20.51 (0.53)***	24.79 (3.59)***
Gender (*1 = M, 2 = F*)		0.90 (0.09)***	0.90 (0.09)***
Age		−0.02 (0.004)***	−0.02 (0.004)***
Education		0.23 (0.05)***	0.23 (0.05)***
Material situation		−0.08 (0.06)	−0.08 (0.06)
Preferred distance		−0.0003 (0.001)	−0.0003 (0.001)
Country-level predictors			
HDI			−3.02 (3.48)
Density (log-transformed)			−0.31 (0.31)
Average temperature			−0.04 (0.06)
Random effects			
Individual-level variance	17.70 (0.25)***	17.19 (0.25)***	17.19 (0.25)***
Country-level variance	7.21 (1.39)***	7.06 (1.38)***	6.81 (1.33)***
Model properties			
−2LL	57693.8	54104.75	54102.86
AIC	57699.8	54120.75	54124.86

Coefficient are unstandardized regression weights with their standard errors in parentheses.
***$P < 0.001$.

of such findings are biologically or environmentally driven, these data further strengthen our conclusion that individual-level factors (including personal history) might modulate odor awareness more than culture-level variables.

In our global study, we examined 3 country-level predictors, but we did not find any of them statistically significant. However, 30% of the variability in social odor awareness was assigned to the level of country. If national wealth, temperature, and population density do not account for the variability in social odor awareness, the question as to which country-level factors are related to importance of odors in social contexts remains unanswered. There are several cultural factors not addressed in this study that could be taken into account while considering odor awareness. Some of them, for example cultural values, might be difficult to quantify, and therefore it seems challenging to measure them in survey research. As discussed above, apart from culture, there are also climate-related indices (e.g. humidity or air pollution) that may be related to olfactory performance and hence odor awareness (Calderón-Garcidueñas et al. 2010). In the light of the current research, the issue of culture- and climate-related predictors of attention paid to odors remains an open question to be addressed in future investigations, that could include also, e.g. less industrialized societies.

There are certain limitations of the current study. The sample sizes were generally too small to be fully representative for participating cultures, and they were often samples of convenience—snowball sampling was frequently used as a method of recruitment. However, all coauthors were instructed to recruit participants from as diverse socioeconomical backgrounds as possible, and the samples were to be balanced in terms of age, gender, and education level. However, we used different methods of recruitment in different locations—we had no standard recruitment procedure. Nevertheless, this is the first study on odor awareness that involves such a large number of diverse cultures and despite certain limitations, our findings expand the knowledge on predictors of odor awareness in social interactions.

In summary, our study revealed that individual characteristics are more strongly related than country-level factors to self-reported odor awareness in social contexts. Although people from different countries differ from one another substantially in social odor awareness, the main differentiating role is played by individual differences. This suggests that people living in different cultures and different climate conditions may still share some similar patterns of odor awareness if they share other individual-level characteristics.

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Conflict of interest

The authors declare no conflict of interest. Andero Teras is a Founder, CEO and Event Marketing Manager of Mõttemaru OÜ, but there are no conflicts of interests with this study.

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