Food Quality and Preference 118 (2024) 105192

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

A short version of odor awareness scale (OAS-6)

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ARTICLE INFO

Keywords:
Odor awareness
Metacognition
Odor perception
Psychometric properties
Assessment

ABSTRACT

People differ in their awareness of odors in the environment. This metacognitive ability can be measured with The Odor Awareness Scale (OAS). However, the OAS consists of 32 items what makes it difficult to use in research where awareness of odors is not the main variable of interest. This study introduces a shortened version of the OAS. Participants completed either the original OAS (n = 268, 72% women) or the shortened OAS-7 version comprising 7 items selected from the original scale (n = 220, 61% women). Based on the validation analyses, one item has been further deleted due to low factor loading. The obtained OAS-6 showed good psychometric properties as established with: confirmatory factor analysis fit indices ($\chi 2 = 17.30$, $p = 0.044$, CFI = 0.977, TLI = 0.962, RMSEA = 0.065, SRMR = 0.039), high reliability (Cronbach's $\alpha = 0.80$, McDonald's $\omega = 0.81$), and temporal stability (test–retest correlation after 6 weeks: $r = 0.89$). The OAS and OAS-6 showed similar correlations with Individual Significance of Olfaction Questionnaire total score and subscales. On average, women scored higher on OAS-6 than men, mirroring the pattern observed in the OAS. In summary, OAS-6 proves to be a reliable and valid tool for assessing odor awareness. Its quick completion time (within 2 min) opens venues for its application in diverse studies exploring metacognitive aspects of olfactory perception, including investigations into the interplay between odorous environments and human health or in clinical research.

1. Introduction

Human breathing is mostly an involuntary act controlled by the autonomic nervous system. Continuous breathing causes constant airflow and inspiration of odorous molecules, resulting in odor-dependent neural activity (Kobal & Hummel, 1998). Yet, people greatly differ in their awareness of these passive odorous sensations during breathing. Some instantly pick up odors in their environment, comment on them, and tune their behaviors accordingly. Others will only notice a smell if it is pointed out to them. Individual differences within this metacognitive ability are known as odor awareness (Smeets, Schifferstein, Boelema, & Lensvelt-Mulders, 2008).

Odorous molecules present in the ambient air may have adverse, but also positive, effects on human health. A variety of molecules present in the ambient air have been demonstrated to impact olfactory system negatively and undermine olfactory performance (Arnold, 2019; Block & Calderón-Garcidueñas, 2009; Calderón-Garcidueñas et al., 1998; Calderón-Garcidueñas et al., 2003, 2010; Cao et al., 2023; Ekström, Rizzuto, Grande, Bellander, & Laukka, 2022; Mussalo et al., 2023), as well as cause wider damage to neurological, respiratory and cardiovascular systems (Block & Calderón-Garcidueñas, 2009; Cohen, 2000; Duan, Hao, & Yang, 2020; Ha, 2021; Hahad et al., 2020; Kühn et al., 2020; Lee, Kim, & Lee, 2014; Romieu, Castro-Giner, Kunzli, & Sunyer, 2008). The presence of some odors may yield a positive effect on human health through olfaction (Oleszkiewicz et al., 2021). Forest Bathing (Shinrin-Yoku) is a Japanese healing practice that involves immersing oneself in nature for a mindful experience. It harnesses the attributes of the olfactory system, where volatile organic chemical compounds (VOCs) emitted by plants and trees have a positive impact on human health (Hansen, Jones, & Tocchini, 2017). Importantly, the positive effect of environmental odors on human health often relies on processes of associative learning, linking odour perception to positive experiences, such as an elevated mood (Dalton & Hummel, 2000). For instance, someone could associate the smell of freshly baked cookies with feelings

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https://doi.org/10.1016/j.foodqual.2024.105192
Received 12 December 2023; Received in revised form 9 April 2024; Accepted 9 April 2024
Available online 10 April 2024
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of comfort and happiness, because they often enjoyed cookies baked by their beloved grandmother. According to the "Misfit" theory (Köster, Møller, & Mojet, 2014), spontaneous conscious olfactory perception emerges when olfactory sensation does not fit the context (either a new odor does not fit the context or there is a novel context to an odor). Odors and contexts are learned by the association throughout the individuals' living day-to-day experience (Arshamian, Willander, & Larsson, 2011), therefore significant individual differences can be expected in terms of conscious odor perception, or odor awareness.

Individual differences can also act as factors associated with odor awareness. Women exhibit greater odor awareness than men. This gender-related difference is attributed to hormonal exposure (Doty & Cameron, 2009; Koelega & Köster, 1974), the increased presence of odorous sensations during female-stereotyped activities (Nováková, Varella Valentova, & Havlíček, 2014), or an overall higher chemosensory sensitivity and memory for odors in women (Doty & Cameron, 2009; Sorokowski et al., 2019). Women indeed report greater odor awareness and interest in odors (Havlicek et al., 2008; Herz & Inzlicht, 2002; Seo et al., 2011; Sorokowska et al., 2018), and on average, also seem to value olfaction more than men (Croy, Buschhüter, Seo, Negoias, & Hummel, 2010). Women more frequently notice odors in their environment as compared to men (Oleszkiewicz et al., 2021).

Age is another factor associated with odor awareness. Preschool children are less aware and attentive to food and environmental odors than adults, but more aware of social odors. This difference reverses with age – while growing up the awareness of social odors decreases and awareness of food and environmental odors increases (Martinec Nováková & Havlíček, 2019), likely due to the incremental olfactory experience. Although olfactory performance generally decreases over time (Doty & Kamath, 2014; Oleszkiewicz, Schriever, et al., 2019; Sorokowska et al., 2015), and people tend to be less aware of odors as they become older (Sorokowska et al., 2018), they consider olfaction as similarly significant throughout the lifespan (Croy et al., 2010).

Finally, it has been shown that both lower education and socioeconomic status are associated with lower olfactory performance and lower odor awareness (Fornazieri et al., 2019; Sorokowska et al., 2018). We conclude that odor awareness is determined by multiple factors, both contextual as well as personal.

Our understanding of odor awareness as the cognitive component of spontaneous olfactory perception and its health effects is still understudied. It is likely, yet unproven, that odor awareness mediates the effects of spontaneous, conscious olfactory perceptions on human health and guides certain reactions to environmental odors. Furthermore, the cultural aspects of odor awareness are to be unraveled. A global study comparing 44 cultures revealed that awareness of social odors is relatively independent of cultural experience (Sorokowska et al., 2018). Recent studies show that both children and adults, embedded in distant cultures, exhibit similar preferences toward odors (Arshamian et al., 2022; Oleszkiewicz et al., 2022) yet vary in chemosensory sensitivity (Oleszkiewicz et al., 2020). These non-obvious findings fuel curiosity about the interplay between olfactory sensitivity and odor awareness in cross-cultural contexts. To address these speculations one needs a practical, short, cross-culturally relevant measure of odor awareness.

There are several existing methods for measuring chemosensory experiences, with some focusing on the significance of odors (Croy et al., 2010) and others specifically targeting odor awareness (e.g. Sorokowski, Sorokowska, Misiak, & Craig Roberts, 2023; for a comprehensive review see: Han, Su, Qin, Chen, & Hummel, 2021). Among the scales designed for assessing odor awareness, there are instruments tailored for both children (Ferdenzi, Coureaud, Camos, & Schaal, 2008) and adults (Smeets et al., 2008). Those intended for adult populations typically evaluate domain-specific odor awareness, such as social (Dal Bò et al., 2021) or body-related odors (Okamoto, Shirasu, Fujita, Hirasawa, & Touhara, 2016; Croijmans, Dijksterhuis, Majorov, & Smeets, 2022). The Odor Awareness Scale (OAS; Smeets et al., 2008) has been designed to tap into four categories of odor experiences (relative to civilization, food and drink, nature, and humans) to represent odors that people encounter daily. While OAS has been successfully used in many studies and presents excellent psychometric parameters (Smeets et al., 2008), a shorter scale could become advantageous to include odor awareness as a secondary measure in studies focused on different research problems or conducted in culturally different regions. A practical benefit of the shorter scale is reduced time required to fill out the questionnaire. Consequently, the likelihood of including the short OAS scale in various studies wherein odor awareness may be a relevant, but not primary factor, is increased (e.g. in the clinical studies). To this end, we propose a shorter version of the OAS scale and present its psychometric properties.

2. Materials and methods

2.1. Ethical statement

Testing was performed in accordance with the Declaration of Helsinki on Biomedical Studies Involving Human Subjects. Written informed consent was obtained from all participants. The entire study design and consent approach were approved by the Ethics Review Board at the University of Wroclaw (3/2021) and the Institute of Psychology (2021/RYHNA).

2.2. Participants and procedure

A total of 488 individuals (67% women) aged 18–74 years (M = 32.84, SD = 12.60) participated in the study between October 2022 and October 2023. The study was conducted in Poland. Participants were randomly assigned to one of the two groups. The first group completed the original version of the Odor Awareness Scale (OAS; Smeets et al., 2008) and the second group completed a shortened version (OAS-7; details concerning the two versions are described in the *Methods* section). The OAS group included 268 participants (72% women) aged 18–67 years (M = 32.31, SD = 11.10). Of those, 34 individuals (94% women) aged 19–31 years (M = 20.8, SD = 2.48) completed the questionnaire again after 6 weeks to test the stability of the scores over time. The OAS-7 group consisted of 220 participants (61% women) aged 18–74 years (M = 33.48, SD = 14.21), with 36 individuals (75% women) aged 18–38 years (M = 21.1, SD = 3.76) participating in the 6-weeks delayed retest. To prevent participants' attrition during test–retest, for the time-stability part of the study we invited students who regularly visit the University.

The two tested groups were balanced in terms of age, $t(486) = 1.03$, $p = 0.305$, but there were proportionally more men in the OAS-7 group than in the OAS group, $\chi^2(1) = 6.74$, $p = 0.009$. We assumed that compromised ability to perceive odors could introduce uncontrolled measurement error in odor awareness. To prevent this, all participants were screened for the common conditions likely to undermine olfactory functions (Welge-Lüssen, Leopold, & Miwa, 2013). Participants in OAS and OAS-7 groups were balanced in terms of health-related characteristics and medical history, as determined by χ^2 test of association. Detailed information about the participants' health are presented in Table 1.

2.3. Methods

The Odor awareness scale (OAS) is a metacognitive measure of awareness of olfactory sensations in the environment (Smeets et al., 2008). It consists of 34 questions that assess how much attention individuals pay to smells and how much they value olfactory sensations. Based on the validation procedure the authors suggest to omit two items, resulting in a final scale of 32 questions (Smeets et al., 2008). The questions are divided into two subscales: a 21-item negative subscale (focused on odors to be avoided) and an 11-item positive subscale (focused on odors to be sought out). Participants use a 5-point Likert scale, with response options ranging from "*never*" to "*always*". In the

Table 1
Health-related characteristics of the study sample.

	OAS group ($N = 268$)	OAS-7 group ($N = 220$)	χ^2
Smoking			
Non-smokers	175 (65.3 %)	152 (69.1 %)	$\chi^2(2) = 0.79$, $p = 0.675$
Current smokers	67 (25 %)	49 (22.2 %)	
Former smokers	26 (9.7 %)	19 (8.6 %)	
Exposure to odors/gas/dust at work	38 (14.2 %)	40 (18.2 %)	$\chi^2(1) = 1.44$, $p = 0.230$
Past COVID-19 infection			
Yes	144 (53.7 %)	128 (58.2 %)	$\chi^2(2) = 1.21$, $p = 0.547$
Probably, but did not take a test	54 (20.1 %)	37 (16.8 %)	
No	70 (26.1 %)	55 (25 %)	
Sense of smell returned to normal after COVID-19			
Yes	98 (36.6 %)	82 (37.2 %)	$\chi^2(3) = 1.07$, $p = 0.783$
Did not experience sensory loss	84 (31.3 %)	65 (29.5 %)	
No	17 (6.3 %)	19 (8.6 %)	
Did not have COVID-19	69 (25.7 %)	54 (22.5 %)	
Other medical conditions			
Allergic rhinitis	85 (31.7 %)	68 (30.1 %)	$\chi^2(1) = 0.04$, $p = 0.848$
Bronchial asthma	19 (7.1 %)	16 (7.3 %)	$\chi^2(1) < 0.01$, $p = 0.938$
Frequent nasal sinuses problems	121 (45.1 %)	83 (37.7 %)	$\chi^2(1) = 2.74$, $p = 0.098$
Often upper respiratory tract infections	66 (24.6 %)	47 (21.4 %)	$\chi^2(1) = 0.72$, $p = 0.395$
History of major head injury	39 (14.6 %)	24 (10.9 %)	$\chi^2(1) = 1.43$, $p = 0.232$
Blocked nose	81 (30.2 %)	59 (26.8 %)	$\chi^2(1) = 0.69$, $p = 0.408$
Nasal polyps	5 (1.9 %)	9 (4.1 %)	$\chi^2(1) = 2.15$, $p = 0.143$
None	77 (28.7 %)	75 (34.1 %)	$\chi^2(1) = 1.62$, $p = 0.203$

Note. Participants could choose more than one medical condition affecting them. Therefore, the frequency of 'Other medical conditions' does not add up to 100%.

present study participants' responses to all questionnaire items were averaged resulting in the final score ranging between 1 and 5. A higher total score in OAS indicates greater awareness of smells in the environment.

For OAS-7 we chose seven items from the original OAS scale (see: Table 2). We aimed to include items describing varied situations when people encounter odors that would not have a conceptual overlap (an example of such overlap is i.e. smelling sour milk and smelling spoiled food). We included items representing both positive and negative olfactory experiences. Additionally, to assure cultural universality, we have chosen items that describe common chemosensory experiences, relevant to people representing various cultures. In the course of validation, we found that removing one more item yields even better results, resulting in a 6-item scale with good psychometric properties (OAS-6).

Individual significance of olfaction questionnaire (ISOQ; Croy et al., 2010) is a 20-item scale measuring the subjective importance individuals attribute to the sense of smell. The questionnaire consists of

Table 2
Items from the original OAS used in the study (OAS-7).

#	Item
#1	When someone is busy in the kitchen, do you notice the odor of the food being prepared?
#2*	When you visit someone else's house, do you notice how it smells?
#3	When an acquaintance smells differently from normal, for example, because of a new perfume, do you immediately notice?
#4*	Do you notice the smell of people's breath or sweat?
#5*	Are you the first one to smell spoilt food in the fridge?
#6	Do you feel cheerful or happy when you pick up a pleasant odor in the air?
#7	Do odors revive strong or vivid memories in you?

Note. Underlined items comprise OAS-6 after exclusion of one item based on factor loadings (see Results section). Items marked with an asterisk (*) were included in the Negative subscale in the original OAS.

three subscales, each containing six items: associations with olfactory sensations (Association), application of the sense of smell (Application), and the willingness to draw consequences from olfactory perception (Consequence). Additionally, the scale includes an Aggravation scale (2 items), which helps identify individuals with olfactory loss who may overestimate their condition when seeking medical advice. Respondents rate the items on a 4-point Likert scale ranging from "*I totally agree*" to "*I totally disagree*". In this study, we presented ISOQ with a 5-point Likert scale ranging from "*I totally disagree*" to "*I totally agree*" to match the scale used in OAS. Higher scores on each subscale indicate greater attribution of significance to that specific aspect of olfactory functioning. The ISOQ demonstrates acceptable internal consistency, with Cronbach's α coefficient of.77 reported in the original study.

We employed ISOQ to estimate the theoretical validity of the short version of OAS. We argue that individuals who find their sense of smell especially important for their daily functioning (ISOQ) will also exhibit greater awareness of surrounding odors (OAS) (Smeets et al., 2008). Therefore, we expected scores in ISOQ and OAS to be positively correlated.

2.4. Statistical approach

Data were analyzed with R (R Core Team, 2017) with the significance level set to $p < 0.05$. We used packages *lavaan* (Rosseel, 2012), *ltm* (Rizopoulos, 2006), and *ggplot2* (Wickham, 2016) for data analysis and visualization. To verify if all the items included in the scales represent the same psychological construct of odor awareness, we conducted a confirmatory factor analysis (CFA). We used the maximum likelihood estimation to estimate the model fit of the OAS, OAS-7, and OAS-6 versions. As the shortened versions comprised only a small number of items, we tested the fit of a 1-factor model treating odor awareness as a general construct. However, based on the original scale (Smeets et al., 2008) we also ran CFA for a 2-factors model treating awareness of positive and negative odors as two independent factors. We used the following model-fit indices: χ^2, Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Squared Residual (SRMR), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI); Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC). All these indices estimate how well the observed data fit the theoretical model. Statistically insignificant χ^2 test value indicates a good fit of the model. Values of RMSEA, SRMR, CFI and TLI range from 0 to 1. Lower values of RMSEA and SRMR indicate better fit and the suggested cut-off criterion for the good model fit is a value below.08. For CFI and TLI higher values are good-fit indicators with cut-off criteria being >0.9 for acceptable and >0.95 for good model fit. AIC and BIC are indices that allow comparison of the goodness-of-fit of multiple models with lower values indicating better fit (see: Schreiber, Nora, Stage, Barlow, & King, 2006; Marsh, Hau, & Wen, 2004, for discussion of model-fit indices). For all the models, standardized factor loadings have been obtained. Factor loadings indicate how much each questionnaire item contributes to the

measured construct. Cronbach's α and McDonald's ω were employed as measures of scale internal consistency (i.e. the extent to which all items measure the same construct). We used Pearson correlation analyses to verify (1) test–retest reliability (i.e. stability of the scores over time) and (2) theoretical validity by verifying the association between OAS scores and ISOQ total and subscales scores. Finally, we verified the correlation between OAS scores and participants' age and analyzed gender differences using the Wilcoxon rank sum test (non-parametric was employed due to differences in the group sizes). Based on the obtained results for the OAS-7, we repeated all the steps of the analyses for OAS-6 (Tables 3 and 4). Validation analyses for OAS-6 have been conducted on the same dataset that has been employed in the validation of OAS-7.

3. Results

3.1. Short OAS validity and reliability

We verified the psychometric properties of the 1-factor model. OAS-7 model showed an acceptable fit according to the SRMR value < 0.059, as well as CFI above.90 (Table 3). However, the values of RMSEA = 0.116 and TLI = 0.861 did not meet the acceptable thresholds for model fit. Moreover, item #6 loaded the overall score moderately (factor loading < 0.50; Table 4), therefore we ran another CFA for a single-factor 6-item OAS version (OAS-6) excluding item #6 from the OAS-7. OAS-6 showed a very good model fit with indices varying from good to excellent: RMSEA = 0.065, SRMR = 0.039, CFI = 0.977, TLI = 0.962, and despite a significant χ^2 test (p = 0.044). Additionally, AIC and BIC indices decreased as compared with the OAS-7 confirming a better fit of the OAS-6 (Table 3). In the OAS-6 all items had a factor loading greater than >0.50 (Table 4).

We compared the 1-factor model-fit indices obtained for OAS-7 and OAS-6 to the indices obtained for the OAS. We found that both OAS-7 and OAS-6 presented a better fit as compared with the OAS scale as indicated by all model-fit indices (except for RMSEA for OAS-7, which was higher than for OAS,.116 and.079 respectively).

The analyses comparing models comprising two factors of odor awareness (positive and negative odors) showed similar goodness-of-fit to the OAS. However, in OAS-7 and OAS-6 the 1-factor models yielded a better fit than the 2-factors models. Factor loadings for all the items were higher for 1-factor OAS-7 and OAS-6 models than for these same items loading two factors (Table 4). Based on the factor analysis we decided to further consider OAS-6 as a candidate for a short version of OAS. OAS-7 is therefore excluded from the further analyses.

OAS-6 demonstrated good internal consistency with Cronbach's α = 0.80, and McDonald's ω = 0.81 respectively. The scores were stable over time with a high test–retest correlation and strong correlation with ISOQ total score and its subscales (Fig. 1). The only exception was the correlation between OAS-6 and the Aggravation scale which was weak. These coefficients are summarized in Table 5.

Table 4
Standardized factor loadings for the short versions of the OAS.

Model	Factor loadings	
OAS-7, 1 factor	#1:.62	
	#2:.82	
	#3:.79	
	#4:.65	
	#5:.56	
	#6:.48	
	#7:.72	
OAS-7, 2 factors	Positive odors	Negative odors
	#1:.63	#2:.82
	#3:.79	#4:.65
	#6:.48	#5:.56
	#7:.72	
OAS-6, 1 factor	#1:.64	
	#2:.84	
	#3:.81	
	#4:.64	
	#5:.55	
	#7:.66	
OAS-6, 2 factors	Positive odors	Negative odors
	#1:.64	#2:.84
	#3:.81	#4:.64
	#7:.66	#5:.55

Note: Item numbers for OAS-6 are the same ordinal numbers from OAS-7.

3.2. OAS scores relationship with gender and age

Women scored significantly higher than men in the OAS (W = 4330.5, $p < 0.001$, rank biserial correlation = 0.31) and OAS-6 (W = 3550, $p < 0.001$, rank biserial correlation = 0.33, Fig. 2). The descriptive statistics for OAS and OAS-6 scores for men and women are summarized in Table 6. Odor awareness did not correlate with age for any of the used questionnaire versions (OAS: $r = 0.09$, $p = 0.160$; OAS-6: $r = -0.11$, p = 0.112; Fig. 2).

4. Discussion

The present investigation demonstrates good psychometric properties of the short version of the Odor Awareness Scale (Smeets et al., 2008). The scale comprises six items and its completion should not exceed 2 min. OAS-6 may be broadly applied in interdisciplinary studies in which odor awareness is an important, yet not central factor. These studies often do not include metacognitive measures of olfactory perception due to time constraints, and we have successfully overcome this problem. The development of OAS-6 may lay the foundations for new insights regarding odor awareness in various populations (e.g. clinical groups suffering from sensory impairments, neurodegenerative diseases, anxiety, depression; people with autism spectrum disorder; but also people with extraordinary olfactory perception like perfumers). Moreover, the OAS-6 is potentially useable in diverse cultural contexts and its brevity facilitates translation and back-translation, thereby expanding the possibilities for cultural validations.

Table 3
Model fit indices for all the tested models.

Model	χ2	RMSEA	SRMR	CFI	TLI	AIC	BIC
OAS, 1 factor	1238.89***	.079	.075	.707	.687	21905.24	22135.06
OAS, 2 factors	1212.96***	.078	.076	.716	.696	21881.32	22114.73
OAS-7, 1 factor	55.60***	.116	.059	.907	.861	4161.74	4209.25
OAS-7, 2 factors	55.58***	.122	.059	.905	.846	4163.71	4214.62
OAS-6, 1 factor	**17.30***	**.065**	**.039**	**.977**	**.962**	**3626.29**	**3667.01**
OAS-6, 2 factors	17.27*	.073	.039	.974	.952	3628.26	3672.38

Note. *-$p < 0.05$, ***-$p < 0.001$; RMSEA – Root Mean Square Error of Approximation, SRMR – Standardized Root Mean Squared Residual, CFI – Comparative Fit Index, TLI – Tucker–Lewis Index; AIC – Akaike Information Criterion; BIC – Bayesian Information Criterion. Bolded is the recommended version of OAS-6.

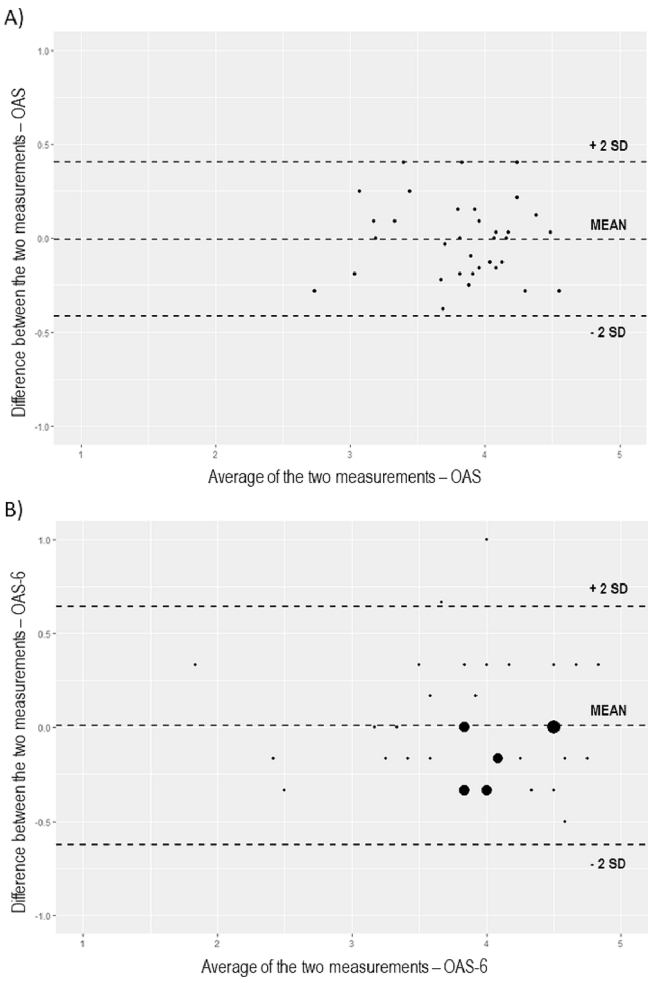

Fig. 1. Bland-Altman plot showing the distribution of score difference between the two measurements against the average of the two scores for OAS (panel A) and OAS-6 (panel B). Note: in the plot for OAS-6 the size of a dot represents overlapping cases (bigger dots mark 2 or 3 overlapping cases). SD = standard deviation.

Our data show that similarly to OAS (Smeets et al., 2008), women on average score higher in OAS-6 than men. This finding is in line with research demonstrating overall superior olfactory performance in women as compared to men (Doty & Cameron, 2009; Sorokowski et al., 2019), their increased interest and importance of odors (Croy et al., 2010; Havlicek et al., 2008; Herz & Inzlicht, 2002; Seo et al., 2011; Sorokowska et al., 2018), as well as greater attention to odors (Oleszkiewicz et al., 2021). Interestingly, our data reveals remarkable variation in OAS scores within gender groups. Thus, other potentially relevant characteristics should be accounted for in future studies to explain individual differences in odor awareness.

Despite the well-grounded age-related trajectory of changes in olfactory perception (Attems, Walker, & Jellinger, 2015; Oleszkiewicz, Schriever, et al., 2019; Sorokowska et al., 2015), our results show that OAS-6 score is independent of age. This is in line with data reported by Croy et al. (2010) showing that the extent to which people consider their olfaction significant is relatively stable across age groups (Shu et al., 2009). In a broader context, this discrepancy indicates that both metacognitive measures (odor awareness and the significance of olfaction) are relatively independent of performance on psychophysical tests. Indeed, people tend to be quite inaccurate in assessing their olfactory performance (Oleszkiewicz, Kunkel, et al., 2019; Pieniak, Lachowicz-Tabaczek, Karwowski, & Oleszkiewicz, 2021). Results of OAS-6 present a robust correlation with all three subscales of the ISOQ, but not the Aggravation scale, which is used to detect individuals experiencing olfactory loss who might exaggerate their symptoms when consulting healthcare professionals. OAS-6 being a metacognitive measure of odor awareness should not be highly correlated with ISOQ items designed to measure desirability bias. This weak correlation further warrants theoretical validity of our scale.

Our study has limitations worth discussing. First, despite selecting items representing both positive and negative odors from the original OAS, the OAS-6 does not reflect the two valence dimensions of the OAS, since the 1-factor model simply presents a better fit. When calculating 2-factor solutions, the perfect fit indicators suggested oversaturation of the model likely due to the small number of items (MacCallum, Widaman, Zhang, & Hong, 1999; Raubenheimer, 2004) for positive and negative odors. OAS-6 positive and negative odors subscales are still accurate measures (they present a similar correlation to the ISOQ scores; Table 6). Thus, we have taken the conservative decision to recommend a 1-factor OAS score. Another limitation that should be addressed is the gender imbalance in our sample. Women more eagerly participated in our study than men. For the OAS subsample the gender ratio (women:men) was 2.6 while for OAS-6 it was 1.6. Despite this, the mean scores for men and women completing OAS and OAS-6 scales were similar pointing to minimal effects of gender imbalance. Furthermore, analyses replicated gender-related effects for both versions of the questionnaire but the effect revealed by our study was medium. It was slightly amplified compared to previous studies reporting rather small effects. Another finding of this study biased by unequal gender proportions is the reliability of the OAS-6 that has been calculated mainly for young females. Although we made active efforts to balance the genders and recruit more

Table 5
OAS and OAS-6 test–retest reliability, internal consistency, and the relationship between the OAS, OAS-6, and ISOQ scores.

Model	Test-retest correlation	Cronbach's α	McDonald's ω	Correlation with ISOQ				
				Total score	Association subscale	Application subscale	Consequence subscale	Aggravation subscale
OAS, 1 factor	$r = 0.89^{***}$	$\alpha = 0.89$	$\omega = 0.90$	$r = 0.78^{***}$	$r = 74^{***}$	$r = 0.62^{**}$	$r = 0.59^{**}$	$r = 0.43^{***}$
OAS, positive odors	$r = 0.87^{***}$	$\alpha = 0.80$	$\omega = 0.82$	$r = 0.74^{***}$	$r = 0.73^{***}$	$r = 0.56^{**}$	$r = 0.54^{**}$	$r = 0.41^{***}$
OAS, negative odors	$r = 0.85^{***}$	$\alpha = 0.83$	$\omega = 0.85$	$r = 0.74^{***}$	$r = 0.68^{***}$	$r = 0.59^{**}$	$r = 0.57^{**}$	$r = 0.40^{***}$
OAS-6, 1 factor	$r = 0.89^{***}$	$\alpha = 0.80$	$\omega = 0.81$	$r = 0.68^{***}$	$r = 0.62^{***}$	$r = 0.55^{***}$	$r = 0.54^{***}$	$r = 0.33^{**}$
OAS-6, positive odors	$r = 0.90^{***}$	$\alpha = 0.67$	$\omega = 0.67$	$r = 0.62^{***}$	$r = 0.61^{***}$	$r = 0.52^{***}$	$r = 0.45^{***}$	$r = 0.30^{***}$
OAS-6, negative odors	$r = 0.79^{***}$	$\alpha = 0.68$	$\omega = 0.69$	$r = 0.61^{***}$	$r = 0.52^{***}$	$r = 0.48^{***}$	$r = 0.54^{***}$	$r = 0.29^{***}$

Note. $^{**}p < 0.01$, $^{***}p < 0.001$; OAS – Odor Awareness Scale; ISOQ – Individual Significance of Olfaction Questionnaire. Cronbach's α for ISOQ: $\alpha = 0.83$, $\omega = 0.85$ for the total score, $\alpha = 0.78$, $\omega = 0.78$ for Association, $\alpha = 0.62$, $\omega = 0.67$ for Application, $\alpha = 0.57$, $\omega = 0.59$ for Consequence.

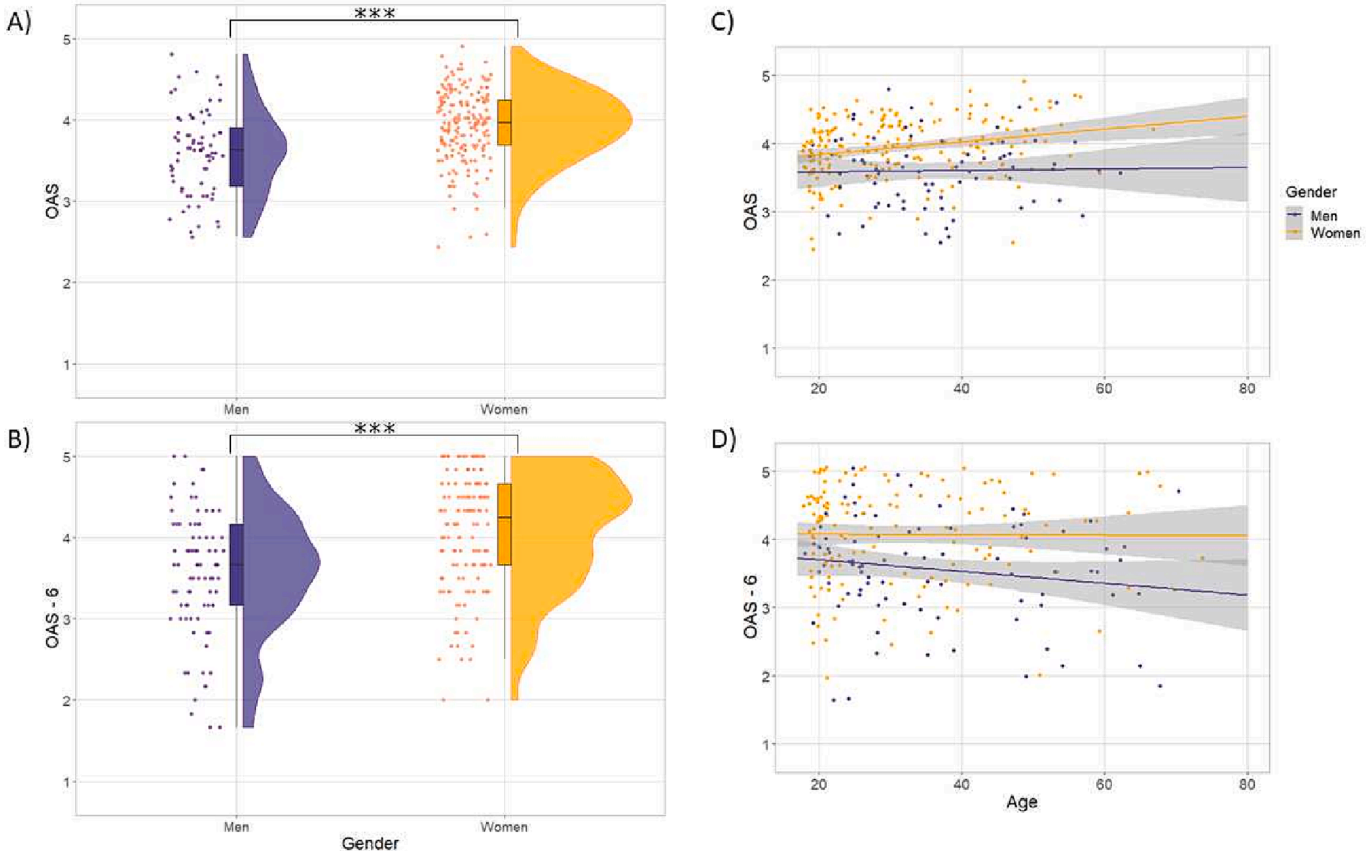

Fig. 2. Gender differences in OAS and OAS-6 scores (Panels A and B); correlations between OAS and OAS-6 scores, and age (Panels C and D). Note: *** $-p < 0.001$.

Table 6
Descriptive statistics for OAS and OAS-6 scores grouped by gender.

		n	Mean	*SD*	Median	Min	Max
OAS	Women	193	3.94	.43	3.97	2.44	4.91
	Men	75	3.60	.51	3.60	2.56	4.81
OAS-6	Women	134	4.07	.72	4.25	2.00	5.00
	Men	86	3.57	.76	3.67	1.67	5.00

male participants, the determination of the actual magnitude of this effect should be the subject of further studies with a more rigorous balance of the research sample. Efforts should be made to encourage men to take the survey. Moreover, the study was conducted in Poland, and participants responded in the Polish language. Prior to the study, we implemented a back-to-back translation process (Vallerand, 1989) to ensure the linguistic equivalence of both language versions, however the validity of the English OAS-6 version was not tested in this study. Thus, future research should consider testing the scale in various languages to assess its cultural and linguistic equivalence and psychometric properties across different linguistic and cultural contexts. Lastly, for the test–retest part of the study, we exclusively recruited students who regularly attend the University to minimize potential drop-outs. We do not have grounds to expect that the reliability of the scale would be different in the student sample as compared to the general population. However, the time stability of OAS-6 should be also verified in other demographic groups in the future.

To conclude, the present study offers a short version of a questionnaire designed to measure odor awareness. Completing the questionnaire should not take longer than 2 min, opening the possibility to apply it in various studies wherein metacognitive measures of olfactory perception can be of interest, such as the interactions between odorous environment and human health or clinical studies. The scale overcomes the typical problem of the study protocol time constraints. This new 6-question format lends itself to easy online application to diverse audiences.

Funding

This work was supported by the National Science Center OPUS grant #2020/39/B/HS6/01533 awareded to Anna Oleszkiewicz.

CRediT authorship contribution statement

M. Rokosz: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis. **M. Pieniak:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis. **D. Marek:** Investigation. **B. Żyżelewicz:** Investigation. **I. Croijmans:** Writing – review & editing, Conceptualization. **M. Smeets:** Writing – review & editing, Conceptualization. **A. Oleszkiewicz:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data are available at https://osf.io/m95z4/.

Acknowledgments

We thank Thomas Hummel for his thoughtful comments.

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